



## THESIS APPROVAL

### GRADUATE SCHOOL, KASETSART UNIVERSITY

Master of Science (Marine Science)

-----  
**DEGREE**

Marine Science

Marine Science

-----  
**FIELD**

-----  
**DEPARTMENT**

**TITLE:** Research and Development on Abalone Culture in Vietnam: Applications of Knowledge from Thailand

**NAME:** Mr. Minh Duc Nguyen

**THIS THESIS HAS BEEN ACCEPTED BY**

-----  
**THESIS ADVISOR**

( Associate Professor Saran Petpiroon, Ph.D. )

-----  
**THESIS CO-ADVISOR**

( Associate Professor Shettapong Meksumpun, Ph.D. )

-----  
**THESIS CO-ADVISOR**

( Assistant Professor Suriyan Tunkijjanukij, Dr.Scient )

-----  
**THESIS CO-ADVISOR**

( Associate Professor Padermsak Jarayabhand, Ph.D. )

-----  
**DEPARTMENT HEAD**

( Assistant Professor Sunan Patarajinda, M.S. )

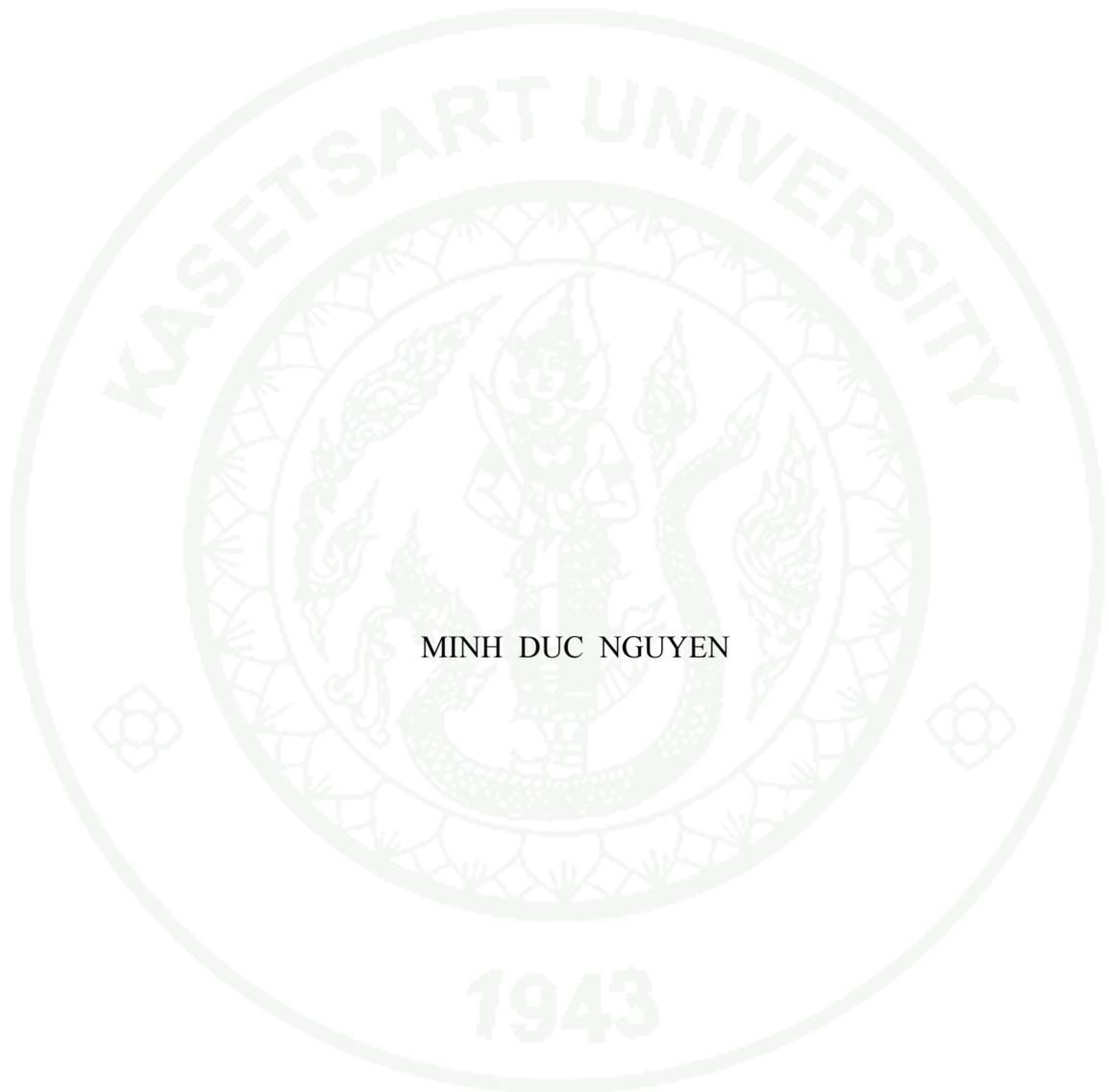
**APPROVED BY THE GRADUATE SCHOOL ON** \_\_\_\_\_

