CMFRI

Course Manual

Winter School on

Recent Advances in Breeding and Larviculture of Marine Finfish and Shellfish

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PROSPECTS OF MOLLUSCAN MARICULTURE IN INDIA

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Introduction

The global aquaculture production is estimated as 54.8 million tonnes (FAO, 2003) of which molluscs contributes for more than 20% (11.1 million t). The rate of increase in production is presented in Fig.1. The major species farmed globally are the Pacific Cupped oyster, clams, mussels, scallops, abalones, etc. (Fig.2). In the recent past, India has made a small beginning (annual production of nearly 10,000 t) in molluscan farming (mussels and oysters) in the state of Kerala, but it is yet to pick up in other maritime states, inspite of its immense potential. The nation has been able to develop full fledged mariculture technologies for edible oysters, mussels, marine pearl production in fucata oysters, and also developed hatchery technologies for pearl oysters, mussels, clams and some species of cephalopods and gastropods.

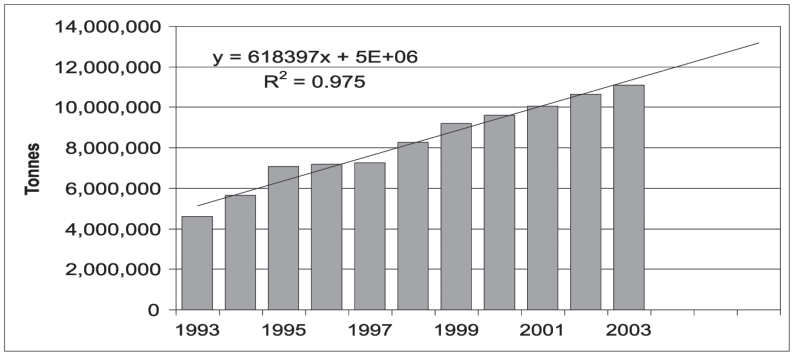

Fig.1. Trend in global farmed mollusc production (source FAO, 2003)

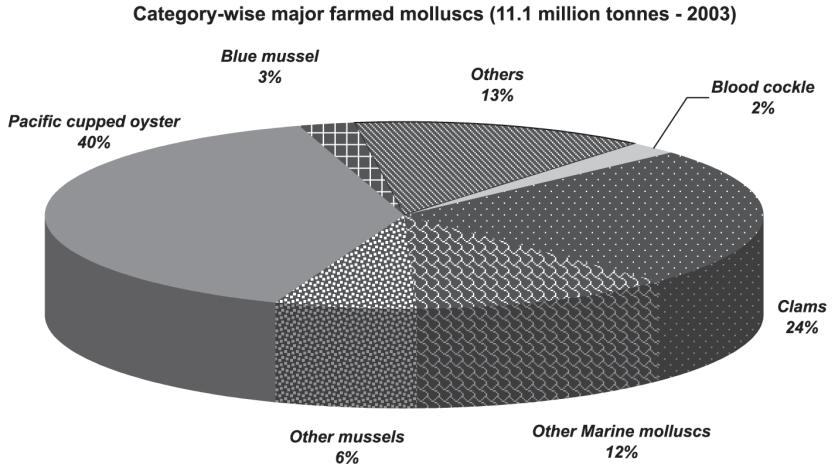

Fig.2. Major groups of molluscs farmed in the world (FAO, 2003)

It is also known that a number of marine species of global interest are endangered and have been recently placed in the Schedule I and IV of the Indian Wildlife Act. The over exploitation of these valuable resources, coupled with their slow regeneration capacities and the occurrence of catastrophic natural disasters have led to a situation where conservation measures are urgently needed. In this context, mariculture, or more aptly ***conservation mariculture***, can play a vital role in rebuilding of endangered and vulnerable marine stocks.

Marine Pearl Culture

Pearl is one of the oldest of the known gems, produced by the living animal called the pearl oyster. India is well known for the production of natural pearls from time immemorial. There are recorded historical evidences that the country had exported this valuable merchandise to Greece and Rome more than 2000 years ago. India has a wealth of pearl producing oysters: the *Pinctada fucata*, which produces golden pearls, distributed in the Gulf of Mannar, Palk Bay and Gulf of Kutch and the black lip pearl oyster, *P. margaritifera*, which produces the famed black pearls, in the Andaman and Nicobar Islands.

