



Lobster Cultivation in Indonesia and Vietnam: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. Author Utama wrote the first draft of the manuscript. Authors AY, YA and RR managed the outline of the manuscript and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The development of spiny lobster (*Panulirus* sp.) cultivation is of particular concern as market demand continues to increase while capture fisheries production remains static and with little chance of increasing. Indonesia has a unique opportunity to build the largest lobster aquaculture industry in the world, based on the significant natural resources of the puerulus settlement. Cultivation of lobster in the country is one solution to maintain the availability of lobster seeds in the waters. The success of Vietnam's lobster industry has generated enormous interest in Indonesia, where is having so much potential for the lobster farming industry. Lobster cultivation activities consist of catching lobster puelurus, juvenile production, and lobster rearing. Vietnam, which has first started lobster cultivation activities, can certainly be an example for Indonesia in developing lobster in its own country. Several innovations that have been successfully developed in Vietnam, such as the process of catching using trawls or using fluorescent lights or cultivation activities using cages that are submerged with a depth of more than 10 m can certainly be examples for Indonesia to consider.

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1. INTRODUCTION

Indonesia has the potential for marine cultivation to reach 12,545,072 ha, while the current utilization is around 117,449 ha [1]. The cultured marine species include snapper, grouper, brood fish, milkfish, seaweed, lobster, and others.

The development of spiny lobster (*Panulirus* sp.) cultivation is of particular concern as market demand continues to increase while capture fisheries production remains static and with little chance of increasing. Indonesia has a unique opportunity to build the largest lobster aquaculture industry in the world, based on the significant natural resources of the puerulus settlement [2]. These seed lobsters can be caught and cultured to produce high-value consumption size lobsters.

Cultivation of lobster in the country is one solution to maintain the availability of lobster seeds in the waters. In addition to obtaining lobster for consumption purposes, lobster cultivation can also be used as a means for restocking of the lobster's broodstock [3]. Opportunities for lobster cultivation in the country are very open due to the lack of aquaculture activities in seawater, including lobster cultivation itself. This is certainly an opportunity that can be utilized given the natural conditions in Indonesia itself that support the potential for lobster cultivation.

Cultivation of lobster in floating net cages (KJA) in Indonesia began to develop in 2000 in the waters of Lombok, West Nusa Tenggara Province [4,5]. At that time, many natural seeds were found attached to buoys and other materials related to seaweed and grouper cultivation [6,7], then the seeds were taken for growing culture activities in the KJA. According to Priyambodo and Jaya [8], in general, the seeds used in lobster rearing businesses in Indonesia are caught from nature. Currently, lobster cultivation can be said to be underdeveloped due to the puerulus in Indonesian waters, which are exported legally or illegally because they are considered profitable. The purpose of writing this review is to provide information about lobster cultivation in Vietnam and in Indonesia.

2. LOBSTER CULTIVATION DEVELOPMENT

One of the efforts that can be done to accelerate the development of lobster cultivation is to know the cultivation techniques that have been carried out and other aspects related to lobster cultivation in countries where lobster cultivation is more developed. Lobster cultivation in Vietnam began in 1992 in Nha Trang City, Khanh Hoa Province. In that year, lobster cultivation in floating net cages was only carried out by 5 families. There are 8 types of lobster found, but only 3 of them are cultivated, namely pearl, sand, and batik lobsters. In 1993, lobster cultivation was carried out by 100 families and in 2003 it became 500 families. Each family carrying 10 cages that installed on 1 raft unit. The peak production of cultivated lobster in Vietnam reached 1,900 tons in 2006.

The success of Vietnam's lobster industry has generated enormous interest in Indonesia, where is having much potential for the lobster farming industry [9]. Interest in developing Spiny Lobster (*Panulirus* sp.) cultivation has grown rapidly in the last few decades [10]. Lobster hatchery technology commercially has achieved various concepts but has not been realized significantly. Commercial production of puerulus produced in hatcheries could be implemented in the next few years [11].