-----  
**DEAN**

( Associate Professor Gunjana Theeragool, D.Agr. )

THESIS

RESEARCH AND DEVELOPMENT ON ABALONE CULTURE IN  
VIETNAM: APPLICATIONS OF KNOWLEDGE FROM  
THAILAND



MINH DUC NGUYEN

A Thesis Submitted in Partial Fulfilment of  
the Requirements for the Degree of  
Master of Science (Marine Science)  
Graduate School, Kasetsart University  
2010

Minh Duc Nguyen 2010: Research and Development on Abalone Culture in Vietnam: Applications of Knowledge from Thailand. Master of Science (Marine Science), Major Field: Marine Science, Department of Marine Science. Thesis Advisor: Associate Professor Saran Petpiroon, Ph.D. 96 pages.

The hatchery production of larvae and juveniles of the tropical abalone (*Haliotis asinina*, Linnaeus 1758) were reported. Techniques were described for broodstock management, controlled spawning by exposure to air at 30<sup>0</sup>C for 2 h. Female abalone spawned with a mean of 1,202,900 larvae. Fertilised eggs measured 180 µm in diameter. With 4.16 % survival rate was obtained during larval rearing. Larvae passed trochophore, veliger and creeping stages after 30 hours and were induced to settle on a mat of diatoms *Nitzschia sp.* containing. The settled spats and juveniles were reared to mean length of 11.44±2.6 mm for 3 months in a rearing tank where they were ready to settle onto shelter transparent film plates of *Nitzschia sp.*

Effects of stocking density and initial size on growth and survival of abalone, *H. asinina* were investigated under the suspended plastic cages. In the first experiment, four stocking densities i.e. 40, 60, 80 and 100 pcs/cage were used. After 6 months, growth in term of shell length, weight and survival rate of abalone at 60 pcs/cage were the highest. The stocking density of 60 pcs/cage was chosen for the second experiment where abalone of three initial size ranges i.e. 4-5, 7-8, and 10-11 mm in term of shell length were investigated in the same manner as the first experiment. It was found that abalone with initial size range of 10-11 mm showed the best survival rate with the value of 82%. Under this circumstance, it is suggested that abalone with the initial size range of 10-11 mm in shell length should be stocked at the density of 60 pcs/cage for the first 6 months of grow-out period under this suspended plastic cages system.

---

Student's signature

---

Thesis Advisor's signature

\_\_\_ / \_\_\_ / \_\_\_

## ACKNOWLEDGEMENTS

First and foremost I offer my sincerest gratitude to my advisor, Associate Professor Dr. Saran Petpiroon and my co-advisor, Associate Professor Dr. Padermsak Jarayabhand, for their valuable advice, continuous guidance, helpful suggestions, kindness and encouragement throughout my study that help me to complete my Master thesis.

