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Assessing of the Economic Feasibility of Capture-Based Mariculture (CBM) of *Panulirus Homarus* in Tharuvaikulam and Thoothukudi District

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ABSTRACT

Lobsters are highly prized commodity and a delicacy for Chinese and Japanese society. In India, there is a high potential for capturing lobster post-larvae and growing these in sea cage culture because India has long coast line. In the present study was conducted in Tharuvaikulam and Thoothukudi district, Tamil Nadu. The aim of this study was to assess the economic feasibility of captured based mariculture of spiny lobster *Panulirus homarus* in open sea. This study also reports the socio-economic potential of spiny lobster culture; mostly total cost of 2 years replacement had been found as 436916, 500787, 363300 and 408915 and revenue statistics and cost benefit ratio were 1: 5.28, 1: 3.9, 1: 1.29 and 1: 1.31in four surveyed farms. This work also suggested the good livelihood opportunity of lobster farming. Satisfactory result of biological analysis was also significant in all surveyed farms. So, this survey work was represented the good potential source of lobster farming and also represented the profitable path of lobster farming.

Keywords: *Lobster, High potential, Sea cage, Economic feasibility, Income generation.*

Lobsters are the highly prized commodity of marine capture fisheries. There is very strong demand for spiny lobsters (Family Palinuridae) in international sea food markets and this is generating interest in the development of aquaculture for these species. The world market for spiny lobsters is approximately 80,000 metric tons annually and is supplied almost entirely by wild fisheries (FAO 2005). Commercial exploitation of lobsters from the Indian seas began in the 1950s. Though widely distributed along the entire coast, major fisheries are located on the north –west, south-west, and south-east coasts of India (Radhakrishnan and Manisseri, 2003). The north-west coast is particularly rich in lobster resources, contributing to nearly three quarters of total lobster landings in India (Kagwad *et al*., 1991). The high value of spiny lobsters and the limited extent of their wild fisheries are generating an increasing worldwide interest in aquaculture (Jeffs and Hooker, 2000). The aquaculture production has increased at an average annual growth rate of 5.8%, from 44.3 million tonnes in 2005 to 73.8 million tonnes in 2014. The value of aquaculture production is estimated at USD 160.2billon in 2014 (FAO, 2014). The aquaculture of spiny lobsters has been of considerable research and commercial interest for many years, as these species possess many of the characteristics that make them suitable for aquaculture; gregariousness, tolerance of a wide range of environmental conditions, fast growth in some species, relatively few diseases, and accepting of a wide variety of natural foods (Mohan et al., 2001). However, the greatest hurdle to the development of aquaculture of spiny lobsters has been their long and complex larval life which lasts for more than 300 days in culture for some species of spiny lobster. Extensive research on larval rearing over the last 40 years or more in Japan, Australia, New-Zealand, India and other countries has demonstrated that whilst the larval culture of spiny lobsters is technically possible, it remains a significant challenge to commercialize for several reasons (Phillips et al., 2000). The relative success of simple sea cage aquaculture methods for spiny lobsters in Vietnam and elsewhere clearly demonstrates the technical feasibility of on growing spiny lobsters. However, further improvements are needed in artificial feeds, growing systems (sea cage and land-based) and disease control if a large and sustainable commercial industry is to be developed in the future that can take full advantage of the advent of hatchery-raised seed. These are the areas in which further scientific research needs to be directed in the short-term. This development is most likely to take place in tropical regions of the world where the fastest growing spiny lobster species are found, and where labour and aquaculture operating costs are frequently lower (Jeena et al., 2011).

MATERIAL AND METHODS

The study area was Tharuvaikulam landing centre in Thoothukudi (Tuticorin) Dist. Tamilnadu, which comes under the Gulf of Mannar Biosphere Reserve. The key informant interviews were conducted in February 2019 in Tharuvaikulam. Although there is significant potential for lobster grow-out in India, but very little is practiced in the country.

The questionnaire contained 42 questions seeking biological and economic information which is associated with stocking, feeding, cost of culture operation, growth rate, harvest equipment requirement, disease problem, market demand, labour, and other miscellaneous information’s. It was conducted interview between the lobster farmer and me and my guide, with my guide acting as the interpreter. Data was collected from 4 fishermen culturing in two different places in Tharuvaikulam. The names of the fishermen are Mr. Michel Divakar, Mr. Baskar, Mr. Jhon and Mr. Venkatesh. We are mentioning all the five farmers serially as ‘Farmer 1’, ‘Farmer 2’, ‘Farmer 3’, ‘Farmer 4’.

