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ONGROWING TECHNIQUES FOR JUVENILE DONKEY EAR ABALONE (*HALIOTIS ASININA*) AT PEMENANG WATERS, NORTH LOMBOK, INDONESIA

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ABSTRACT

Abalone is one of the most prized sea delicacies in the world. In Indonesia, although donkey ear abalone (*Haliotis asinina*) forms a valuable fishery, little is known about its culture techniques. A study has been conducted to find out the most suitable technique for ongrowing donkey ear abalone, for to the local farmer in Indonesia. Juveniles used in study were collected from the southern Lombok coastal waters. They were reared in different type of structure (CNC = circular net cage and TNC = tyre net cage) and set at different depths. Juveniles were fed ad-libitum by macroalgae, *Gracilaria* spp. Results of the study showed that juveniles of donkey ear abalone have a better growth when cultured offshore in a TNC than in CNC. To gain a better growth, juveniles abalone need to be reared in cages which provided more shelter and less light. Donkey ear abalone was considered a hardy species, survival rate was not influenced by the type of structure (CNC or TNC) and setting position (depths).

Keywords: Culture technique, growth, juvenile, *Haliotis asinina*, ongrowing offshore, CNC, TNC

INTRODUCTION

Abalone is member of a large class (Gastropoda) of molluscs having one-piece of shell. They belong to the family Haliotidae and the genus *Haliotis*, which means sea ear, referring to the flattened shape of the shell. Abalone is one of the most prized sea delicacies in the world.

Abalone has been cultured worldwide using many different culture methods. Commercial abalone farms throughout the world are now intensively producing abalone to meet increasing market demand. The worldwide interest in culturing abalone is still growing and, in the near future, it is expected to grow even more as a result of the competitive markets for live abalone (Viana, 2002). There have been extensive studies on commercially important abalone species for aquaculture. Every country involved has cultivated its own native species because it is simpler to deal with, in relation to water condition (temperature, salinity) and suitability of natural food (macroalgae).

Varieties techniques have been applied to raise numerous species of abalone, including the donkey ear abalone (*Haliotis asinina*). There are three different methods of commercially culturing abalone to a marketable size. Those are: (1) land-based farming in tanks, raceways, and ponds with intensive feeding; (2) containment rearing in offshore areas; and (3) ocean ranching in closed private areas (Hahn, 1989a; Setyono, 1997).

Land-based farming requires a large initial investment in land, facilities and equipment, and has high ongoing costs for pumping water and air (aeration), operation, and labour. However, this method allows greater control over the culture process and simplifies the animal's maintenance, in return for additional effort and expense (Hahn,

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1989b). This method is commercially practised in California for growing *H. rufescens* (McMullen & Thompson, 1989), and *H. cracherodii* (Ebert & Houk, 1984), in Taiwan for *H. diversicolor supertexta* (Chen, 1984), and in New Zealand for *H. iris* (Tong & Moss, 1992).

Containment rearing is an offshore farming method that uses containment pens, cages, or barrels, suspended from piers, docks, or long-lines, in protected areas. McMullen & Thompson (1989) noted some advantages and disadvantages of this method. The advantages of this method include: suitable natural growing conditions; low costs; protection in the containment pens from both marine and human predators; controlled food supply for optimal feeding; ability to polyculture with other aquaculture species; easy access for feeding, managing, and harvesting; moderate labour costs; absolute ownership and owner identification; and facilities for raising abalone in high stocking densities. The disadvantages of this method are: difficulties in maintaining the structures; loss of equipment and animals through storms and poaching; and problems occurring from "fouling" of the structures.

Out planting on the ocean floor is called ocean ranching or ocean floor rearing. This method involves placing juvenile abalone on a suitable substrate and allowing them to grow in the wild to adult size (McMullen & Thompson, 1989). This technique has the advantage of avoiding the high capitalization and energy costs associated with inland rearing. However, this method is less aplica-bility because of the following reasons (McMullen & Thompson, 1989): stocking the underwater habitat with abalone seed is difficult and time consuming; it is impossible to isolate the stock from animal and human predation; difficulties in monitoring the feeding regime; and the harvest of marketable stock requires costly underwater diving labour. The percentage of recapture in ocean ranching is low, and very dependent on species and site, with 5-10% for hatchery seed and 20-25% for natural seed (Saito, 1984). Schiel (1993) found that the annual mortality rates of hatchery-raised juvenile *H. iris* transplanted into natural habitats at the Chatham Islands, New Zealand were 27.6 to 98.8%.