On the Indonesian island of Lombok, in the early 2000s puerulus especially the Sand Lobster species (*Panulirus homarus*) were observed to settle naturally in seaweed and floating net cages used for grouper culture [12]. Seaweed and fish cultivators recognized that these small lobsters have an opportunity, to give the high market value of lobsters [13,14]. They started looking for puerulus and developed a special method to catch and keep them in special cages for lobster rearing. By the mid-2000s, the method of capturing puerulus had changed to the one which was used in Vietnam, and more than 600,000 were caught in 2008/2009 [15]. Over the following years, puerulus capture methods were refined, and although components of the Vietnamese approach were applied such as the use of lights to attract puerulus, the puerulus capture method in Lombok developed a unique character such as "Krendet" that made from net or "Pocong" that made from net and cement

paper [16]. By 2015, the capture of puerulus by methods developed in Lombok had extended to the entire southern coast of Java and Sumbawa.

According to Erlania et al.; [6], the availability of abundant lobster seeds in nature can be

managed through good grow-out cultivation technology, so that it can provide much greater added value to the economy of coastal communities than only selling the caught seeds.

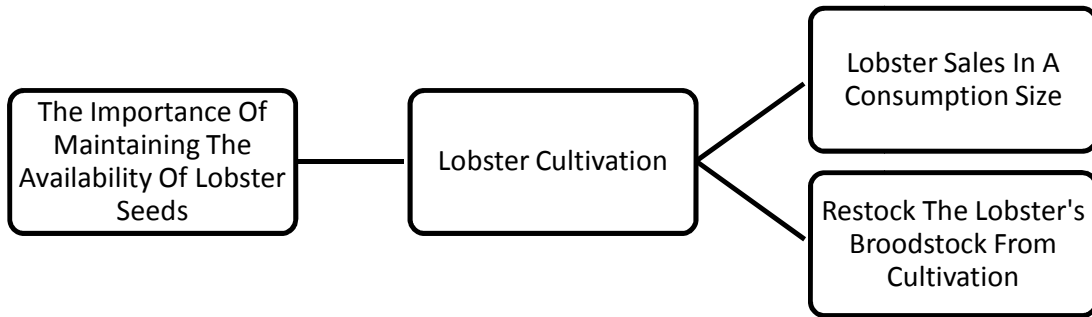


Fig. 1. Flowchart of the importance of lobster cultivation



Fig. 2. Sand lobster (*Panulirus homarus*) [17]

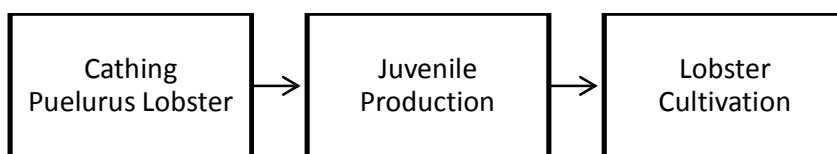


Fig. 3. Flowchart of the process of lobster cultivation

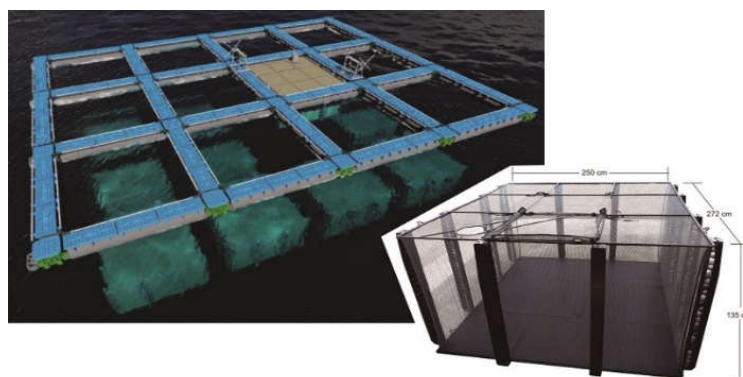


Fig. 4. Illustration of lobster net cage style in vietnam [10]