The data generated in the survey were used in the bio-economic model. The model inter relates a biological model of species growth and an economic model of cost and returns to know the economic feasibility of the culture. This model was used in the economic analysis.

Biological Model

The biological model measures the lobster biomass gain over the culture operation. Biomass gain at harvest is measured by dividing the quantity of feed used during growth phase with the weight of harvested lobster after culture operation.

Biomass gain at harvest, $b_h = qF/W_h$

Where, qF = Quantity of feed used during period.

W_h=weight of harvested lobster.

The biological model generates the individual lobster weight at harvest, which is used in the economic model (S. Ajmal Khan et al., 2006).

Economic Model

The economics is very important for any culture operation. We can see that in around the world as well as India lobster is economically important and lobster culture nowadays is being grow up in Indian seas. The annual gross margin is a simple net revenue which can be calculate as shown in equation:

$$NR = TR - TC$$

Where, NR = Annual net revenue.

TR = Annual total revenue.

TC = Annual total cost.

Total revenue is a function of individual lobster harvest weight and price as shown in equation:

$TR = W_H * P_H$

Where, WH = Total weight of production (kg).

PH = Price of harvested lobster.

This is dependent on individual weight.

Total costs of production are function of restocking costs and a number of miscellaneous fixed and variable costs. The fixed costs include labour, cage and other capital and contingency costs. The variable costs are seed, feed and interest costs, while costs are incurred over about 3- 4 months period only, there is only two crop per year, hence costs are shown on annual basis. This allows the calculation of annual gross margin (Jhonson et al., 1991)

The formula is:

$T_C = C_S + C_F + C_L + C_C + C_O + C_M$

Where is,

T_C=Total cost.

Cs =seed costs.

C_F =Feed costs.

C_L =Labour cost.

C_C =Cage cost.

C_O=other capital cost.

C_M =Contingency costs for miscellaneous purchases.

Annual seed cost, Cs are a function of stocking and cage parameters as shown in the following formula:

Cs =SR*Sc*Nc*Ps

Where is,

SR =Stoking rate.

Sc=Average size of cage.

Nc=Number of cages.

Ps =Price of seed.

Annual feed costs are calculated by quantity of feed and price of feed in different months as shown in the following formula:

$C_F = Q_F * P_F$

Where is,

Q_F=Quantity of feed.

P_F=Price of feed.

For annual gross margin, cage and other capital costs are annualized by dividing the costs by the number of years to replacement (S. Ajmal khan et al.,2006)

Survival rate was calculated by using following formula,

Survival rate (%) = No. of live lobsters at harvest*100/No. of lobster at initial stocking (Radhakrishna et al., 1990).

RESULTS AND DISCUSSION

Type of Culture

Rectangular cage was used for spiny lobster culture in Tharuvaikulam. The Spiny lobsters were collected from Kanyakumari and stocked in the cage. These cages were used in this culture. The cages were made up with iron frame and covered with HDPE nets.

Net cage

Net cage was very important material for open sea cage farming. The net quality should be good so that it can protect the lobsters from predators. Mesh size for the net cages must be selected according to the species if and also to ensure good water exchange. Proper water flow enhances water quality, reduces stress, improves feed conversion and allows holding more species. Net specification should be predator protection or outer net ‘HDPE’ braided. Grow out or inner net cage should be braided and twisted.

Net cages should be as per the dimensions of the cage frame and depth of the water at the site. The net must be fastened to the cage frame. Here nets are fastened with simple nylon ropes. This is not so lusting for harsh conditions. So, these ropes were exchanged when there is any damage. The cost of each cage in all the surveyed culture is about 25000-30000 rupees including mooring system. The cages weight was around 180 kg in all observed culture. All farmers are using these cages more than two years. Mostly all the visited farms having 6 cages in operational condition (fig-1).

