

ABALONE (*Haliotis asinina* L): 5. EARLY JUVENILE REARING AND ONGROWING CULTURE

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ABSTRAK

ABALONE (*Haliotis asinina* L): 5. PEMELIHARAAN ANAKAN PADA TAHAP AWAL DAN BUDIDAYA PEMBESARAN. *Minat untuk membudidayakan abalon di banyak negara di dunia masih terus berkembang dan tumbuh pesat mengingat harga jual abalon cukup tinggi dan cenderung terus meningkat. Berbagai macam teknik budidaya digunakan untuk membudidayakan abalon, termasuk abalon tropis (*Haliotis asinina*). Indonesia adalah negara kepulauan, memiliki wilayah perairan pantai yang luas dan cocok untuk membudidayakan abalon. Perairan laut di Indonesia sangat produktif, pakan alami untuk abalon (makro-algae) sangat melimpah. Semua metoda budidaya abalon dapat diterapkan di Indonesia, tergantung pada tujuan dan sistem budidaya yang dipilih. Pada tulisan ini diuraikan lebih lanjut tentang pemeliharaan anakan pada tahap awal, budidaya pembesaran anakan hingga mencapai ukuran layak jual, dan pakan alami (makro-algae) yang cocok dan disukai oleh abalon tropis.*

INTRODUCTION

Abalone is a very popular and delicious food. Therefore these animals have a high demand with a high market price. However, abalone production from wild fisheries is continuing to decline in the recent decades. Therefore, 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 around the world (VIANA, 2002).

There have been extensive studies on commercially important abalone species for aquaculture. Every country has cultivated its own native species because of ecological consideration, and it is simpler to deal with the animals in relation to water quality (temperature and salinity) and suitable natural food. The native cultured abalone species of different countries is summarised in Table 1.

Successful effort on hatchery techniques and greater market value of some species, deliberated several countries introduce a new species from other geographical different area. The introduced new species of abalone can grow

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very well in a controlled environment. They grow even better than in their origin. However, there are ecological considerations in culturing exotic species, including possible ecological impacts, genetics and diseases.

A variety of techniques are used to raise numerous species of abalone, including *Haliotis diversicolor* in Taiwan (CHEN, 1984), *Haliotis discus hannai* in Korea (FAO, 1990), *Haliotis australis* and *Haliotis iris* in New Zealand (TONG & MOSS, 1992; CLARKE & CREESE, 1988), *Haliotis fulgen* in California (AVILES & SHEPHERD, 1996), and the tropical abalone, *Haliotis asinina* in Philippines (CASTANOS, 1997) and in Indonesia (SETYONO, 2003).

There are two different path ways by which the cultured abalone will ultimately reach the consumer. The first path is using hatchery reared juveniles for reseeding depleted area, to restore the natural abalone population to a capable level of maintaining a fishery production. The second path is commercially rising abalone to market size and selling it directly to the consumer. There are three different methods of commercially culturing abalone to a market size. These are: land-based farming in tanks, raceways, and ponds with intensive feeding; containment rearing in offshore areas; and ocean ranching in closed private areas (HAHN, 1989). SETYONO (1997) has noted some advantages and disadvantages of these method. To choose which method should be used to grow out abalone, there are many factors to be considered, including economical, ecological, geographical, and even political.

Indonesia is an archipelago country and has many coastal areas that 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 very 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. The acceptable method, there-

fore, depends upon the goal and the extent of the culture system.

EARLY JUVENILE REARING

In recent years, many countries have developed abalone hatcheries to produce seed for enhancement of natural stock and for growing in commercial farms. Culture techniques for tropical abalone have been adapted mainly from the studies done on *H. diversicolor supertexta* (JARAYABHAND & PAPHAVASIT, 1996). Although much can be learn from well-established techniques, many aspects of abalone culture must be tailored to suit the local species, environmental conditions, and possibly more importantly, the economic and political conditions of the country (FLEMING & HONE, 1996). The basic established techniques need to be optimised for specific species and geographical areas.

