CMFRI

Course Manual

Winter School on

Recent Advances in Breeding and Larviculture of Marine Finfish and Shellfish

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ABALONE CULTURE

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Abalones, commonly known as ear shell are economically important marine gastropods belonging to the genus *Haliotis*. There are about 100 species of the abalones in the world. Abalone occur in all major oceans of the world but they appear to be more abundant in the temperate zone. Large abalones are mainly distributed in the temperate zone, while small specimens are typically found in topics and the cold zone.

The body of abalone is divided into three parts: head, foot and saccate intestine. Head is located on the anterior pat of the body and comprises a mouth, appendages and sensory organs. It has a pair of tentacles and two eyes at the tip of eyestalk, which originates at the bottom of the tentacles. Foot of the abalone is a creeping organ of muscular tissue, which lies on the ventral pat of the body. The well-developed foot has a broad sole, which allows the animal to strongly adhere to rocks and other had substrates. The intestinal sac is located on the dorsal side of abalone and has several internal organs. The abalone shell is formed by the secretion released from the epidermal cells placed at the font margin and tip of the mantle. Abalones belong to one of the most primitive gastropods and its round elliptical ear shaped shell has a row of respiratory pore located along the left margin. As the animal grows, older pores are successively filled in and closed. The number of open pores and shell exterior and interior colour varies among different abalone species. The abalone uses its foot to crawl from one place to place in a typical snail-like manner. The foot of an abalone is not suited to crawling or clinging onto sand. As a consequence, abalones are generally found only in areas of had rock o coral. In face of threat, abalone uses their foot to cling tightly onto rock and pull their shell down to protect the soft pats of their lips and foot. Wild abalones are herbivores and their diet changes during the different phases of their development. In their early phase of life, the abalone larvae are planktonic. When the larvae settle and becomes spat, they use their radulae to scrape coralline algae and slime (mixture of microalgae and bacteria) off the surface of rock. When abalones approach adulthood, their food changes to large seaweed. In wild, adult abalones sometimes gaze on seaweeds attached to the sea-bed. Abalones prefer red algae, tolerate some brown algae and accept only very few types of green algae.

Water quality determines the suitability of an environment for abalone growth. Abalones prefer water with the salinity of open ocean water and avoid low saline areas. Generally, abalones prefer shallow, turbulent waters with high levels of dissolved oxygen. Because of this and their preference for hard surfaces, abalones are usually found on exposed rocky headlands in cool areas.

Abalone meat, that is, the flesh of the foot and the muscle attaching it to the shell, is the most demanded part of abalone and highly priced. Abalone meat contains about 20 % protein. It is considered to be one of the best and most valuable seafood in various parts of Asia. Abalone shell have blue grey mother of pearls that can be made in to several types of jewellary and inlays. Abalones can also be used to produce pearls, especially “mabe’ and blister pearls. Abalone is valuable as an ingredient in Chinese medicine and its viscera can be made into good quality glue.Humans have exploited abalones for many thousand of years. The first fisheries of abalone were in china and Japan over 1500 years ago, but it is only in the last 30 years that the fisheries for abalone have burgeoned worldwide and becomes economically important in many countries. Important abalone fisheries have existed in Australia, China, Japan, Mexico, New Zealand, South Africa and United States of America.

The red abalone, *Haliotis rufescens* is the largest of the abalones in the world often weighing over 1.7 kg. Red abalone has traditionally been the most popular and commercially important species in California.Unlike the temperate species, the tropical abalone species are smaller in size and less in abundance. The major tropical abalones are *H.diversicolor supertexta, H. asinine, H. ovina* and *H.varia.* Of these, H*. asinine* enjoys distribution in Japan, Thailand and Philippines. The other two species are abundantly distributed along the Andaman sea coast of Thailand. All tropical abalone species grow less than 10 cm in shell length.

In India abalones are found from Arabian Sea and Persian Gulf to the Bay of Bengal around Andaman and Nicobar islands as well as near Sri Lanka and is represented by only one species *Halitosis varia*. It grows to maximum shell length of 80 mm. It is moderately distributed in Gulf of Mannar along Pamban and Tuticorin areas of southern Tamil nadu.