2.1 Lobster Species

Lobster (*Panulirus* sp.) is a marine animal belonging to the crustaceans with hard skin and included in arthropod group. It has five life stages starting from the egg sperm production process, then the puelurus or larval stage, postlarvae, juvenile, and adult. Lobsters are nocturnal animals that are active at night, during the day preferring to stay in coral holes, and later at night come out of hiding to find food around shallower corals at high tide. Sea lobsters live in rocky and sandy areas of water. There are at least seven species of lobster in Indonesia, namely the Sand Lobster (*Panulirus homarus*), Batik Lobster (*Panulirus longipes*), Rock Lobster (*Panulirus penicillatus*), Pakistani Lobster (*Panulirus polyphagus*), Pearl Lobster (*Panulirus ornatus*), Bamboo Lobster (*Panulirus versicolor*), and Red Batik Lobster (*Panulirus femoristriga*).

For more details, here is the taxonomic order of lobsters according to the ministry of marine and fisheries (KKP) [1]

Kingdom :	Animalia
Phylum :	Arthropoda
Subphylum:	Crustacea
Class :	Malacostraca
Order :	Decapoda
Family :	Palinuridae
Genus :	Panulirus
Species :	Panulirus sp.

The most abundant species are sand lobster and pearl lobster. The first capture of puerulus was carried out in the southeastern part of Lombok Island where the natural conditions were sufficient to support fisheries. Stocks of adult lobsters in Lombok are rare because there are very few reef areas suitable for lobster habitats. In Lombok, more than 99% of puerulus caught are sand lobster and pearl lobster species with the proportion of catches of these two species changes every year [18]. Overall, sand lobster puerulus catches were the most abundant (between 65 and 85%), and pearl lobster between 15% and 35%. Recently, the catch of puelurus lobster has spread to the southern coast of Java and Sumbawa, where the existence of lobster species is same as Lombok.

Just like in Indonesia, Vietnam does not yet have lobster hatchery technology that can support lobster cultivation activities commercially, thus relying on the availability of lobster seeds in nature for their cultivation activities [19]. The types of lobster species in Vietnam are almost the same as in Indonesia as well as the percentage of their existence so that only sand lobster and pearl lobster are used for cultivation [20]. However, both in Indonesia and in Vietnam, when lobster hatchery technology can support commercial aquaculture activities, it is not impossible that lobster cultivation activities no longer rely on their availability in nature and can

cultivate lobsters with species other than sand lobster and pearl lobster.

3. LOBSTER CULTIVATION ACTIVITIES

Cultivation activities that rely on natural seed supplies do not only occur in lobsters. In the case of spiny lobster farming, Vietnam has shown that aquaculture relying on wild seed supplies can be successful and sustainable. Likewise in Indonesia, significant seed resources have been identified that can be used to build a lobster rearing industry.

Lobster Cultivation activities consist of catching lobster puerulus, juvenile production, and lobster rearing.

3.1 Catching Puerulus Lobster

In the early years, methods were developed to catch juvenile lobsters, usually by creating a habitat where juvenile lobsters would settle. Small diameter holes are drilled into the rock and wooden posts, and this material is placed in shallow water along the shoreline. Fishermen will periodically dive into this habitat and manually retrieve the juvenile lobsters that settle. This method is gradually being replaced by catching puerulus using various nets while actively swimming through coastal waters in search of suitable habitats. Catching the puerulus quickly proved to be more effective than catching juvenile lobsters, as puerulus numbers were often much higher. Methods evolved and catch rates increased as shrewd fishermen began to understand the oceanographic conditions that had the highest abundance. These conditions are characterized by coastal areas protected from large waves, in reservoirs often with fringing islands, moderate currents, where puerulus will swim, and often near river mouths where turbidity increases. Nets set across currents will effectively intercept puerulus as they swim through the dark hours [15,21].