A major problem in abalone seed production in the hatcheries was the high mortality during the settlement phase (EBERT & HOUK, 1984). The success of settlement depends on competent larvae making contact with a suitable substratum before the larvae starve to death (MCSHANE, 1992). CAPINPIN *et al.* (1998) and SETYONO (2003) noted that the most important for successful larval settlement for tropical abalone (*H. asinina*) are suitable substrates and sufficient diatoms.

The improvements of culture techniques in recent years have had a significant impact on abalone production. Besides suitable substrate and sufficient diatoms, survival and growth rates of early juvenile stages can be improved by developing a reliable system for maintaining water quality. For example, the system could employ a bio-membrane filter grown on coral debris and the water be treated through UV-light before entering the rearing tanks (NIE *et al.*, 1996), and the system should provide suitable water temperature (PAUL & PAUL, 1981) and salinity (SINGHAGRAIWAN *et al.*, 1992).

SETYONO (2003) reported that veligers of *H. asinina* settled within 3-4 days. Settlement and feeding of early juveniles is crucial. At this stage, high mortality occurs, especially when diatoms as a main food source are limited. Juvenile *H. asinina* fed on diatoms, *Nitzchia* spp., grew to approximately 0.5 mm in shell length (SL) in 2 weeks and 1.5 mm SL in 2 months. A significant growth in SL occurred after the second month, and juveniles reached a size of 10-20 mm SL in 3-5 months. After reaching a size of 10 mm SL, juvenile *H. asinina* are capable to feed on soft part of macroalgae (*Acanthophora*, *Gracilaria*, and *Hypnea*). The fact that some juveniles reached sizes larger than 30 mm SL within six months of rearing revealed that *H. asinina* has the potential to grow to market size cocktail abalone (50-60 mm SL) in less than 2 years. This ongrowing time can be shortened by provided the juvenile with good rearing conditions including good water quality and flow, and suitable and accessible food.

High variability in growth rate is common in *Haliotis* spp. (DAY & FLEMING, 1992). LILLEY (2001) found that an extensive growth heterogeneity occurred in the New Zealand blackfoot abalone, *H. iris*. Abalone in the larger size-class was found to be competitively superior. Therefore, regular grading, for example every 2 months, is needed to prevent grazing competition. SETYONO (2003) has observed that large juveniles climbed on top of small juveniles. The behaviour of large juveniles may limit the movement of small juveniles, affecting the uptake of food. There was evidence that growth of small abalone improved in the absence of larger conspecifics (MGAYA & MERCER, 1995).

Creeping juveniles of hatchery-reared tropical gastropods are mostly fed with *Navicula* spp. and *Nitzchia* spp. (JARAYABHAND & PAPHAVASIT, 1996; DWIONO et al., 1997; SETYONO & DWIONO, 1998). However, the most acceptable and suit-

able diatom species for feeding early juvenile *H. asinina* is still unknown. For example, *Chaetoceros* spp. was the most accepted diatom for *H. kamtschaticana* (PAUL et al., 1977), and *Tetraselmis suecica* was used to feed newly settled *H. rufescens* (OWEN et al., 1984). More variables in food, including the size and species of diatoms, will likely improve the success of juvenile rearing.

ONGROWING CULTURE

A variety of techniques are used to raise numerous species of abalone. Tropical abalone (*H. asinina*) is a hardly marine snail. The juvenile can be reared on land in tanks made from concrete or fibre glass, or in the sea using a net cages constructed by fitting together wooden or steel frames and covering them with netting material, and/or in a barrel. The structure of net cages can be rectangular (Figure 1), circular (Figure 2), and also can used unused tyre covered by net (Figure 3). Shelters are set inside the cage using a polyvinyl chloride (PVC) pipe, and a closed meshed window is fixed to provide access into the cage. Cages were then suspended below the water surface from a floating raft offshore.