The Farming Technology

The technology for pearl production, based principally on the Japanese methodology of pearl production, was tried and developed successfully in the Indian pearl oysters by the CMFRI. The technology essentially involves the introduction of an artificial bead along with a secretory mantle tissue into a recipient oyster. The tropical marine environment of India is found conducive to foster the formation of perfectly spherical pearls within a period of 6-8 months.

Marine Mussel Culture

Marine mussels form one of the most dominant cultivable species all over the world. They give the highest conversion of primary producers (phytoplankton) to human food, and culture of mussels in the column waters can increase the seafood production several fold. In India, the green mussel *Perna viridis,* and the brown mussel, *P. indica* are distributed in the rocky coastal areas where they support a traditional sustenance fishery, but, scope for increasing natural production from the existing beds is rather limited.

Marine mussel farming technology using the rope method was developed by scientists of CMFRI in the late nineteen seventies. The technique suited for open sea conditions found few takers and subsequently in the mid nineties the technique was modified to suit estuarine habitats with marine conditions. Due to low risks involved in such operations and due to the increasing demand for mussels in northern Kerala, coastal fishers in north and central Kerala readily accepted the technology.

Salient Features of the Technology

The technique for farming mussels is very simple and uses the property of mussels to adhere to a solid substratum using its byssus. Young mussels of 15-30 mm size are collected from natural beds during the settlement season and wrapped around a thick nylon or coir rope using degradable cotton netting. The mussels attach to the ropes in about 3-5 days and within a week the cotton netting disintegrates. These ropes are then suspended from either a rack, long line or raft structures.

Rack Method: This method is especially suited for estuaries and shallow seas. Bamboo or casurina poles are driven into the bottom spaced 1-2 m apart. These stakes are connected horizontally with poles. The horizontal poles should be above the level of water at high tide. Seeded rope can be suspended in to the water for farming from these poles. Three seeded ropes can be suspended from one square metre area of the rack.

Long Line Method: This method is considered ideal for unprotected open sea conditions. Synthetic rope of 16-20 mm diameter is used for the long line (main line). The main line is supported with 220 litre barrels tied to it, spaced at 5 m. The long line and barrels are anchored in position at either ends using concrete blocks and nylon ropes. Seeded ropes are suspended from the long line.

Raft Culture: Ideal for open sea conditions, which are not rough. Square or rectangular rafts are made with sturdy bamboo or casurina poles. Buoyancy for the raft is given by tying 5 barrels of 200 litre capacity (metal oil barrel painted with anticorrosive paint or synthetic barrel). Ideal size of the raft is 5x5 m. The rafts are to be positioned at suitable site in the sea using anchors (grapnel, granite, concrete). Three seeded ropes can be suspended from one square metre area of the raft.

Uptake of Technology and Success Stories

The success of mussel farming in Malabar Coast of Kerala can be gauged from the fact that from a production of about 20 tonnes in 1996 it has reached 4000 tonnes in 2004 – 2005. From the economic evaluation it is found that the estimated production was 634 tonnes/ha and estimated profit per farmer was Rs.6752/farmer/season. Now it has reached a stage, where, by using CMFRI technology and the financial assistance from State Govt. under the SGRY (Swarnajayanthi Gramaseva Rosgar Yojana) and Co-operative Banks, more and more Women Self Help Groups are coming up in Northern and Central Kerala for mussel farming in the backwaters adjacent to their houses. Subsidies, bank loans and other financial assistance are a part and parcel of the programme and it essentially focuses attention on poverty alleviation through organized SHG's. Agriculture loans from farmers' co-operative banks have also helped the farmers. The amount sanctioned for mussel farming by the banks range between Rs. 8,000 and Rs. 9,000 per member with 40 to 50 % subsidy and a repayment period of 5 years at 12.5% interest per annum. Equipped with financial aid, the women SHG's have contributed significantly to the development of mussel farming in the state. The number of mussel ropes per farm varies between 300 and 900 with the yield ranging from 28 to 40 tonnes depending upon the initial stocking. Initially the harvest was in a single bulk by the beginning of June before the onset of monsoon forcing the farmers to sell the product at a very low price. To solve the marketing problems, they have phased out the harvesting to a longer period from April till the onset of monsoon in June, with the farmers harvesting 5 to 10 ropes per day and selling it to women vendors who sell it in the local markets.