I owe my deepest gratitude to my co-advisor Associate Professor Dr. Shettapong Meksumpun who created great ideas and provided valuable advices for my study. I also would like to show my gratitude to co-advisor Assistant Professor Dr. Suriyan Tunkijjanukij for his helpful comments and suggestions in my research.

I would like to thanks the ACMECS (Ayeyawady-Chao Phraya-Mekong Economic Cooperation Strategy) scholarship of TICA (Thailand International Development Cooperation Agency) for financial supports.

Thanks are also given to Assistant Professor Sunan Patarajinda, to all members and fellows in the Department of Marine Science, Faculty of Fisheries for their distinguishable cheerfulness and cooperation.

In addition, this research could not have been completed without the support of Dr. Nguyen Thi Bich Thuy. My grateful thanks also go to the field team led by Mr. Nguyen Nam for helping me gather relevant document and information.

I am indebted to Dr. Nguyen Van Hao and my colleagues to support me throughout many years. Lastly, but in no sense the least, I express my thanks and appreciation to everyone whose name is not mentioned here and my family for their understanding, motivation and patience.

Minh Duc Nguyen

April 2010

**TABLE OF CONTENTS**

	<b>Page</b>
TABLE OF CONTENTS	i
LIST OF TABLES	ii
LIST OF FIGURES	iv
INTRODUCTION	1
OBJECTIVES	3
LITERATURE REVIEW	4
MATERIALS AND METHODS	13
RESULTS AND DISCUSSION	24
CONCLUSION AND RECOMMENDATIONS	42
Conclusion	42
Recommendations	44
LITERATURE CITED	46
APPENDIX	53
CURRICULUM VITAE	96

**LIST OF TABLES**

<b>Table</b>		<b>Page</b>
1	Commonly mentioned important species of <i>Haliotis</i>	5
2	Embryonic and larval development stage of <i>H. asinina</i>	27
3	Temperature and salinity of seawater in larval rearing tanks	28
4	Survival rate of juveniles <i>H. asinina</i> after 3 months period	30
5	Biomass with different initial size of abalone	39

**LIST OF TABLES (Continued)**

<b>Appendix Table</b>	<b>Page</b>
1 Data of water quality	54
2 Length and weight of abalone growth at different initial size at 4-5 mm (60pcs/cage)	56
3 Length and weight of abalone growth at different initial size at 7-8 mm (60pcs/cage)	61
4 Length and weight of abalone growth at different initial size at 10-11 mm (60pcs/cage)	66
5 Length and weight of abalone growth at different stocking density at 40 pcs/cage	71
6 Length and weight of abalone growth at different stocking density at 60 pcs/cage	76
7 Length and weight of abalone growth at different stocking density at 80 pcs/cage	81
8 Length and weight of abalone growth at different stocking density at 100 pcs/cage	86
9 Survival rates at different stocking density of abalones	91
10 Survival rates at different initial size of abalones (60pcs/cage)	91
11 Length of early juveniles rearing abalone	92

## LIST OF FIGURES

Figure		Page
1	The life cycle of Donkey's ear abalone, <i>H. asinina</i>	7
2	Total catches (tonne) data in the Vietnam abalone fishery (MoFI, 2008)	10
3	Total juveniles data in the Vietnam abalone production (RIA3, 2009)	11
4	Conditioning tanks for abalone broodstock	13
5	Mature female abalones showing its green ovary (A) and male a milky whitish gonad (B)	14
6	Spawning tanks for abalone broodstock	15
7	Settling tanks of abalone with transparent film plates covered with epiphytic diatom	16
8	40-60 days old juveniles abalone set on a transparent film plate	17
9	Laboratory culture the diatom <i>Nitzschia sp.</i> (A), Outdoor mass culture of diatom <i>Nitzschia sp.</i> (B).	18
10	Measurements for shell length and shell width of abalone spat by vernier calliper and digital camera	19
11	Abalones culture in plastic cage	20
12	Seaweed diets of abalone culture	21
13	Measurements for shell length and shell width of abalone by rulers	22
14	Developmental stages of <i>H. asinina</i> : (1) Fertilized egg, (2) First polar bodies, (3) second polar bodies appear on the fertilized egg, (4) 2-cells stage; (5) 4-cells stage, (6) 8-cells stage, (7) 16-cells stage, (8) 32-cells stage, (9) 64-cells stage, (10) Gastrula stage, (11) Trochophore, (12) Newly hatched trochophore	24