Maximisation of growth is an important factor for successful commercial aquaculture. A variety of factors such as food quality (MAI et al., 1995), stocking density (MGAYA & MERCER, 1995), and water quality (FALLU, 1991) are known to influence the growth of juvenile abalone.

Clumping/aggregation behaviour exist in *H. asinina*. SETYONO (2003) reported that in the sized group of 40.1-47.0 mm SL, the mean daily increase in shell length and body weight was higher in juveniles reared in higher stocking density than in lower stocking density. This phenomenon also occurred in small sized juvenile *H. tuberculata* in which the biomass growth increased as density increased (MGAYA & MERCER, 1995).

There is density-dependence for space and food in juvenile *H. asinina*. SETYONO (2003) found that the optimum stocking density in an outdoor tanks culture is 50 and 38 juveniles m^{-2} for juveniles with initial size of <40 mm SL and >40 mm SL, respectively. While the optimum stocking density in cages offshore was 80 juveniles m^{-2} .

Juvenile *H. asinina* reared in an outdoor tank had feeding rates on fresh macroalgae (*Gracilaria* spp.) ranged from 20% to 23% of body weight each day (SETYONO, 2003), while juvenile reared in cages offshore had feeding rates of 15-25% of body weight per day (CAPINPIN *et al.*, 1999). Generally, feeding rates per unit of biomass are higher in smaller and fast-growing juveniles than in larger abalone (MARSDEN & WILLIAMS, 1996). Higher feeding rate occurred at a lower stocking density is common in haliotids (MARSDEN & WILLIAMS, 1996; SETYONO, 2003). Variation in feeding rates of abalone are not unusual as abalone are known to be erratic feeders, sensitive to a number of environmental and physiological influences (GREENIER & TAKEKAWA, 1992).

SETYONO (2003) reported that growth of cultured juvenile *H. asinina* in cages offshore was not affected by the setting position (depth) of the cage. The daily increase in shell length and body weight of cultured abalone offshore are affected by environmental factors such as water quality (HARRIS *et al.*, 1999), waves and currents (CHAN *et al.*, 1985), feeding rates and food consumption rates (MARSDEN & WILLIAMS, 1996).

Haliotis asinina are hardy animals. Survival rates on juveniles cultured in net cages offshore of Pemenang, West Lombok was 93-95% (SETYONO, 2003) and in Philippines was 94-98% (CASTANOS, 1997). Moreover, survival rates are not effected by density, type of structure and setting position (depth).

In practical, juvenile *H. asinina* can be reared in a structure which provide suitable shelter but enough water flow through the con-

tainment. In a commercial application, 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. It is possible to rear abalone in a polyculture system. For example: polyculture of abalone and pearl oyster, or abalone and seaweed culture. This system will optimise the use of such floating structures (raft and buoys). In the first example, pearl oysters can be suspended at a deeper position (5-10 m) while abalone can be suspended near the surface (1 m). Fouling algae on the raft (*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).

FOOD PREFERENCES

Investigation into feeding behaviour, especially the effect of diet on juvenile growth is important. The right type and quantity of algal diets could increase the growth of juvenile abalone. Studies on feeding habit show that abalone like to feed on the soft part of algae. They prefer *Ulva* to *Gracilaria* (CHEN, 1984): Previous work shows that *H. asinina* preferred red algae to brown algae (TAHIL & JUNIOMENEZ, 1999). SETYONO (2003) reported that juvenile *H. asinina* reared in cages offshore preferred first to graze on *Gracilaria*, followed by *Hypnea*, *Kappaphycus* and *Ulva*, and then lastly on *Laurencia*. These macroalgae were abundant in coastal areas around Lombok Island.