The institute had set up several demo farms and conducted training in selected villages every year. The Institute also regularly offers training programmes for state fisheries and bank officials so that they are well equipped to process the applications of farmers seeking financial assistance. All the efforts put in has been fruitful and the state today produces 7500 tonnes of farmed mussels annually. More than 450 families in Kasargod, Kannur, Kozhikode, Thrissur, Malappuram, are now the proud owners of mussel farms. In the serene coastal regions of Kerala, mussel farming has established itself as a part time avocation, earning the trust of the villagers. The additional income generated through the culture was used for the education of their children, for the repayment of the loans and a portion was kept as a reserve for culture operations of the coming season. During 2002-03 mussel farming has spread to Ratnagiri district in southern Maharashtra, where more than a dozen mussel farms have come up. The first mussel farmer in the country, Shri. Gul Mohamed, was awarded the prestigious *Karshaka Shiromani Award* of 2002 constituted by the Ministry of Agriculture, Government of India.

Edible Oyster Farming– Success Stories

Oysters occur in shallow waters and form subsistence fisheries in several coastal regions along the Indian coast. Of the six species of oysters, the Indian backwater oyster, *Crassostrea madrasensis* is the dominant species having a wide distribution. Characters like high tolerance to environmental variation and rapid growth have made oysters a candidate species for commercial farming in some parts of India. Being a filter feeder, it gives high production per unit area and eliminates the clause for additional expenditure on supplementary feed. Since the early seventies, scientists of the CMFRI have taken up R & D programmes on all aspects of oyster culture and as a result, a complete package of the technology is now available in the country.

Salient Features of the Technology

Oyster seed is collected either from the natural beds or produced in hatcheries, on suitable cultch materials. For spat collection from wild, suitable spat collectors are set at the appropriate season. For Indian conditions, the rack & ren method is advocated for which the oyster shell ren is used as spat collector. The rens are made by stringing 5 6

cleaned oyster shells on to a 3 mm nylon rope at spaced intervals of 15 20 cm. The collectors are suspended from racks at the time of settlement of spat. The rack and ren method is most ideal for shallow estuaries, bays and backwaters. A series of vertical poles are driven into the bottom in rows to which horizontal bars are connected on top of the poles. Oyster strings (rens with spat) are suspended from the racks. The spat collection and further rearing can be carried out in the same farm site. The oysters reach harvestable size (80 mm) in 7 8 months. Harvesting is done manually. The meat yield is 10% of the total weight. 80 10 tonnes/ha (10 12 kg/string) is obtained by this method of culture.

Uptake of Technology and Success Stories

Based on demonstration trials, commercial production of edible oysters adopting CMFRI technology was started in Ashtamudi Lake (Southwest coast) in 1996 and the initial production was 20 tonnes by a single farmer. Gradually, with financial support from BFFDA and Gram Panchayat schemes, fishers, especially women groups, in Ashtamudi and Kayamkulam Lakes have started edible oyster farming on a larger scale and the annual production is estimated as 800 t. In 2001-2002 there were about 140 oyster farms in Kerala covering an area of 2.2 ha. The total production during 2005-2006 was about 1400 tonnes shell-on, providing 140 t meat which costs Rs. 60/ kg and worth Rs. 84 lakhs from 9 months of farming. A rapid socio-economic survey conducted among the farmers revealed that most of the oyster farmers of Kayamkulam Lake utilized the money to meet their daily requirements. The regular income to the families is through fishing and the fishers become unemployed when the trawl ban is implemented during monsoon. For these fishers the money from the sale of 5 to 10 rens per day was the main source of income for the family. Some farmers have utilized the money for meeting the initial expense connected to school reopening (for purchase of books, uniforms etc.). Surveys conducted among the oyster farmers of Ashtamudi Lake and Kayamkulam Lake showed that the farmers have no complaints regarding the technology. They have utilized the profit (ranging from Rs. 700 to Rs. 25,000 depending on the farm size) for various family commitments such as repayment of existing loan taken for house construction, daughters wedding, children's education etc. They were of the opinion that regular oyster farming is an additional income for their family with minimum financial input. The women SHGs in Ashtamudi and Kayamkulam, with financial assistance from BFFDA and Gram Panchayat have taken up oyster farming as a part time avocation which ultimately reflects on the rural development of the area.

