

**Aquaculture-Based Enhancement and Restoration of
Many-colored Abalone Resources (*Haliotis diversicolor* Reeve, 1846)
in Bach Long Vi National Marine Protected Area, Vietnam**

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Abstract

Many-colored abalone (*Haliotis diversicolor*) is high commercial species in Vietnam. Meanwhile, these resources have been over-exploited, thus, artificial breeding was implemented to restore natural abalone resources. After sourcing the broodstock, many-colored abalones were stimulated to reproduce during October – December 2013 at the Abalone Seed Center in Bach Long Vi, Hai Phong City. The results showed that veliger larvae developed from 11h – 36h after breeding. Abalone juveniles reached to 4.5 mm (shell length) at the age of 42 days. Survival rate of abalone juveniles 1-2 mm (28 days old) was 0.92%, 3.80%, and 24.00% at larvae densities 7.5, 6.8, and 1.6 larvae/cm² algae board, respectively. After 2 months (October – November), 30,000 juveniles of 4.5 mm shell length; 33,800 juveniles of 3 mm shell length; 45,500 juveniles of 2 mm shell length; and many small larvae were collected at the Bach Long Vi Abalone Seed Center. More than 6,000 juveniles of 4.5 mm shell length were released to Bach Long Vi National Marine Protected Areas for conservation in April 2014. The restoration assessment was briefly carried out in June 2015, and found that almost all individuals were found to have average shell length of 3.4 cm in Bach Long Vi National Marine Protected Area. This is an initial achievement of aquaculture and juvenile rearing to release and protect the many-colored abalone resources in Viet Nam.

Keywords: abalone, enhancement, *Haliotis diversicolor*, nursery rearing

Introduction

Many-colored abalone (*Haliotis diversicolor*) is the valuable seafood in Viet Nam and all over the world, and considered as one of the greatest foods in the diet of ancient kings. Abalone meat has high nutritional value and is widely favored. Simultaneously, abalone contains valuable medicines useful for people's health and believed to cure many human diseases. In addition, the inner shell of abalone is beautiful nacre used in fine arts technology. Therefore, the many-colored abalone is now highly commercial in the market in Viet Nam. Nevertheless, in view of its high commercial value, the abalone resource has been over-exploited not only for domestic demand but also for export. According to the statistical data, 37.0 tons of dried abalones were produced in Bach Long Vi Island before 1987. Since then, the quantity decreased to only 1.0 ton in 1992. The main cause of such decrease was excessive exploitation, use of destruction-explosives, use of chemicals - anesthesia, as well as potential pulse and high-pressure lamp. Once depleted, the recovery of abalone populations is very slow, taking 2 to 3 years to grow from juveniles to adult and reproduce for the first time. Thus, this resource is now in danger of exhaustion and restoration could be difficult. In order to protect the abalone resource, the People's Committee of

Bach Long Vi Island divided the water column and tidal area square to the fishermen for management. Therefore, the abalone resources have been improved partly. However, that was just natural abalone farming, and still could not meet the demand of growing market. Nowadays, one of the effective conservation measures of natural resources is artificial reproduction for producing seeds that are released to the sea. At the same time, seeds are also supplied to fishers for commercial farming thus, reducing the fishing pressure on the natural abalone resources. Thus, the Research Institute for Marine Fisheries has been taking charge of implementing the project on "*Improvement of the technology models of artificial breeding and conservation of many-colored abalone resources in Bach Long Vi Island*". The project which has been implemented from 2012 to 2015 in the Bach Long Vi Seed Center, aims to restore and conserve abalone resources, increase income and alternative livelihoods for local communities. After the project, it is expected that technical model for artificial breeding of the many-colored abalone would be improved and stabilized. As a result, huge amount of abalone seeds have been produced for restocking and restoration of the natural abalone populations in Viet Nam.

Activities and Results

In order to attain the above goal, the following activities have been implemented:

- From July to October, 2013: collecting and conditioning of abalone broodstock
- From October to December, 2013: induced spawning and larvae rearing

Conditioning and induced spawning

Healthy many-colored abalones were collected from natural waters then kept in the concrete tanks in the hatchery, separating the males from the females. The main food of given was seaweeds (*Gracilaria* sp., *Sargassum* sp., and *Hypnea* sp.). The broodstocks were provided dried seaweeds (*Laminaria* sp.) in winter. The amount of seaweeds given was about 15–20% of broodstock weight, and put in broodstock tanks 2-3 times a week (**Fig. 1**). Gonads were checked weekly for maturity, and if the gonads were at stage IV (developed stage), male and female individuals were put together in one tank with the ratio of 3 females to 1 male for induced spawning.