Although the Vietnamese lobster farming industry is well established today, the coastal communities of Lombok are not aware of the methods used by the Vietnamese. As a result, Indonesians developed their unique method of capturing seeds and continuing to grow them. It was only in 2013, after a comparative study in Vietnam by a group of Indonesian cultivators, there were several methods resulting from the application of methods obtained from Vietnam and adapted to water conditions in Indonesia so

as to produce the most effective puerulus fishing method currently used [22]. Methods Indonesia shares with Vietnam is the practice of intercepting puerulus as they swim; However, instead of using trawl nets, artificial habitats are placed through the water column, where puerulus settle. The development of the Indonesian method is well described by Bahrawi et al. [23,24], and the effectiveness of various habitat materials and their positions for maximizing catch are detailed in the report of Priyambodo et al. [16,22,25].

In contrast to Vietnam where nets are actively deployed and released daily, the hatchery in Indonesia is anchored in place and only moved or released when the conditions are less favorable to be placed. One of the most significant methods borrowed from the Vietnamese was the application of lights to seed fishing gear, which was first implemented in 2013 [26,27]. A fluorescent or incandescent lamp mounted above the frame resulted in significantly increased capture rates, possibly due to positive phototaxis of the swimming puerulus. Indonesian seed fishermen visit their fishing frames every morning to remove each habitat panel and manually remove any deposited seeds hiding in habitat crevices.

Both in Vietnam and Indonesia, captured seeds are immediately placed into containers filled with fresh seawater, sometimes aerated. These containers are returned to the beach and are often sold to seed traders (middlemen) who then move the seeds to shelters where they can be packaged for transport to farmers [28,29]. Storage facilities are usually tanks, with imperfect filter conditions. Seeds are most often graded by species and quality, and placed in a plastic sieve that floats in the tank. Once sold, they are counted and put in plastic bags with a capacity of about 4-5 L, almost always by aeration and sometimes by oxygen injection. The plastic bag is then placed in a styrofoam box to be transported by road to the destination. In Vietnam, transport may be up to 1000 km from the more northern fishing grounds to the central and southern coasts where most aquaculture occurs. In Indonesia, seeds can be transported over short distances to adjacent farms, or more commonly to airports for export to Vietnam.

3.2 Juvenile Production

Cultivation of lobster seeds to market size is carried out in two different stages, the juvenile

production stage from puerulus to about 3 grams or larger, and then the cultivation stage to a suitable size for marketing to consumers. In Vietnam, this phased approach is very different, and, in many cases, there are nursery growers who do only the nursery stage, selling seeds to nursery growers who grow to market size. In Indonesia, where currently there is only farming for minimal market size, the difference between the nursery and grow-out phases is less noticeable. As the lobster farming industry in Indonesia develops and matures, it is hoped that the same phased approach will emerge, reflecting the different systems and methods used for each to achieve high survival and growth rates.

Because the seed lobsters are very small, about 12 mm long and <5 mm in diameter, the cages used to accommodate and maintain lobsters are relatively small with small mesh sizes. In Vietnam, there has been considerable development of cage types and management systems to achieve the greatest survival and growth rates for the young. Currently, two methods represent a large proportion of juvenile production in Vietnam. Underwater cages, usually rectangular in shape, are placed on the seabed in relatively shallow waters less than 5 m. The cage is box-shaped, with steel bars with a diameter of 10–15 mm covered with a shading type net with a mesh size of less than 3 mm. The size of the cage varies from 1 m × 1 m × 1 m height to 3 m × 2 m × 2 m height. The box cage is equipped with a PVC pipe filling tube, 100 mm in diameter and long enough to reach the surface. Lobster seeds are placed in cages at densities between 50 and 100 per m², and the cages are left on the seabed for the treatment phase, usually 6–16 weeks. Fresh food is provided daily. At harvest, the cages are lifted to sea level into the boat and the young lobsters are removed through the eyelets in the net.

3.3 Lobster Cultivation

Vietnam's early production system consisted of very simple fixed cages in shallow water, less than 3 m deep. A rectangular grid net is supported within an outer frame made of roughly carved wood or bamboo, 10–15 cm in diameter and 4–5 m long, mounted on vertical posts embedded in the sediment. Each cage usually has a mesh cover to provide shade, and the base is placed on top or suspended above the

seabed. Cages placed on the seabed have a layer of sand across the floor, while those installed at the bottom have a gap of about 0.5 m from the seabed.