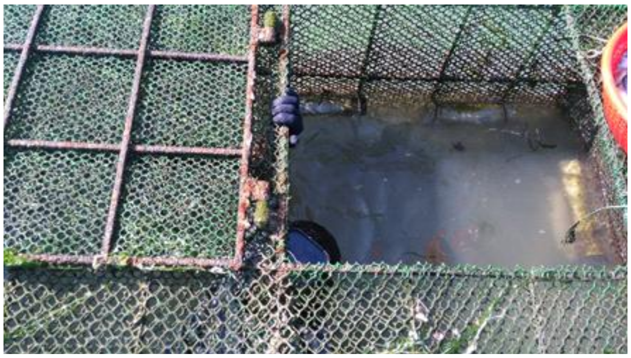

Fig:1 Cage opening for monitoring

Mooring systems

Mooring systems is very important for the operation of open sea cage. It can be as such so that it can withstand harsh waves and adverse weather conditions. The cages have hold which is made with iron. The cages are placed at the depth of 6' near the shore. Anchors, chains are used to fasten the box-cage. Buoys are used to mark the cage because the cages are submerged in water during high tide. For identifying the cage at night reflecting marker lights are used to detect the cages. The cages are stand in one place by their individual weight.

Total Number of Fishermen

There are 4 fishermen encaged in cage culture of lobster in Tharuvaikulam, surveyed. In culture 1, the farmer running his farm on his own. His family members are helping him for doing this culture. In culture 2, one labour is maintaining this culture. He has been given 10000 rupees/month. He is doing this as a part time work. During harvesting 2 more labours from his family are employed. They are also taken 650-1000 rupees/day. In culture 3, the farmer running his farm with one partner. In culture 4, the farmer is running with two labours. He has given 9000- 9500 rupees/month.

Total Number of Cage

All cultures are open sea cage culture. In all culture the total number of cages were 4- 6. all cages are placed at a 6' water depth in the sea shore. In culture 1 the measurement of the cage is (7*7*3.5)', in culture 2 the size of the cage is (6.9*6*3.5)', cage size is (6*6*3.5) in culture 3 and in culture 4 cage size is (7*7*3.5). These cages are lusted for at least 2 years (fig-2).

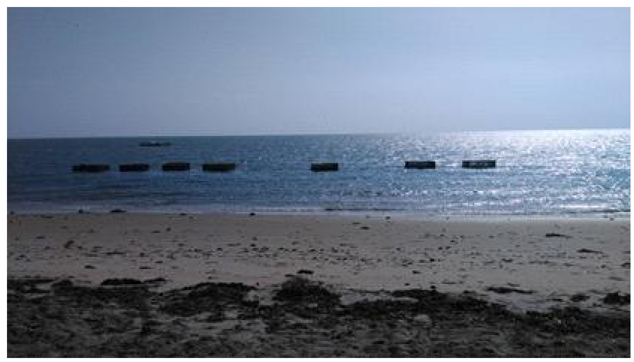

Fig:2 Cages are placed near shore

Species

Both cultures in Tharuvaikulam are culturing scalloped lobster *Panulirus homarus*. Mostly 50 gm. size of lobsters are collected from Kanyakumari and stocked in the cage in the month of November. All surveyed culture farms are stocking 80 gm. size lobsters. The cost of lobster juvenile is 700/kg (fig-3).

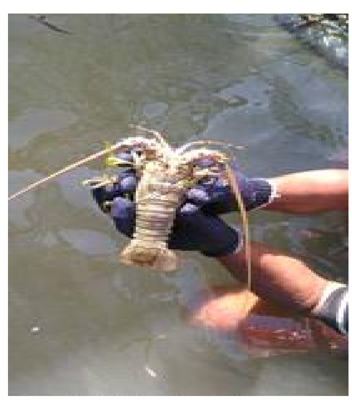

Fig:3 *Panulirus homarus*

The growth rate of this species is higher than other species of lobster and apart that they are highly available in Tamil Nadu coast triggers this species as a culturally suitable. In all culture, they are generally culturing it for 3-4 months and then harvest at 150 gm size in an average.

Stocking Density

There was no fixed stocking density which is followed through scientific method. They generally stock the juvenile according to the size. Farmer 1, told that he stocked 1000 individuals/cage each weighs about 50-80 gm. The stocking density is @68/ m^2 which is good and also biologically suitable. Farmer 2, told 50 gm weight of lobster is stocked @1200 Individuals/cage. Here the stocking density is @96/ m^2. In case of farm 3 and farm 4 stocking densities are @95/m^2 and 90/m^2. These data are totally collected from farmers only.