**LIST OF FIGURES (Continued)**

<b>Figure</b>		<b>Page</b>
15	Developmental stages of <i>H. asinina</i> : (1) Early veliger, (2) Veliger, (3) Late veliger, (4) Peristomal stage, (5) Early larvae, (6) 24-hrs larvae, (7) 30-hrs larvae, (8) Creeping larvae, (9) 10 days-old juvenile	26
16	Developmental stages of <i>H. asinina</i> : (1) 14 days old juvenile, (2) 16 days old juvenile, (3) Juvenile with first respiratory pore, (4) 45 days old juvenile	27
17	Relationship between the shell length (mm) and rearing time (day) of juvenile <i>H. asinina</i> .	29
18	Growth in term of shell length (mm) under four different stocking densities of abalone	32
19	Growth in term of weight (g) under four different stocking densities of abalone	33
20	Survival rates with different stocking density of <i>H. asinina</i> reared in plastic cages	34
21	The changes of length abalone during culture	37
22	The changes of weight abalone during culture	37
23	Survival rate with different initial size of abalone <i>H. asinina</i> reared in plastic cages	38

# RESEARCH AND DEVELOPMENT ON ABALONE CULTURE IN VIETNAM: APPLICATIONS OF KNOWLEDGE FROM THAILAND

## INTRODUCTION

Abalones are the common name given to molluscs in the genus of *Haliotis*, which means “sea ear”. There are about 70 species of abalone distributed worldwide (FAO/UNDP, 1990; Daume *et al.*, 1999). Abalones are slow-growing marine gastropods which live in rocky and shallow waters near stands of algae. The abalone shell is characterized by having a shallow, ear-shaped shell with a series of respiratory holes along the dorsal-lateral shell margin. They are mostly found on substrata of granite and limestone (Bryan and Qian, 1998). However, newly settled abalones prefer to live on encrusting coralline algae (Westaway and Norriss, 1997). They were attached to the underside of rock and boulders with their powerful muscular foot, from which they are not easily dislodged. Abalones occupy the low intertidal and high subtidal zones of exposed coasts in clear, well oxygenated and high salinity sea water (Fallu, 1991).

There have been extensive studies on commercially important abalone species for aquaculture. Every country has cultivated 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 (Capinpin *et al.*, 1998). Development in culture abalone of land-based and sea-based grow out sites is limited by appropriate investment partners, native title issues and concerns over potential impacts on drift seaweeds (Gosling, 2003). Additionally, the Donkey’s ear abalone (*H. asinina*) is being evaluated for culture in the tropical areas of the Pacific Ocean. Aquaculture development planning in several states has identified abalone as a high priority based on current investment and industry potential. This is especially true for the Pacific Ocean, particularly along the East Asian countries (SEAFDEC, 2000).