Although factory-made feeds have been formulated for lobsters, to date little has been available, and the diet for lobsters consists of fresh seafood including shrimp, crab, fish, and mollusks. Smaller lobsters tend to be fed twice a day while larger lobsters are fed once a day. There is daily cage cleaning of excessive bio-fouling, uneaten food, and loose lobster shells. Periodically, the cage nets are removed and replaced with clean nets, and the used nets are cleaned with a high-pressure hose. Lobster grading is applied to minimize size variation within the cage, and therefore rearing is often characterized by 3 phases between gradations, from stocking at 50 g to 200 g, 200 g to 700 g, and 700 g to 1 kg.

4. HEALTH AND DISEASE

Diseases and health problems of farmed lobsters cause huge losses in lobster production. Lobster disease in the lobster aquaculture industry in both Indonesia and Vietnam has become a significant problem. In recent years, the milky disease have received the most attention in lobster aquaculture.

According to Priyambodo [30], the milky disease in Indonesia was confirmed in lobsters in the village of Telong Elong in eastern Lombok in 2012 with the *Rickettsia*-like bacteria. In Vietnam the milky disease outbreak also occurred in 2012 with the same *Rickettsia*-like bacteria. Although lobsters that infected with the milky disease respond positively to antibiotic treatment, prevention is key to the long-term sustainability of the industry.

There are a number of precautions that can be taken to reduce the vulnerability of the disease and, if it is integrated, are likely to reduce the risk of losses due to diseases and health problems to a negligible level. First, site selection is important, then provide a much cleaner and nutritionally complete diet, and increase disease resistance, and effective cage maintenance benefits health management, including daily cleaning of waste and uneaten food from the cage, and periodically change the net cage [31].

5. INNOVATION OF THE VIETNAM'S LOBSTER CAGE-STYLE METHOD

A more recently developed method consists of a cage suspended in deeper water, usually more than 10 m deep in water with the cage suspended about 5 m below the surface. These cages are usually spherical in shape with a diameter of 1 m and a height of 0.8 m, the shape is maintained through a circle of steel bars measuring 10–15 mm at the top and bottom for juvenile production. There is a central opening in the center of the top surface which is operated by a straw-like arrangement of holes. These cages are usually stocked at 100 puerulus per m² and raised to the surface daily to inspect juveniles, remove uneaten food debris and provide fresh food. While in the lobster rearing phase, the cage is suspended with a water depth of 10–30 m. The size of the cage varies depending on the size of the lobster stocked with the cage shaped like a block.

This method appears to favor the survival and growth of juveniles to large sizes better than submerged systems. The diet for both stages consisted of finely chopped fresh fish, crustaceans, and mollusks, with each farmer following the preferred combination. It is clear that the diet of crustaceans and mollusks favors superior fish production, but this must be offset by the higher costs of these ingredients. Fresh trash fishes tend to be purchased daily from the local fish market.

Survival and growth are variable, and the best operators can achieve survival of over 90% and harvest sizes of around 3-5 g after 6 weeks, 10–30 g after 12 weeks and 30-50 g after 16 weeks for further juvenile production until the consumption size.

6. CONCLUSION

The success of Vietnam's lobster industry has generated enormous interest in Indonesia. Vietnam, which has first started lobster cultivation activities, can certainly be an example for Indonesia in developing lobster cultivation activities in its own country. Several innovations that have been successfully developed in Vietnam, such as the process of catching using trawls or using fluorescent lights or cultivation activities using cages that are submerged with a depth of more than 10 m can certainly be examples that can be developed also in Indonesia.

Some things that certainly still have to be developed together are from the lobster hatchery sector regarding how to produce puelurus so as not to have to rely on seeds from nature so that the sustainability of lobster can be maintained.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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