Indonesia covers more than 17,500 islands, in which many coastal areas are suitable for growing abalone. The ocean is very productive and natural food for abalone (macroalgae: *Gracilaria* spp., *Hypnea* spp., *Ulva* spp., *Kappaphycus* spp.) is abundant. All of the mentioned culture methods, whether land-based farming, containment rearing in offshore areas, and/or ocean ranching, are suitable to be set up in this country. However, in this study we focused on containment rearing techniques that applicable to grow out juvenile donkey ear abalone offshore.

This study is part of subsequent research on donkey ear abalone, included size structure, morphometric, size at first maturity, reproductive biology, broodstock conditioning, induced spawning, embryonic and larval development, and food preferences (Setyono, 2004; 2005a; 2005b; 2005c; 2006a; 2006b). This study will focus on ongrowing techniques for offshore culture. In this study, simple method employed in two types of containment structures, i.e. circular net cages (CNC) and unused tyre covered with netting material (TNC). These structures used materials which were readily available in the local markets and applicable for the local fishermen. The best technique will be evaluated based on the survival and growth rates of the reared juveniles.

MATERIAL AND METHODS

Juveniles

Juveniles used in this study were collected from the shallow coastal waters of southern Lombok, Indonesia (Figure 1). The juveniles were removed from the substratum gently. Collection was done during low tides, and the juveniles were held alive in a plastic bag filled with seawater. Water was changed frequently every 30 minutes during the collection period of 1-3 hours.

Subsquently, the juveniles were placed in a plastic container filled with seawater and aerated using a portable dry cell battery aerator. Juveniles were then brought to the laboratory and placed in a holding tank (a concrete tank measuring 2 m length, 0.75 m width, 1.5 m depth). The tank was filled with fresh seawater at ambient temperature (27°C) and aerated. Juveniles were kept in the holding tanks at least for two weeks before treatments were applied. They were fed ad libitum with macroalgae, *Gracilaria* spp.

Culture techniques

Experiments on culture techniques were carried out offshore of the "LIPI Marine Laboratory", Pemenang, North Lombok, Indonesia (Figure 1). The location is about 100 km from southern Lombok coastal waters where the juvenile abalone were collected. This location was chosen due to the easy access and safety of placing the structures and working offshore areas.

Two types of containment structures were used, i.e., circular net cages (CNC) and tyre net cages (TNC). These techniques used materials which were readily available in the local markets and applicable for the local abalone fishermen. Circular net cages (CNC), measuring 40 cm in diameter and 60 cm in height, were constructed by fitting together steel frames and covering them with netting material. Each cage was divided into three partitions. A piece of polyvinyl chloride (PVC) half pipe (12.5 cm x 25 cm) was placed inside each partition for shelter (Figure 2). Each partition had an internal surface area for juvenile attachment of 0.5 m^2 and had a closed meshed window to allow access into the cage. Tyre net cages (TNC) constructed of unused tyres with a size of 50 cm in diameter and 14 cm in depth were covered with netting material (Figure 3). TNC had an internal surface area for juvenile attachment of 0.5 m^2. A closed meshed window was fixed on the top to allow access to the cage.

Both structures were suspended at 1 m and 4 m below the water surface hanging on a floating raft offshore Pemenang, North Lombok. Each