Seed production of abalone

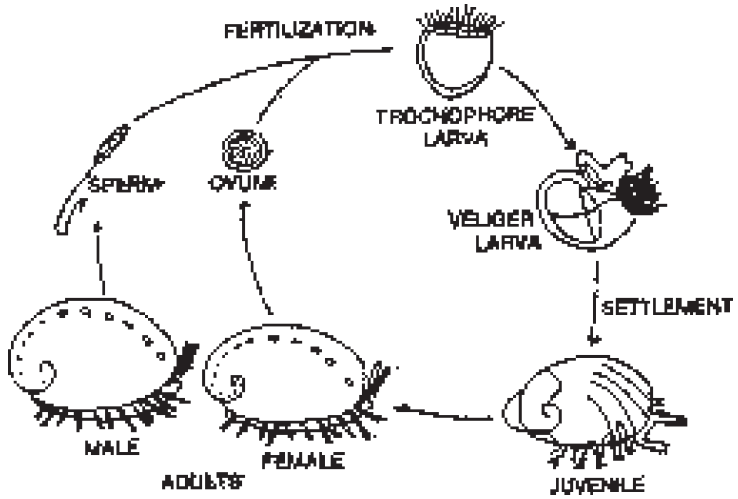
With the increased demand for the abalone meat, various countries have started culture of abalone on a commercial scale. Japan is the pioneers in abalone culture and later the interest in cultivating this valuable shellfish has spread into various parts of the world. Presently, Japan is acknowledged leader in developing techniques for the mass production of juvenile abalones.

Owing to importance in the world aquaculture scenario, CMFRI initiated research on abalone culture in India with the native species *Halitois varia*. The restricted and moderate distribution of abalones necessitates production through aquaculture. The first step in abalone culture is to standardize the techniques for seed production including spawning, fertilization and hatching, larval rearing, induced settlement and metamorphosis and production of juveniles. CMFRI achieved success in the seed production of abalone *Haliotis varia* at Mandapam regional centre during 1998 – 1999. During breeding season, the spawning of *Halioits varia* normally occurs during two to thee days before /after new moon or full moon days. During these periods, adult abalones were collected using a chisel without causing damages to foot and transported to laboratory for induced spawning. After transportation they were acclimatised to laboratory conditions by placing them in 1-ton FRP tanks with running water facility. Although natural spawning of matured animals were noticed in hatchery, desiccation method (exposure to air for about 2 hrs) was found more effective in inducing spawning. Fully ripe male gonads were creamy white and in the females it was dark blue/green in colour. Spawning occurred in late night or early morning hours.

Fertilized spherical eggs measuring 180 – 200 ì in diameter were collected by siphoning and filtering through a 50 ì sieve. Excess sperms were found detrimental to the success of hatching. Repeated washing with clean filtered seawater during filtering removed excess sperms and obtained 40 – 60 % average fertilisation. In about 12 hours after fertilization, free-swimming trochophore larvae hatched out from the egg. Average rate of hatching was around 70 %. The phototactic trochophores were siphoned out from the water and transferred to larval rearing tanks containing clean filtered seawater. The trochophore larval stage extends only to 10 – 12 hours. The trochophore larvae transformed into next stage, veliger, about 24 hours after fertilization. The veligers were also phototactic and behave same as trochophore larvae and measured to 210 ì in length.

In the late veliger larvae, the foot mass protrudes to the top of the shell at the completion of the larval shell. The late veliger stage extends upto the 3rd day of the post fertilization until it reaches the gliding stage. On the 4th day of post fertilization, the floating veligers began to settle on substrates. This stage, termed as gliding stage, is most suitable for transferring to settling containers. The larvae actively crawl with its foot, but do not stop its swimming behaviour unless suitable settlement substratum is present. Larvae when it reaches the next stage, creeping stage, require suitable feed in sufficient quantities. A mat of benthic diatoms comprising mainly of *Nitczhia* and *Navicula* was found to be most ideal food. For *Haliotis varia* the free-swimming larval rearing period ranged from 4 to 5 days when water temperature was 27^{0}C. The creeping larvae measured 260 ì in length. On 5th day of post fertilization most of the larvae ceased swimming and crawled over the diatom mat provided in the settling tanks. Maximum settlement was observed along the vertical surfaces of the container. Once the larvae settled on the mat and started feeding it seldom detached from it.