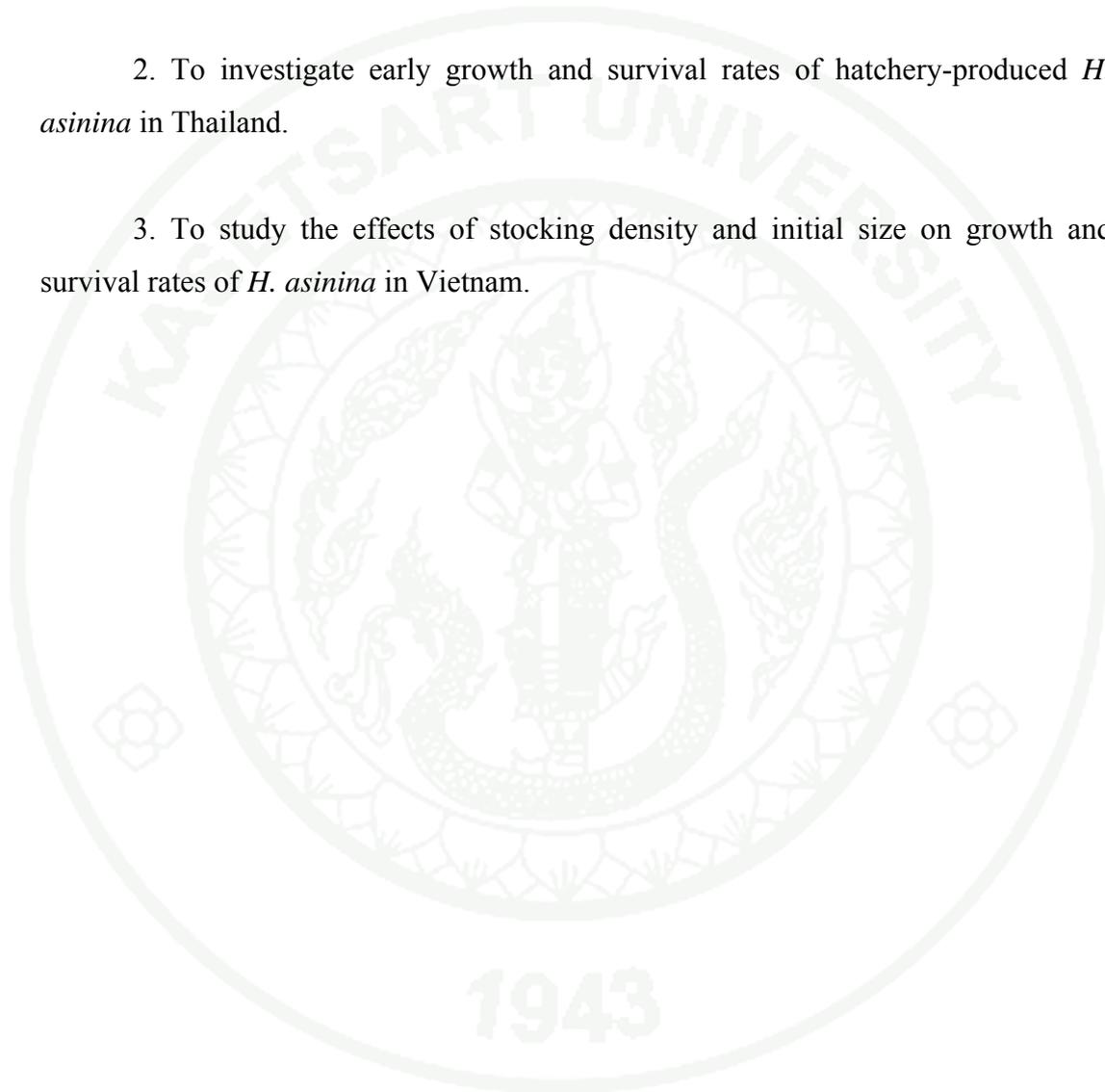
Successful efforts on hatchery techniques and greater market value of some species have led several countries to introduce a new species from other geographical different areas. The introduced new species of abalone can grow very well under a controlled environment. They grow even better than their native origin. However, there are ecological considerations in culturing exotic species, including possible ecological impacts, genetics and diseases (Huner and Brown, 1985; Gallardo and Buen, 2003). In fact, East Asian countries are now in a position to become a major contributor to the world aquaculture production of abalone following very significant investment proposed in warm water abalone farms, with much of it having been realized. Furthermore, Donkey's ear abalone culture techniques have been developed in Asian countries and there are the principal states within areas that have investment in abalone culture (Degman *et al.*, 2001).