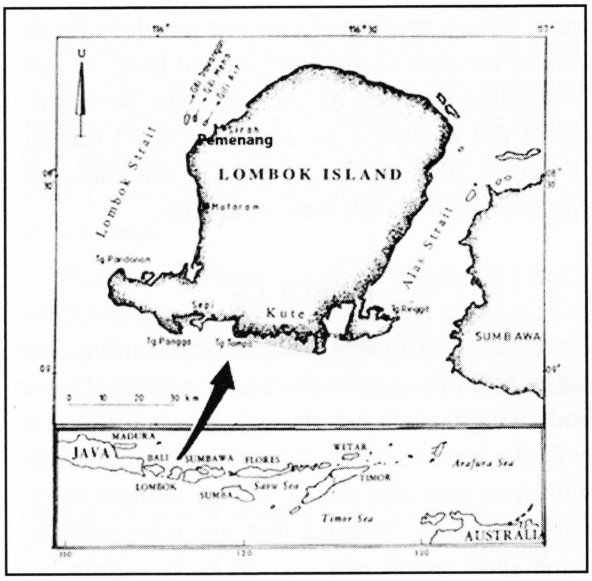

Figure 1. Map of Lombok Island showing area of juvenile collection (Kute coastal waters) and ongrowing Area of Pemenang waters, North Lombok, Indonesia

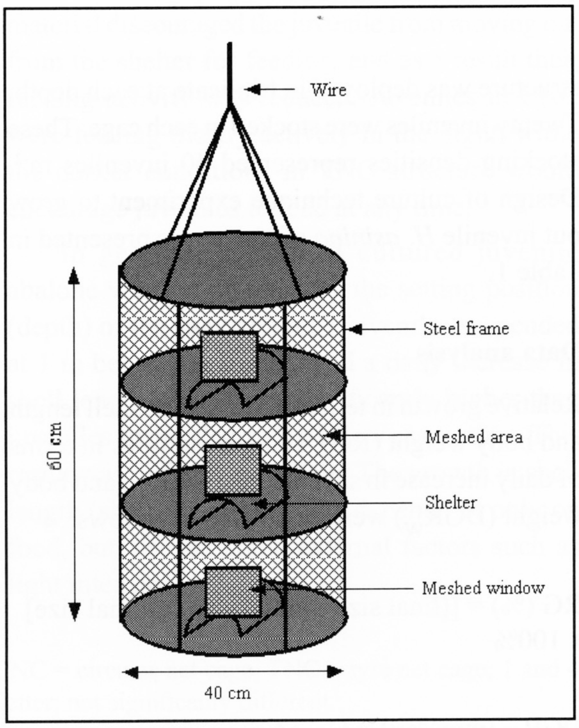

Figure 2. Schematic drawing of circular net cage used to grow out Juvenile *Haliotis asinina* offshore Pemenang, North Lombok, Indonesia

Table 1. Design of Culture Technique Experiment to Grow out Juvenile *H. asinina* offshore Pemenang, North Lombok, Indonesia

Structure	Circular net cages (CNC)		Tyre net cages (TNC)	
Depth	1 m	4 m	1 m	4 m
Replicates	3	3	3	3

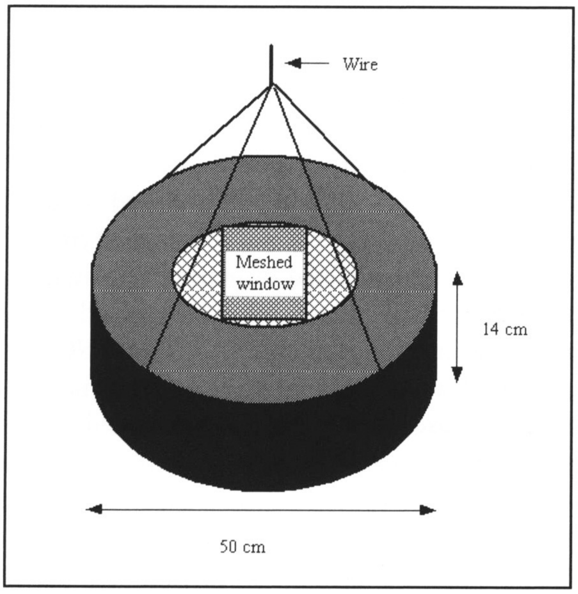

Figure 3. Schematic drawing of tyre net cage used to grow out juvenile *Haliotis asinina* offshore Pemenang, North Lombok, Indonesia.

structure was deployed in triplicate at each depth. Twenty juveniles were stocked in each cage. These stocking densities represented 40 juveniles m^{-2}. Design of culture technique experiment to grow out juvenile *H. asinina* offshore was presented in Table 1.