Peristomial growth the first step in the metamorphosis started in 6th day leading to the transformation of the round tubular larval shell to one, which resemble the flat abalone shell. The animal at this stage actively feeds on the diatoms and clears diatom mat areas by moving with their muscular foot. The mortality of settled larvae occurs when sufficient quantity of mat is not provided. The peristomial growth stage spat measured 288 ì x 218 ì in diameter. On the 16th day the shell becomes almost flat like the adult and shell colouration started as violet, but still transparent. At this stage, animal measured 820 ì x 670 ì in diameter. On 26th day, larvae transformed into juvenile with formation of first respiratory pore. At this stage, it measured about 2.2mm. On 46th day animal grows to size of 2.6 mm and 3 pores were formed. As abalone spat grows, there comes a time when they are too large to eat micro algae, and are ready to start eating seaweeds. Small spat grows well on micro algal feed; growth slows down when it reaches juvenile stage. When the spat grown to size of >2mm seaweed like Ulva and some red algae were given as food.



Farming of abalones

On a worldwide basis, there is a lot of interest in farming abalones. Research and development is being undertaken in many areas and in some places abalone farms are well established. The Japanese pioneered abalone farming. Seed production is still a large scale enterprise in Japan and 15 – 20 mm seed are grown, sold to fishermen's cooperative unions and used to stock in the ocean. Few abalones are grown to market size in farms, but in recent years the industry developed and there has been some grow out in land-based farms and from rafts in the ocean. *Haliotis discus hannai* is the primary abalone species supporting abalone culture industry around globe accounting for more than 70 % of the world abalone aquaculture production. Important species of abalones cultured in various counties are given below:-

Haliotis discus hannai	Ezo abalone	Japan
H.diversicolor		Taiwan
H. rufescens	red abalone	California and Mexico
H. kamtschatkana	Pinto abalone	Northern coast of North America
H. tuberculata	ormer	Europe
H. kamtschatkana	Pinto abalone	Europe
H. rubra	Blacklip abalone	Australia
H.iris	Papua	New Zealand

Various methods are used for farming of abalones

Ponds: Abalones can be grown in still water ponds or natural tide pools. The big disadvantage with still water ponds is that abalones do not grow fast and can stocked only in low densities. The main reasons are that abalones are not stimulated to feed without current flow and that water quality quickly declines if the abalones are heavily stocked or fed at high rates. Some water movement and improvements in water quality can be obtained by aerating still water ponds.

Cages: Another way of growing out abalones is to place them in an enclosure in the sea. The natural movement of water removes wastes and stimulates the abalones to feed. The common cage abalone farming is a smaller barrel. The open end is closed off with cloth and they are hung below buoys and rafts. Flow that results from wave movement can be as effective for water exchange and as a stimulant for abalone feeding. Algae settle on the meshes of the cages, in some areas reaching a stage where they can block water flow. A novel idea for a cage is to use submerged concrete pipes with mesh covering the open ends. These lay on the sea bottom and are serviced by divers. It is labour intensive and diving time can be costly.

Raceways: Raceways ensure a fast movement and good exchange of water. The fast current helps keep the containers clean and maintain water quality. Turbulence generated by water movement helps to remove toxic gases. The water flow in a race stimulates abalone to feed and therefore grow faster. The main disadvantage of raceways is that it generally requires pumping of water and because of it, in some places it will expensive. Generally races are straight channels or circular. Often the abalone races are rectangular in shape, with a width of 1.5m and depth of 0.5 – 1.0m. The common length of the raceways could be 10 – 20 m. The desirable flow rate in the raceways is about 1000 litres/hour. In nature abalone hide away in shady areas and they move away from light. So it is desirable to provide hideouts, which may improve the final harvest. The most common shelter are the traditional roofing tiles or PVC pipes cut down the middle. These are semi circular in cross section and can be placed with open side down on the floor of the race.