Although abalones occupy a low position in world landings statistics at 11,500 tonnes in 1997 and decreasing to 10,800 tonnes in 2005 (Gordon and Cook, 2001), comprising less than 1% of the total molluscs landing, they command moderate to high prizes in many countries, especially in East Asia. The relative scarcity and high prizes in world markets of abalones has created much interest in their cultivation, with many countries undertaking in support of their emerging new industries (Gibson, *et al.*, 2007).

The success of abalone culture depends on selection of the best species for a given culture environment. The primary selection criteria are good growth and survival rate, locally available feed, proven culture technology and established markets (Fermin and Buen, 2002). Most importantly, production costs must allow for a reasonable profit margin at a price that is competitive with abalone from other sources. This strategy is still used today with a small number of farms growing to market size in land-based tanks and from rafts (Spencer, 2002; Capinpin *et al.*, 1999).

## OBJECTIVES

1. To provide information on embryonic and larval development of hatchery-produced *H. asinina* in Thailand.
2. To investigate early growth and survival rates of hatchery-produced *H. asinina* in Thailand.
3. To study the effects of stocking density and initial size on growth and survival rates of *H. asinina* in Vietnam.



## LITERATURE REVIEW

### 1. Biology of Donkey's ear abalone (*Haliotis asinina*, Linnaeus 1758)

Abalones are marine gastropods which have one shell and a large muscular foot that is used to attach themselves by suction to hard substrates. This is the edible part of the animal which accounts for more than one third of the abalone's live weight in Vietnam. The tropical Donkey's ear abalone (*H. asinina*) is being studied in Vietnam to determine its suitability for culture, commercially. This species offers a dilemma for the grower because it can grow very fast, which reduces the production cost. This tropical species have a lower wholesale price compared with the temperate ones.

#### 1.1 Classification of Donkey's ear abalone (*Haliotis asinina*, Linnaeus 1758)

Abalones are generally classified into a single genus named *Haliotis*. They are hierarchically classed as *Archaeogastropoda*, as their anatomy and development are those of the typical snails. Detailed reviews of the biology of abalones have been published by Mottet in 1978.

Scientific classification of the Donkey's ear abalone is described below.

Kingdom: *Animalia*

Phylum: *Mollusca*

Class: *Gastropoda*

SubClass: *Prosobranchia*

Order: *Archaeogastropoda*

SuperFamily: *Pleuromariaceae*

Family: *Haliotidae*

Genus: *Haliotis*

Species: *asinina*

## 1.2 Commercially important abalone species

The species of most abalones are too small or too rare to be of interest to the abalone farmer or fisherman. Only about twentyfive species are currently commercially utilized and almost all of these come from temperate waters.

**Table 1** Commonly mentioned important species of *Haliotis*.

Species	Common name	Location	Shell length (mm)
<i>H. fulgens</i> *	Green, southern green or blue.	Mexico, Pacific coast of USA.	125-200
<i>H. rufescens</i> *	Red abalone	~ ~ ~ ~	>275
<i>H. corrugata</i>	Pink or corrugated	~ ~ ~ ~	150-175
<i>H. assimilis</i>	Threaded	~ ~ ~ ~	>200
<i>H. sorenseni</i>	White or Sorensen	Pacific coast of USA	125-200
<i>H. cracherodii</i>	Black	~ ~ ~ ~	75-125
<i>H. walallensis</i>	Flat or northern green	Pacific coast of USA and Canada.	75-125
<i>H. kamtschntkana</i>	Northern or pinto	~ ~ ~ ~	100
<i>H. discus hannai</i> *	Ezo awabi	North Japan, North China, Siberia	180-200
<i>H. discus</i>	Kuno awabi (black)	~ ~ ~ ~	200
<i>H. gigantea</i>	Madaka	South Japan	250
<i>H. sieboldii</i>	Megae	~ ~ ~ ~	170
<i>H. diversicolor diversicolor</i> #	Tokobushi	Hong kong	50
<i>H. diversicolor supertexta</i> #	Tokobushi	South Japan, Taiwan	50
<i>H. asinina</i> #	Mimigai, Donkey's ear.	South Japan, Thailand,	70-100
<i>H. rubra</i> *	Black lip	Australia	120-140
<i>H. laevigata</i>	Green lip	~ ~ ~ ~	130-140