Data analysis

Relative growth in terms of increase in shell length and body weight (RG), and growth rates in terms of daily increase in shell length (DGR_{sl}) and body weight (DGR_w) were calculated as follows:

RG (%) = [(final size - initial size) : initial size] x 100%

DGR_{sl} (mm/day) = G_{sl} : t

DGR_w (g/day) = G_w : t

G_{sl} was increase in shell length (mm), G_w is increase in weight (g), and t was number of rearing day.

Survival rates (SR) were determined at the end of the study and the values were calculated as follows:

SR = (N_{tn} : N_{to}) x 100%

N_{to} wass the number of animals at initial rearing time, and N_{tn} wass the number of animals at the end of rearing.

Statistical analysis

Daily increment and relative growth in shell length and body weight between different structures and depths were analysed using a nested analysis of variance. A Scheffe Post Hoc test was used to identify significant differences between the mean values of different treatments. The statistical analysis was performed using the software package DataDesk 4.1 (Data Description Inc., Ithaca, New York, USA.). Analysis of covariance was performed to test the effect of initial sizes on growth increment. Univariate analysis of variance (no effect of initial sizes) and Tukey tests were performed to test the differences in mean increase in shell length and body weight between structure trials. Square root transformation was done for the data of increase in shell length and body weight. Univariate analysis of variance was performed using the software package SPSS 11.0.0 for Windows 2001 (Chicago, USA). The statistical significance level (P) was set at 0.05.

RESULTS

Juveniles used in this study have an initial size range of 26-39 mm in shell length and 4-13 g in body weight (data not shown). It was difficult to collect a large number of juveniles from the wild with a narrow size range. It was evident in the wild collected juveniles that juveniles with the same shell length can vary in body weight and vice versa. Setyono (2005a) reported that population of donkey ear abalone in southern Lombok waters reached sexual maturity at shell length of 40.1 - 45.0 mm for males and 50.1 – 55.0 mm for females. That can be said that juvenile donkey ear abalone with a shell length less than 40 mm was still in a growing phase. The data of mean shell length and body weight at initial and final rearing times, daily increase and relative increase in shell length and body weight, and survival rate are presented in Table 2.

The mean initial sizes in shell length and body weight were not significantly different (Nested analysis of variance, P>0.05) between structures (CNC and TNC) and between setting positions (1 m and 4 m below sea surface). Nested analysis of variance for daily increase in shell length and body weight and for relative increase in shell length and body weight shows that mean daily increase and relative increase in shell length were not significantly different between structures, but significantly different between setting positions. Mean daily increase and relative increase in body weight were not significantly different between structures, as well as between setting positions.

The highest mean daily increase in shell length was found in juveniles reared in TNC-1 m which was significantly different from the other groups. The mean daily increase in body weight was also found to be highest in TNC-1 m, which was significantly different from CNC-1 m and CNC-4m, but not different from TNC-4 m (Tables 2).

Changes in mean daily increase in shell length and body weight at 2-weekly intervals was presented in Figure 4. Because of the largest daily growth rate, both in shell length and body weight, juveniles in TNC-1m grew faster than the other groups.

Relative increase in shell length and body weight (Table 2) shows clearly that at the end of rearing times (10 weeks), juveniles in TNC-1m have the largest percentage of growth increment in terms of their initial size compared to juveniles in the other treatments.

DISCUSSION

In this part of the study, growth rates were found to be higher in juvenile abalone reared in tyre net cages (TNC) compare to circular net cages (CNC). The first possible explanation of this result was that juveniles in TNC expended less energy against water movement when they were foraging for food. Juveniles moved securely inside the tyre while feeding. While in CNC, tidal currents and/or waves affected them when they moved out from the shelters for feeding. It is Chan *et al.* (1985) who reported that more than 90% of the total food intake in seafarmed animals is expended for locomotion and other activities in coping with vigorous water movement (wave and current). The second explanation was that the netting material discouraged the juvenile from moving out from the shelter for feeding, and as a result their feeding activity was reduced. Juveniles in CNC were feeding mostly actively in the night, while the darker conditions in TNC structure would encourage juveniles to feed at any time.