Feeding: Cost efficient feeding of grow out abalones is a key to economic success. A variety of methods of feeding can be used. Farmed abalones can fed fresh or preserved seaweed. As an alternative to natural food, grow out abalones can be fed formulated diets or even normal land grown vegetables. Because of the abundance and ease of availability brown seaweeds are used as feed for many of the abalone arming operations. But the brown seaweed are generally not as nutritious as red, with low levels of protein and they are often much tougher. Green seaweeds are usually poor in nutrition and disliked by abalones. But Ulva and *Calerpa brownii* are the two exceptions to this. Ulva has a thin almost transparent, leaf and that is readily accepted by abalones. Red seaweeds are the preferred food of abalone and they are highly nutritious. The main speccis of red algae used in abalone farming are *Corallina, Lithothamnium, Gracilaria, Jeanerettia and Porphyra.* The ideal amount of food to give to an abalone is as much as it can eat a no more. Feeding rate should be of 1/5 weight of the abalone in case of fresh seaweeds. But in case of dry feeds, 1/20 weight of the abalone should be given as feed per day. Feeding frequency may be of one or two times a day.

Rearing experiments of *Haliotis varia* conducted by CMFRI

Juvenile rearing: Rearing experiments with juvenile abalones were conducted at CMFRI. These juveniles were reared in FRP tanks with daily 100 % water exchange. The feed given was chopped green seaweed Ulva *lactuca*. Tanks were provided with dead coral stones as hide out for juvenile abalones. A survival of 70 % was obtained after a period 200 days. The abalones were grown to size of 8.96mm during this period. Different kinds of feeds like red coralline algae, which gave growth of 11.32mm, and green filamentous algae, which gave a growth rate of 9.70mm, were also tried in juvenile rearing. It was also observed that green filamentous algae showed slightly retarded growth after a certain time of rearing.

Rearing of adult abalones: Adult sized abalones collected from wild were reared in captivity in order to study their adaptability in captive condition. For rearing of adult abalones different methods like miniature raceway, cage and barrel culture were tried. FRP tank of 1-ton capacity was converted into a race type culture system. This tank was kept in a slightly inclined position with fresh water entering into the tank from one end and leaves the tank from the other end. Flow was adjusted so that feed given in the tank did not wash out from the tank. Coral stones were places in one end of the tank as hide out abalones. Feeding on these tanks was done using chopped green seaweed *Ulva lactuca* once in three days. The survival in these tanks was about 70 % after a period of 6 months of rearing. Growth cannot be monitored because of the slow growth of the animal, since we have introduced adult animals. Cages were also tried in the culture of abalone. Old barrels were used as cages for farming abalones. Old barrels were cut into two halves vertically and the open end was covered with old fishnets. Holes were drilled on the body of the barrel to ensure sufficient water flow. Coral stones were placed in the barrel, which acts as a substratum for abalones and also as weight to keep the barrels submerged. These barrels were suspended from racks. After the introduction of abalones into cages, the opening of the cages were tightly secured and feeding was done using finely chopped fresh seaweeds. Experiments with different kinds of feeds like *Ulva lactuca* and *Gracilaria edulis* and G*racilaria crassa* showed that *Ulva lactuca* was suitable feed for the abalone *H. varia.* Since there is a flow of seawater though a barrel, the animals were healthy and feeding.

In India, abalones are represented by a single species *H.varia*, which grows to maximum of 80cmm shell length. Although large abalones are very popular in many countries, the demand for small or cocktail abalones of 40-70 mm shell length is increasing and it is preferred over bigger abalones in some places. Considering this, there is a potential for the farming of Indian species of abalone by developing suitable technologies for seed production and faming.