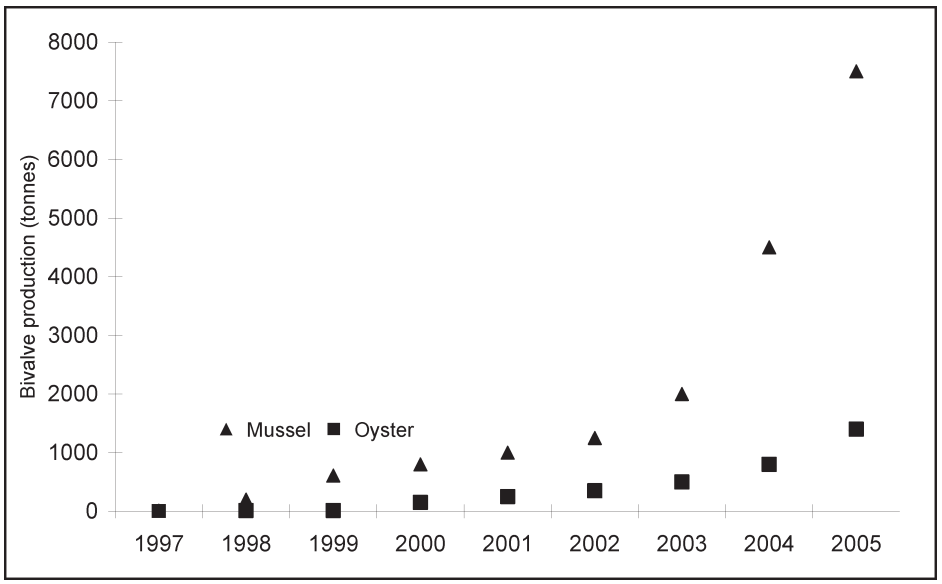

Fig.3. Estimated production trend in mussels and oysters from India

The employment opportunities open to the women fishers are fish marketing, shrimp peeling, fish processing, ownership of small stores etc. Participation of women Self Help Group in edible oyster farming, a small-scale aquaculture industry, is high. There are five major activities in oyster farming such as ren making, farm construction, harvesting, post-harvest processing and marketing. Of which women were involved more in ren making (boring and stringing empty shells and suspending) and post harvest processing such as cleaning, shucking and packing. The male members usually do farm construction and harvesting. Marketing in some locations (Kayamkulam Lake) was done exclusively by women while in Ashtamudi Lake the marketing was through Government agencies.

Clam and Cockle Farming

Several species of clams belonging to the families Arcidae, Veneridae, Corbiculidae, Tridacnidae, Solenidae, Mesodesmidae, Tellinidae, and Donacidae occur along the Indian coast. However cultivable species are restricted to Veneridae, Aricidae and Corbiculidae. Experiments on clam culture were done in the Kakinada Bay using *Anadara granosa*, the dominant cockle resource of the region. Seed clams of *A.granosa*, with mean length 24.3 mm, mean weight 6.7 g were collected during low tide from the bay and stocked at densities 140 and 175 nos. per m^2 (Narasimham,1980). After 5.5 months of culture the clams attained 25.5 to 32.9 g weight and 39.2 to 42.7 mm length. The retrieval was 83.4 to 88.6% when pen enclosures are used and 41.5 % without pen. Production rates of 39 to 41.6 t/ha/ 5.5 months are obtained when pen culture is practiced and 21t/ha/6 months when pen is not used. Thus both retrieval and production rates are reduced by about 50% in blood clam culture if pen is not used.

In Mulky estuary, in Karnataka, in experimental culture *Meritrix meritrix* grew from 23.6mm to 37.5 mm average length in 4 months with a survival rate of 75.5 months.(Rao *et al*., 1989).The major clam resource of Kerala state is the black clam *Villorita cyprinoides*. Experimental culture of this resource was done in the Vembanad lake (Kripa *et al.,* 1999). Clams production rates in different stocking densities were tried and it was suggested that with a stocking density of 500 nos/ m^2 about 1.2 t of clam can be harvested in 6 to 7 months.