In general, growth of cultured juvenile abalone was not affected by the setting position (depth) of the cage although juveniles suspended at 1 m below sea surface had a daily increase in shell length which was significantly higher than juveniles suspended at 4 m below sea surface. This result was difficult to explain. The growth in shell length (shell formation) may depend not only on food, but also on some external factors such as light intensity.

Table 2. Growth of abalone juveniles during experiment. CNC = circular net cage, TNC = tyre net cage; 1 and 4 m: Position of cases down from water surface; superscript letter: not significanly different.

Variable		Rearing	techniques	
	CNC-1m	CNC-4m	TNC-1m	TNC-4m
Initial SL (mm)	32.55±1.68	35.36±1.74	34.26±0.30	34.71±0.39
Final SL (mm)	36.46±1.81	38.05±1.58	39.31±0.52	38.39±0.20
Initial BW (g)	7.21±1.15	9.27±1.61	7.77±0.39	7.65±0.45
Final BW (g)	9.91±1.19	12.09±1.55	12.24±0.37	11.31±0.16
Daily increase in SL (mm)	0.055 ± 0.006^{a}	0.038 ± 0.002^{b}	0.072 ± 0.003^{c}	$0.053 \pm 0.007^{a,b}$
Daily increase in BW (g)	0.039 ± 0.006^{a}	0.040 ± 0.002^{a}	0.064 ± 0.003^{b}	$0.052 \pm 0.005^{a,b}$
Relative increase in SL (%)	12.4 ± 1.6^{a}	8.1 ± 0.8^{b}	15.1 ± 0.4^{a}	10.7 ± 1.5^{b}
Relative increase in BW (%)	$41.7 \pm 9.3^{a,b}$	34.8 ± 9.5^{a}	60.7 ± 4.0^{b}	$50.0 \pm 6.3^{a,b}$
Survival rates (%)	93.3 ± 6.7^{a}	95.0 ± 5.0^{a}	95.0 ± 0.0^{a}	93.3 ± 3.3^{a}