Survival Rate

In culture 1, the survival rate is 95%. This is very impressive. Because they are totally dependent upon the fresh feed like clam, trash fish, squid etc. No artificially formulated feed was used. In culture 2, the survival rate is 85.7% because of more stocking density and only one type of feed was mainly used which is by- catch fishes and also the later has given low quantity of feed per day and also faced more cannibalism in his culture due to the feed demand. In culture 3, the survival rate is 85% Because they are facing cannibalism problem. In case of culture 4, the survival rate is 93% which is well and good because of their well management of farm and for using fresh clam meat and trash fish as feed.

Feeding Method

In all culture the feeding is done manually. In culture 1, was unable to estimate the actual quantity of feeds used on a daily rate or for the total crop cycles. In a day they give feed one time in morning (From around 10am- 12pm). Fresh by-catch fish is used for feeding the lobster. For each day feeding the feed cost is 700 rupees. The feed is generally collected from nearby landing centre.

Culture 2, gives clam feed mainly. He also gives trash fish, squid etc sometimes. Feed is generally given in the morning. The fisherman told that, he prefers high tide for feed broadcast. The cost of feed for per day feeding is 300 rupees. Per day the quantity of feed is 30 kg. In case of culture 1, the quantity of feed is high but the cost is low. But in culture 2, cost is higher for feeding per day. This actually varies region to region.

Culture 3, mainly feeding on clam meat, squid meat and trash fish. Morning time is scheduled for feeding. This also prefers high tide for feed broadcast. The cost of feed for per day feeding is 400 rupees.

Culture 4, gives clam meet and trash fish mainly. He also gives sometimes squid meat. Feed is generally given in the morning same as other surveyed farms. The cost of feed for per day feeding is 507 rupees.

No artificial feed is used in all culture. This has the disadvantage. Because we cannot get the expected growth by feeding this low value feed. The fisherman did not measure the feed quantity. We suggest him to use artificial feed but he expected that the manufactured diets to be more expensive than current diets Jones et al. (2007) argues that the current low value finfish diet is not ideal, some nutritional deficiencies are likely as evidenced by the pale pigmentation of the mature lobsters. Therefore, using other species of molluscs and crustaceans to supplement the finfish diet may be necessary. Using a manufactured diet that combines local essential ingredients could also reduce the reliance on low-value finfish as well as improve lobster quality.

Adoption of manufactured diets early in the development of the industry has other benefits. Compared with low-value finfish, pelletized diets would reduce local pollution and water quality degradation since a smaller mass of feed would be used but with greater efficiency (fig- 4).

Fig:4 Feeding of lobster

Moulting

Moulting is the general phenomena of any crustaceans. Actually, moulting accelerate growth. The more the animal will moult the growth of the animal will be high. In culture 1, the lobster moults 3 times in a culture period. The moulting occurs at 35 days during culture period. The next moulting also occurs 35 days interval. In culture 2, informed that in 3 months the lobsters moult 5 times. No special care has been taken during this period. The lobsters first moult generally after 30 days of stocking. In culture 3, lobsters moult 3 times in a culture period which seems as same as culture 1 and in culture 4, moulting occurs in between the interval of 30- 35 days.

Harvesting

Harvesting in culture 1, is done by whole cage method. The box-type cages are lifted from water and the live lobsters are harvested and collected in basket or bags. Harvesting is generally done by hand picking in culture 2. For harvesting 2 more labours were employed for this purpose. One fisherman catches the lobster and others collect the lobsters in a cement bag. In culture 3, harvesting is also done by whole cage method. In culture 4, labours are working for harvest. The lobsters are collected live for exporting in the foreign market. Harvesting is generally done in night time in all surveyed farms (fig- 5).

Fig:5 Harvested lobster

Disease

No severe disease has occurred or known to this all culture. In culture 1 the red shell disease has occurred mainly during summer months. But oil spill from nearby Oil Company and sewage from shrimp farm has contaminated the water sometimes and Red Shell Disease has seen in culture 3. For this the growth rate is hampered. No prophylactic measures have been taken till this time.

Fouling

Fouling is not a great matter of concern as told by the fishermen. Generally, barnacles attach on the net and it damages the net cage. All the fishermen generally clear the barnacles by manual method (fig-6)

Fig:6- Fouling of cage by algae.