In the Bach Long Vi hatchery, four methods of induced spawning were adopted: UV-sterilizing, drying exposure, increasing water-flow and pH. All these induced spawning methods were found effective in the hatchery. The male individuals responded positively with all these methods with

Larvae and early juveniles rearing

Rearing density played an important part in larvae growth and survival rate of abalone juveniles. Specifically, rearing density impacted strongly to the abalone juveniles at 1-2 mm and 28 days old. Results showed that the survival rate was obviously different, at averages of 7.50 larvae/cm²; 6.80 larvae/cm²; 1.60 larvae/cm²

Husbandry of juveniles

In this project, the juveniles 5-7 mm and 7-10 mm were tested in two different temperatures, at 16° and 25°C. The results showed that smaller juveniles ate more seaweeds in 25°C than in 16°C and the average food consumption was 60 g seaweeds/3 days. Similarly, food consumption average was 80 g seaweeds/3 days at 25°C in abalone with 7-10 mm shell length. After 2 months (October – November, 2013), 30,000 juveniles of 4.5 mm shell length; 33,800 juveniles of 3 mm shell length; 45,500 juveniles of 2 mm shell length; and many small larvae

- From December, 2013 to March, 2014: rearing of abalone juveniles
- In April, 2014: releasing abalone seeds to tidal areas and coral reefs for stock enhancement
- From May, 2014 to 2015: monitoring and assessing the survival and growth of abalone juveniles

100% ejaculation, but the female individuals responded differently with such methods. The spawning rate fluctuated from 52.8% (pH method) to 72.2% (drying exposure and water-flow). After 2 months (October – November, 2013), 2 million larvae were produced in Bach Long Vi Abalone Seed Center.



Fig. 1. Abalone juveniles rearing in Bach Long Vi Seed Centre

algae board. Survival rate of abalone juveniles with 1-2 mm (28 days old) was 0.92%; 3.80%; 24.00% at larval densities of 7.5; 6.8; and 1.6 larvae/cm² algae board, respectively. Therefore, abalone juveniles of with 1-2 mm shell length are recommended for rearing at densities of 2-5 larvae/cm² algae board.

were collected in Bach Long Vi Abalone Seed Center (**Fig. 2**). Finally, the total abalone juveniles harvested was 137.96 individuals as result of abalone rearing from October 2013 to April 2014. The average growth rate was more than 1.0 mm/month. The growth rate was very high from December 2013 to April 2014, especially in March and April. The size average was 8.7 mm shell length (fluctuating from 6.4 mm to 17.3 mm) in April 2015. The average survival rate was 6.64%.

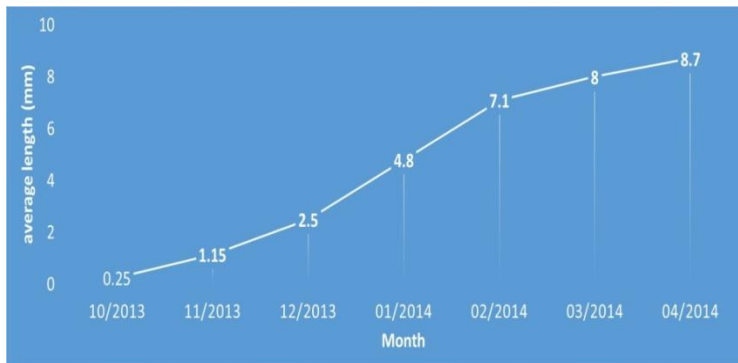


Fig. 2. Growth rates of abalone juveniles from 10/2013 to 04/2014



Fig. 3. Releasing of abalone juveniles to the sea for conservation in Bach Long Vi National Marine Protected Area, Viet Nam

Restock and stock enhancement

More than 6,000 juveniles of 4.5 mm shell length were released to Bach Long Vi National Marine Protected Areas for conservation in April 2014. The restoration assessment was briefly implemented in June 2015, and almost all

individuals were found to have average shell length of 3.4 cm. This is an initial achievement of aquaculture and juvenile rearing to release and protect many-colored abalone resources in Viet Nam.

Conclusion

- Broodstock conditioning and artificial breeding of abalone was successful. About 1,250,000 – 2,000,000 larvae and 137,960 juveniles (6.4-17.3 mm length) were collected with survival rate of 6.90-11.00%.
- Fishers have been trained and breeding techniques transferred to fisheries communities and study trips conducted to the hatchery for visitors.

- Released 6,000 juveniles (1cm length) to Bach Long Vi National Marine Protected Area on 15th April 2014 for conservation.
- Almost all released individuals were found with average shell length of 3.4 cm 1 year after restoration assessment. This is an important scientific basis for restocking and stock enhancement of abalone in Viet Nam.

Recommendations and Way Forward

- The seabed structure, environment and seed size need to be taken into account in detail before restocking. After releasing abalone seeds to tidal areas and coral reefs, monitoring and assessment should be carried out regularly.
- Aquaculture-based enhancement and restoration of many-colored abalone resources is potential and important for recruitment of abalone. These factors play important role in reducing the fishing pressure on natural

abalone resources and increasing incomes of fishers, and creating alternative livelihoods for local communities. The participation of local communities is therefore necessary in aquaculture-based enhancement for abalone resources.

- The technical model of artificial breeding and aquaculture-based enhancement of many-colored abalone resources need to be generated and expanded for large-scale operation in the near future in Viet Nam.