In the two main estuarine systems of Kerala, re-laying of clams is practiced (Kripa *et al.,* 1999). Clam fishers of Vembanad Lake collect the seed of *Villorita cyprinoides* during the spat fall season, mainly June and November and stock them in the water bodies adjacent to their residence to be harvested at a later stage. Apart from this they sort the seed clams from the fishery landings as and when they occur and stock them for further growth. In the same manner, the clam pickers of Ashtamudi Lake collect seed of *Paphia malabarica* and stock them during January – February to be harvested later. This method of clam culture termed relaying or semiculture in a way protects the resource from depletion. It allows the clams to grow to their full potential and gives the clams a chance to utilize their reproductive potential before being fished.

Prospects for farming of other mollusc species and farming innovations

Abalone Pearls: Abalones are one among the few mollusks known for producing gem quality pearls and highly priced meat. The nacre of abalone shell is often multihued in tunes of silver, orange, pink, green, blue and lavender. The abalone pearls are superior to pearls produced from freshwater mussels and comparable to best marine pearls. CMFRI achieved initial success in the half pearl production from abalones during 1998-'99 at its regional center, Mandapam. Earlier attempts to produce pearls in abalone by fixing a nucleus on the inner side of the shell of the animal were not successful due to dislodgment of the nucleus by powerful foot movement of the animal. Due to sustained efforts a comprehensive method was developed and pearl production became a reality.

Mabe Pearls: A mabe pearl is a dome shaped or image pearl produced by placing a hemisphere or miniature image against the side of the oyster shell interior. In India, the technology for producing mabe pearls is already developed in the freshwater mussel and in the Indian pearl oyster *Pinctada fucata*. P. fucata can produce mabe pearls within 2 months and its commercial prospects are great as a souvenir and jewellery.

Akoya Pearls: In India, attempts have been made to produce fucata pearls similar to Japanese Akoya by implanting larger oysters grown in Kollam Bay along the southwest coat of India (Kripa *et al.,* 2003). The largest cultured pearl

obtained in this experiment had a diameter of 7.88 mm weighing 0.68 g and the average nacre thickness was 1.37 ± 0.27 mm.

Earlier work done along the east coast has shown that under tropical conditions, acceptable pearls are produced within 4-5 months with nuclei of 2–3 mm diameter and in 15-18 months with nuclei of 6-7 mm diameter. However, this study shows that along the southwest coast of India, the nacre production is faster and the period of rearing nucleated oysters can be considerably reduced to produce Akoya type pearls in India.

On-shore Pearls: On shore pearl culture studies were initiated from Visakhapatnam in 1996. Experiments were conducted on several aspects and many related parameters were refined and standardised. A small demonstration cum research facility of onshore pearl culture has been established in the premises of CMFRI, Visakhapatnam. A record growth of above 100 mm was achieved for *Pinctada fucata*. Good quality pearls ranging from 6 to 9 mm were produced in about 12-15 months. Many pearl oyster of above 7 years are still active. Apart from *P. fucata*, other species adopted for onshore (land based) system are *Pinctada maxima, Pinctada margaritifera* and *Pinctada chemnitz.*

Tissue Cultured Pearls: Countries like Japan, China, United States and Canada initiated marine invertebrate tissue culture. Among these countries, Japan is the pioneer country carrying out research in pearl oyster for the purpose producing *in-vitro* pearl through tissue culture. Visualizing the importance of the work in view of deterioration of natural environment India too entered in to the field of marine invertebrate tissue culture research, as it is one of the pearl producing countries in the world. Expertise in the field of research has already been developed and a fully functional marine invertebrate tissue culture laboratory has been established at Tuticorin from where tissue cultured pearls has been produced for the first time in India.

Make-up pearls: These are pearls in which their natural colour is manipulated through controlled feeding of trace metals. Initial experiments have shown very encouraging results for the production of make-up pearls.

Giant Clam Nurseries: The giant clams are a traditional food source for the people of Indo-Pacific. The flesh of giant clams is eaten by many communities and the shells are used either as ornaments or for utilitarian purposes. In recent times, giant clams have become significant specimens for the aquarium trade. As a result over exploitation has led to the extermination of many of the local species. Thus, from the 1970s research into the reproduction and larval culture of giant clams became important and many hatcheries and ocean nurseries have been set up in Indo-Pacific area for stock rebuilding of these valuable species.