Predator invasion

All farmers were told that the predator problem is a reason of loss but not so big problem. I was informed that generally Parrot fish and crabs are invading in culture. Crabs and one species of fish, *Epinephala ssp.* prey on lobsters. So regular checking of net cage is needed for protecting the lobsters. For this damage, farmers always repair the net cage immediately. In all culture crab is the common predator.

Cannibalism

In all culture cannibalism has occurred during the moulting period. Cannibalism also seen when the demand of feed is high. Cannibalism is not a big problem because the percentage is very low.

Socio- Economics

Culture 1; Mr. Baskar doing this culture as a part time work. Besides he drives his auto for additional income. His family has 6 members. All the members of his family help him to maintain the culture. He is earning profitable money from culture.

Culture 2; Mr. Michel Divakar was also doing other work apart from the lobster culture. In this culture he employs 2 labours during harvesting period. He generally earns 10000 rupees for maintaining this culture.

Culture 3; Mr. Jhon working with his partner Mr. Shiva. Mr. Jhon's share is more than his partner. They are doing all farm management and culture management by themselves.

Culture 4; Mr. Venkatesh is a government employer. apart from this culture. In his culture he employs 2 labours for every management.

Biological Analysis

Biological analysis is very important to know about the growth rate, biomass gain, health of the animal. In all culture the biomass gain differs. In case of culture 1, the biomass gain is 1: 3.15. In case of culture 2, the biomass gain is 1: 1.35. In case of culture 3 and culture 4 biomass gain are 1: 1. 42 and 1:1. 33. Here farm 3 is having most good biomass and farm 1 is lowest biomass.

Economic Analysis

In farm 1, the cost of each cage is 30000 rupees which is quite high. The seed cost is 209916 rupees and the labour cost is nil. The feed cost is low because they generally use low quality trash fish and also clam feed which cost around 10 rupees/kg. Other capital cost includes farm house, bags for holding the lobster which cost about 15000 rupees. The miscellaneous purchases include floats, net repairing rope, torches, reflecting marker light etc which cost about 5000 rupees. In farm 2, the cost for each cage is low which is 25000 rupees. The difference in cost is actually for net quality and maintenance. The seed cost is 250387 rupees. In farm 2 the stocking density is high so the cost for seed is higher than farm 1. The farm has one labour for running the farm. The labour cost is 31000 rupees. The feed cost is 50400 rupees. The cost of feed for per day feeding is 700 rupees. Other capital costs like farm house, cement bags are about 12000 rupees. The miscellaneous purchases cost about 7000 rupees. In farm 3, the cost for each cage is 25000 rupees. The seed cost is 192000 rupees and the labour cost is nil because the farmer runs his farm with his partner. The feed cost is low because they are not using good quality trash fish and also clam feed. Other capital cost about 16000 rupees. The miscellaneous purchases include floats, net repairing rope, torches, reflecting marker light etc which cost about 4500 rupees. In farm 4, the cost for each cage is 27000 rupees which is quite low than other farms. The seed cost is 209916 rupees and the labour cost is 38000 because the farmer runs his farm

Table 1. Economic analysis of all surveyed farms.

Different Expences	Farm 1: Mr. Baskar			Farm 2: Mr. Michel Divakar			Farm 3: Mr. Jhon			Farm 4: Mr. Venkatesh		
	Number Required	Cost (Rupees)	Time To Replacement (Years)	Number Required	Cost (Rupees)	Time To Replacement (Years)	Number Required	Cost (Rupees)	Time To Replacement (Years)	Number Required	Cost (Rupees)	Time To Replacement (Years)
Cage Cost	6	180000	2	6	150000	2	5	125000	2	4	108000	2
Seed Cost		209916			250387			192000			209916	
Labour Cost		0			31000			0			38000	
Feed Cost		27000			50400			26000			33000	
Other Capital Cost		15000	2		12000	2		16000	2		15000	2
Contingency Costs For Miscellaneous Purchases		5000			7000			4500			5000	
Total Cost		436916			500787			363500			408916	

Table 2. Revenue Statistics and Cost Benefit Ratio.