Although many species of seaweed can be used to feed abalone, only *Gracilaria* meets the requirement of ample supply and low price. The use of *Gracilaria* to feed juvenile *H. asinina* promoted high growth in the long-term and is considered suitable for abalone farming as reported by CAPINPIN & CORRE (1996). It is not surprising that almost all abalone farmed in Taiwan use *Gracilaria* as the main food (CHEN,

1984). The availability and suitability of *Gracilaria* to feed abalone, *H. asinina*, was practised in Thailand (SINGHAGRAIWAN & SASAKI, 1991) and Philippines (CAPINPIN & CORRE, 1996; CAPINPIN *et al.*, 1999).

SETYONO (2003) observed that juvenile *H. asinina* fed with a single-species diet of *Gracilaria* or *Ulva* has better growth rates than the juveniles fed with single diet of *Laurencia*, or *Kappaphycus* or *Hypnea*. CAPINPIN & CORRE (1996) found that juvenile *H. asinina* fed with *Gracilaria* grew faster than those fed with *Kappaphycus*. However, SETYONO (2003) reported that the highest growth rate was found in juveniles which were fed with mixed diet of macroalgae. It is suggested that mixed diet of macroalgae provide the juveniles with suited nutritional requirement.

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Table 1. Countries and their cultured native abalone species.

Countries	Cultured abalone	Sources
Ireland	<i>Haliotis tuberculata</i>	MGAYA & MERCER, 1995
Spain	<i>Haliotis canariensis</i>	PENA, 1986
Mexico	<i>Haliotis fulgen</i>	AVILES & SHEPHERD, 1996
	<i>Haliotis rufescens</i>	BERNAL <i>et al.</i> , 1992
USA	<i>Haliotis kamtschatkana</i>	PAUL <i>et al.</i> , 1977
	<i>Haliotis rufescens</i>	EBERT & HOUK, 1984
South Africa	<i>Haliotis midae</i>	SALES & BRIZT, 2001
Australia	<i>Haliotis rubra</i>	FLEMING & HONE, 1996
	<i>Haliotis roei</i>	KEESING & WELLS, 1989
	<i>Haliotis asinina</i>	COUNIHAN <i>et al.</i> , 2001
New Zealand	<i>Haliotis iris</i>	HOOKE & CREESE, 1995
	<i>Haliotis australis</i>	MOSS, 1999
China	<i>Haliotis discus hannai</i>	NIE <i>et al.</i> , 1996
Taiwan	<i>Haliotis diversicolor</i>	CHEN, 1984
Japan	<i>Haliotis discus discus</i>	KOJIMA, 1981
	<i>Haliotis discus hannai</i>	UKI & KIKUCHI, 1982
	<i>Haliotis discus</i>	UKI & KIKUCHI, 1984
Korea	<i>Haliotis discus hannai</i>	YOO, 1989; FAO, 1996
Thailand	<i>Haliotis asinina</i>	SINGHAGRAIWAN & SASAKI, 1991
	<i>Haliotis ovina</i> and	JARAYABHAND & PAPHAVASIT, 1996
	<i>Haliotis varia</i>	
The Philippines	<i>Haliotis asinina</i>	CAPINPIN <i>et al.</i> , 1998
Indonesia	<i>Haliotis asinina</i>	SETYONO, 2003

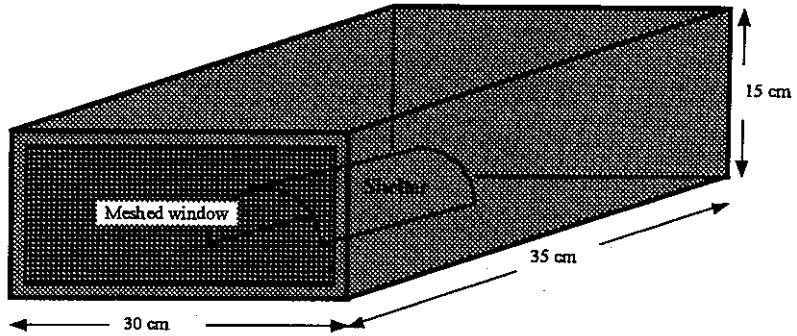


Figure 1. Schematic drawing of rectangular net cages used to grow out juvenile *Haliotis asinina*.