Innovations in Mussel Farming:

(1) Use of flexible plastic strips (instead of nylon ropes) and ease of filling up the pre-stitched cotton biodegradable tubes with mussel seed as compared to the manual drudgery of stitching are recent innovations. This directly resulted in halving of the labour cost involved in seeding. Results of the economic analysis indicate that by using the improved method, marked gains (by 48%) could be made in the rate of return. The use of FPS as seeding substrate and pre-stitched cotton biodegradable net tubes can therefore be recommended for use to estuarine mussel farmers.

(2) Seeding is one of the most critical activities in mussel farming. The process which is physically demanding (as farmers have to kneel and bend down to do it) is crucial to the success of farming as the uniform attachment of mussel seed around the rope is dependant on how well it is done. Now, to reduce the physical strain and to increase efficiency during this process, a semi automated mussel seeder has been designed and developed.

(3) To help farmers strip mussels from ropes a manually operated de-clumping machine was designed and fabricated. This has also been field tested successfully in North Kerala mussel farms.

Gastropod Culture

Many gastropod species are consumed and are also used as curios and ornaments. *Babylonia* sp., commonly known as 'Whelk,' is a much sought after marine gastropod and it fetch a good foreign exchange. This edible gastropod

is an important food species in the Indo-pacific region. The breeding, spawning and larval development of *Babylonia spirata* has been successfully carried out by CMFRI. Other species such as the Top shell *Trochus* sp., the turban shell *Turbo* sp. And the sacred chank *Xancus pyrum* are exploited for creating curios. Due to heavy exploitation their status is endangered and there is need to take up conservation mariculture of these resources.

Floating Upweller Shellfish Nursery System

Upwelling is an efficient way to pass water vertically through a three dimensional mass of shellfish seed resting on a mesh in order to culture them from a hatchery size to a field nursery or grow-out size during the first season of growth. A floating upweller system (FLUPSY) takes the silos and places them floating just above the surface of a water body or floating tank, thereby reducing the "head" that makes pumping water so expensive in land-based systems. FLUPSYs move water through the use of tidal flow, airlifts, paddlewheels or pumps.

Bivalves and harmful algal blooms

Of the 4000 marine planktonic microalgae described to date, approximately 80 toxic species and 200 noxious species have been implicated in the formation HAB's. The major toxin producing algae are dinoflagellates followed by diatoms. Though toxic blooms have been known to occur for centuries, there has been a phenomenal increase in the HAB records in coastal waters in the recent years. Most harmful species become hazardous only when their concentration exceeds a threshold level, which varies with species.

Depuration of farmed bivalves

Bivalves are filter feeders in their feeding habit. During this process they accumulate all suspended biological materials including harmful microorganisms. Before the product reaches the market, these materials have to be removed from their gut. The process of such purification is called depuration. Simple depuration can be achieved by starving the bivalves in clean and filtered seawater/ brackishwater for a certain period of time. More effective depuration can be achieved by using disinfected water in the depuration process.

Environmental impact assessment of suspended bivalve culture

Bivalves are sedentary organisms that require substrate for spat settlement and subsequent growth during which time they filter feed on phytoplankton, detritus, protozoans and bacteria. It is well known that large scale mariculture can pose complex ecological and management problems. Impacts on primary productivity, current patterns, sedimentation, benthic productivity and community structure are now being studied.

Triploid oysters: Triploids are generally infertile and it has many advantages. Triplody therefore results in better growth rate in animals as no energy is wasted for reproduction. Triploid oysters have been successfully produced at CMFRI. Protocol for induction of triploidy by application of heat & cold shock and chemical (cytochalasin-B & DMAP) shock have been optimized.

Integrated farming: Edible oyster and mussels have been experimented in integrated farming. Integrated farming of edible oyster and mussel from the same rack structure was introduced in the Ashtamudi lake ecosystem. Similarly, preliminary experiments are being conducted for testing the feasibility of growing finfishes; shrimp and crabs in cages suspended in the same farm and have given encouraging results. The use of bivalves as bio-filters in shrimp ponds has also been experimented.

Cephalopod culture: Although considered as highly evolved molluscs, the laboratory breeding and grow-out of some cephalopod species have been carried out successfully by the CMFRI.

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