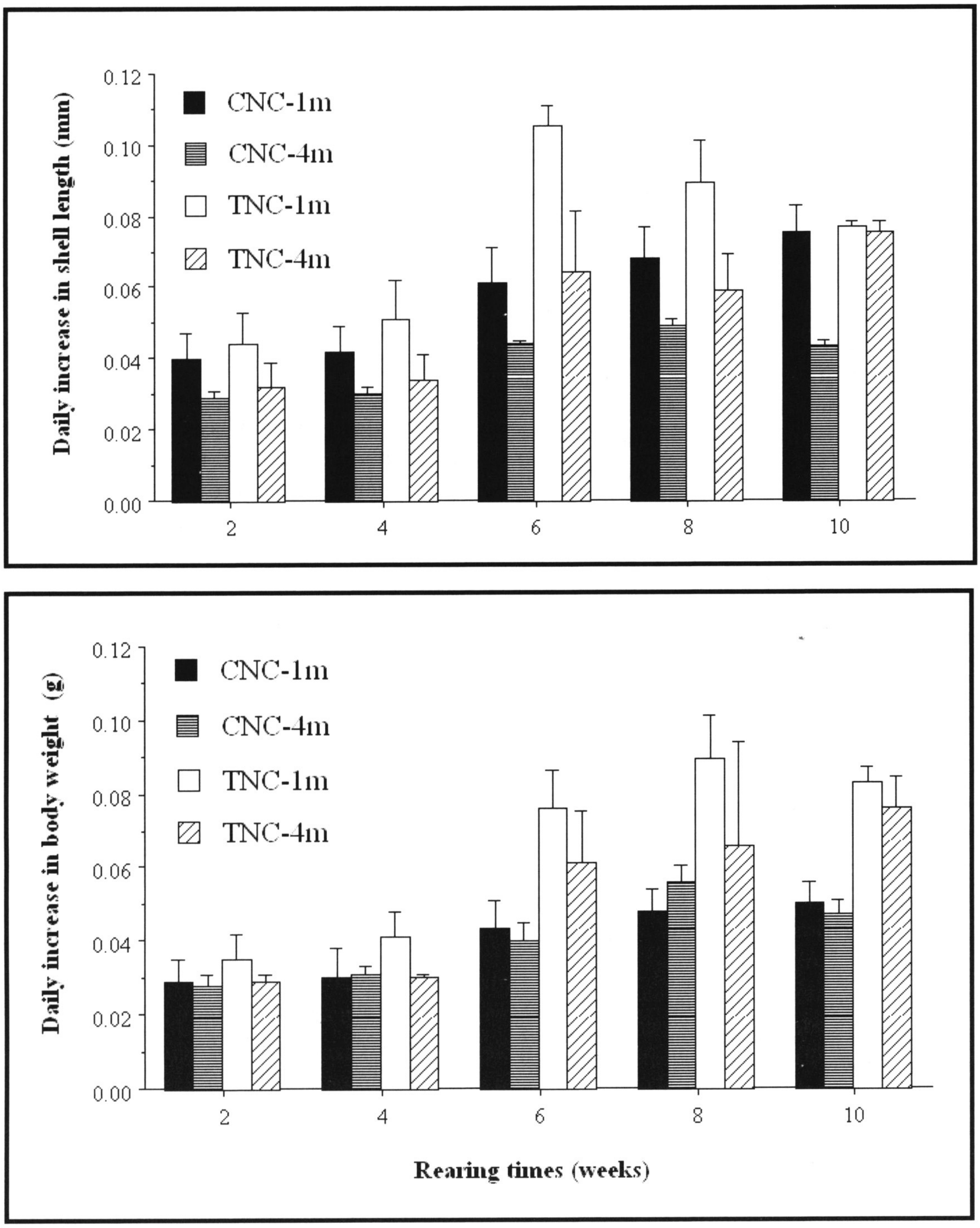

Figure 4. Changes in daily increase in shell length (top) and body weight (bottom) of juvenile *H. asinina* reared in different structures (CNC and TNC) and setting positions (1 m and 4 m from sea surface) offshore Pemenang, North Lombok, Indonesia. Values are mean $\pm$ standard error. CNC = circular net cage, TNC = tyre net cage.

Growth as measured by daily increase in shell length (0.072 mm) was comparable with *H. asinina* at similar size (30-50 mm) fed with *Gracilaria* spp., but cultured in indoor tanks in Thailand (0.061 mm) (Singhagraiwan and Sasaki, 1991). However, the daily increase in shell length of juvenile *H. asinina* in the present study was lower than their counterpart in the Philippines reared in net cages in the sea. The daily increases in shell length and body weight were 0.117 mm and 0.225 g in the Philippines (Castanos, 1997). These differences could be affected by environmental factors such as water quality (Fallu, 1991; Harris et al., 1999), waves and currents (Chan *et al.,* 1985), feeding rates and food consumption rates (Marsden and Williams, 1996). Increases in feeding rates and food consumption will increase the body size (in terms of body muscle). An increase in muscle weight is indicative of good consumption or feeding rates (Barkai and Griffiths, 1988; Fermin, 2002). Feeding rates and food conversions were not measured in the present study due to high variability resulting from the loss of algal fragments out of the cages.

Survival rates observed in the present study (93–95%) were not significantly different between structures and setting positions. This result was comparable with juvenile *H. asinina* at similar size reared in cages in the Philippines, where survival rates ranged from 94 to 98% (Castanos, 1997).

In a commercial application, tyre net cages can be replaced by cages constructed from wood, bamboo and/or rattan which provide more shelter for the juveniles, but enough water flow through the cages. Polyculture of abalone and pearl oyster, or abalone and seaweed culture should optimize the use of such floating structures (raft and buoys). In the first example, pearl oysters could be suspended at a deeper position (5–10 m), while abalone can be suspended near the surface (1 m). Fouling algae on the raft, such as *Gracilaria* spp. and *Hypnea* spp. could be used to feed abalone. In the second example, seaweed could be cultured in the surface, while abalone could be suspended in a deeper position (4 m).

CONCLUSION

In general, growth of cultured juvenile *H. asinina* was affected by the type of structure and setting position. Juvenile *H. asinina* cultured offshore in a cage which provide more shelter area have better growth than cultured in less shelter area. Survival rate was not influenced by the type of structure and setting position. Juvenile donkey ear abalone would grow better when it was cultured in cages which had more shelter and less light.

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