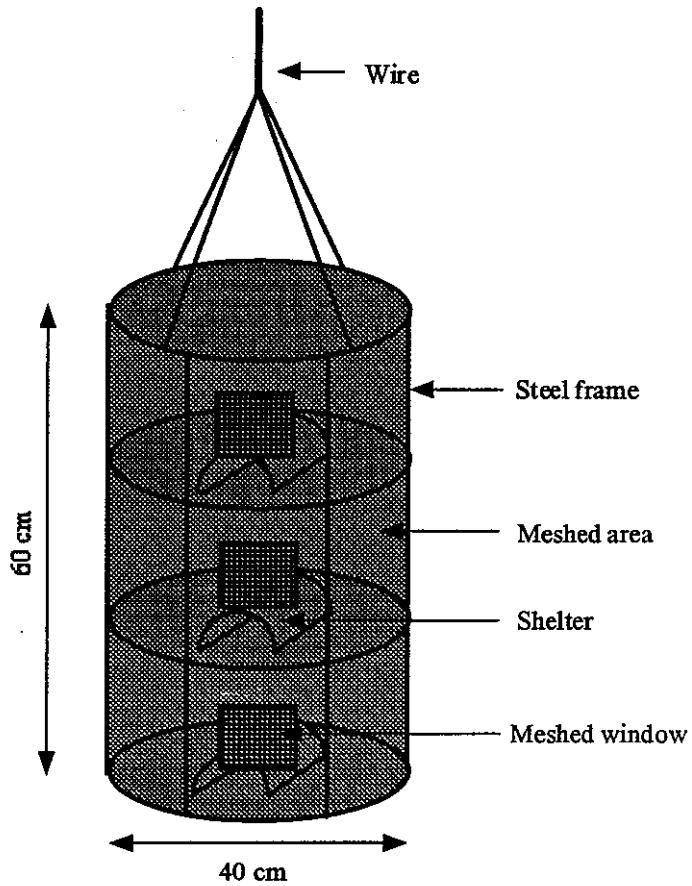


Figure 2. Schematic drawing of circular net cages used to grow out juvenile *Haliotis asinina*.

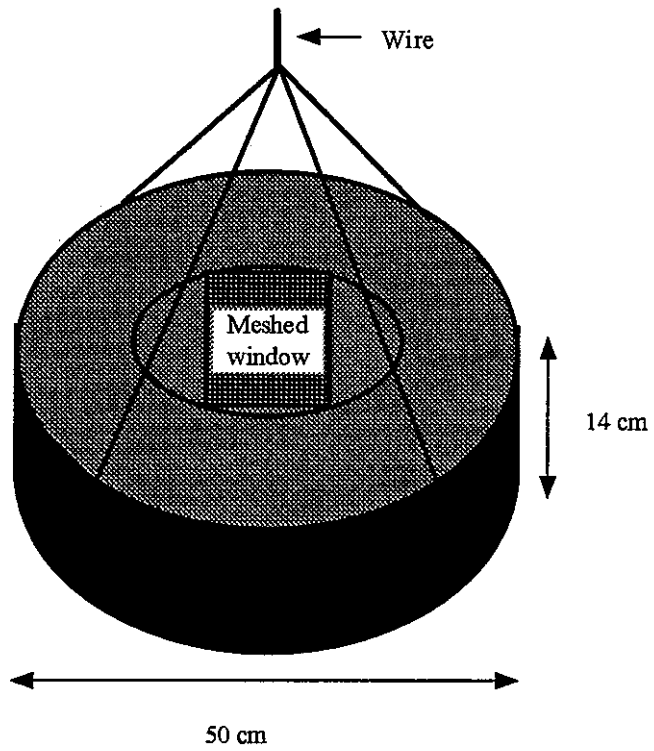


Figure 3: Schematic drawing of tyre net cage used to grow out juvenile *Haliotis asinina*.