Annual statistics	*Farm 1*	*Farm 2*	*Farm 3*	*Farm 4*
Total revenue (rupees/crop)	1795500	1671840	1899240	1656200
Net revenue(rupees/crop)	1456084	1252053	1467000	1256400
Cost benefit ratio	01:05.3	01:03.9	01:01.3	01:01.3

with 2 labours. The feed cost is quite high because they use high quality trash fish and also clam feed. Other capital cost includes farm house, bags for holding the lobster which cost about 15000 rupees. The miscellaneous purchases cost about 5000 rupees (Table- 1).

Revenue Statistics & Cost Benefit Ratio

In culture 1, the annual total revenue was 1795500 rupees and the annual net revenue was 1456084 rupees. The cost benefit ratio was 1:5.28, indicating that for every rupee they spent, the farmer gained 5.28 rupees. In farm 2, the annual total revenue was 1671840 rupees and the annual net revenue was 1252053 rupees. The cost benefit ratio was 1:3.9, indicating that for every rupee they spent, the farmer gained 3.9 rupees. In culture 3, the annual total revenue was 1899240 rupees and the annual net revenue was 1467000 rupees. The cost benefit ratio was 1:1.29, indicating that for every rupee they spent, the farmer gained 1.28 rupees. In culture 4, the annual total revenue was 1656200 rupees and the annual net revenue was 1256400 rupees. The cost benefit ratio was 1:1.31, indicating that for every rupee they spent, the farmer gained 1.31 rupees. The total revenue is higher in culture 1 than other culture because of the higher production and market demand according to surveyed data (Table- 2)

The spiny lobster is very priced product in market and it is a luxury food item around the world especially Asia. The result of this analysis suggests that the culture of spiny lobster *Panulirus homarus* is biologically feasible in open sea box type cage culture. Increasing of productivity through higher growth rate is needed, so universities and research institutes have to come forward to look in to this aspect for development of this culture. In both culture they are using box-type net cage. The cost of the cage is high (around 25000-30000 rupees). So, preparation of low costed cage is essential. The spiny lobster aquaculture is based on the collection of post-larva and early juveniles from the wild. Collection of post-larvae from the natural environments will not put pressure on the fisheries stocks. There are indications from post- larvae collection studies that collectors only remove a small fraction of the number of post- larvae in the water column and that a very large number of are lost mainly due to predation or lack of appropriate settlement habitat (Mohan et al, 2001).

Farmers fed the lobster largely on low value finfish, majority of which they are buying from nearby landing center in Tharuvaikulam. Although manufactured diets are not available to the Indian grow out farmers yet, the farmers generally indicated willingness to try them. Feeding trials have found that fresh mussels consistently produce best growth rates in cultured spiny lobsters over and above other less expensive feed products (Abdullah et al, 2014).

The financial analysis suggests that all cultures are commercially successful. The cost benefit ratio was good in all cultures. The mortality was very low compared to shrimp, so the production rate is very high. The feed cost was significantly lower because of the use of low value fin fish and locally available clam and squids. This study also reports the socio-economic potential of spiny lobster culture; mostly total cost of 2 years replacement had been found as 436916, 500787, 363300 and 408915 and revenue statistics and cost benefit ratio were 1: 5.28, 1: 3.9, 1: 1.29 and 1: 1.31in four surveyed farms. Satisfactory result of biological analysis was also significant in all surveyed farms.

CONCLUSION

The spiny lobster is much priced product in market and it is a luxury food item around the world especially Asia. The result of this analysis suggests that the culture of spiny lobster *Panulirus homarus* is biologically feasible in open sea cage culture. Increasing of productivity through higher growth rate is needed. Universities and research institutes have to come forward to look in to this aspect for development of this culture.

The financial analysis suggests that all cultures are commercially successful. The cost benefit ratio was good in all cultures. The mortality was very low compared to shrimp, so the production rate is very high. The feed cost was significantly lower because of the use of low value fin fish and locally available clam and squids. Lobster farming in India will be a viable alternative livelihood for Indian fishers if significant development can be done. From this study we can conclude that lobster culture in open sea cages is economically suitable. Currently cost benefit ratio is modest to high and largely dependent on the price and availability of lobster seed and other operational costs. In all cultural farms, they harvested the lobsters after it grows about 150 gm. to minimize the potential mortality. If they harvest the culture until the lobsters are larger (approximately 300 gm.) they can fetch more money.

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