**Table 1** (Continued)

Species	Common name	Location	Shell length (mm)
<i>H. roei</i>	Roe's	~ ~ ~ ~	70-80
<i>H. iris</i> *	Paua and Black	New Zealand	170
<i>H. australis</i>	Silver, queen paua	~ ~ ~ ~	125
<i>H. virginea</i>	Virgin, white paua	New Zealand	70
<i>H. tuberculata</i> *	Ormer	Europe (France & chanel Isles)	120
<i>H. midae</i> *	Perlemoen	South Africa	90

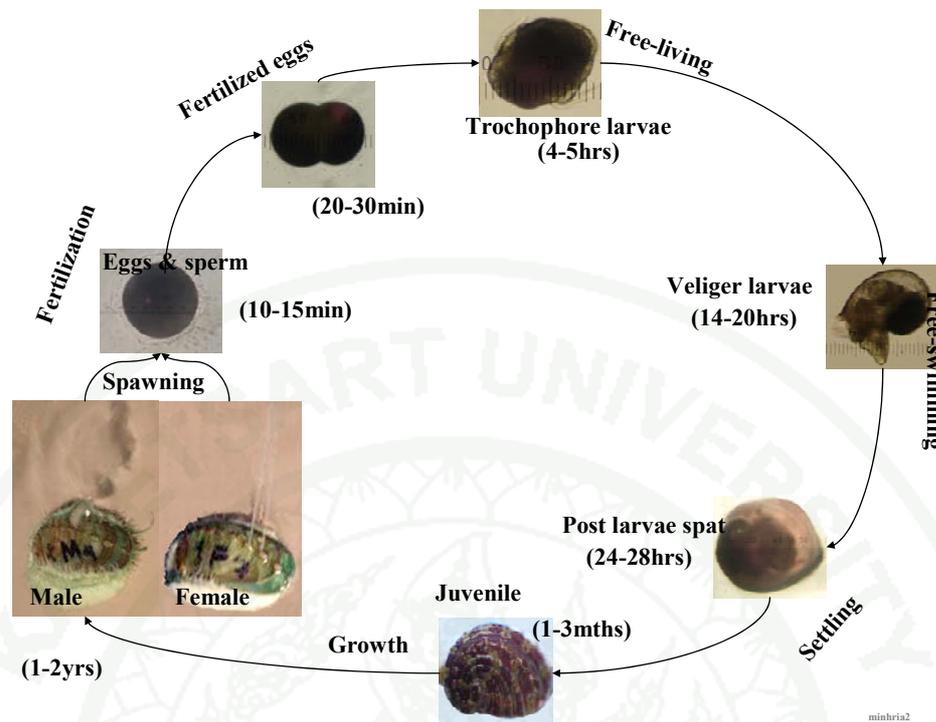
\* Farmed species, # tropical species.

**Source:** Adapted from Jarayabhand and Paphavasit (1996)

### 1.3 Natural life cycle

Life cycle of abalones has evolved to match their environments. Changes in the environment act as a stimuli for a change in behaviour or condition. The stimuli that initiate the change are called trigger.

Life cycles of the Donkey's ear abalone are described as follows. Male and female abalones spawn in April to August. Spawning may not occur every year. Mass fertilization occurs in the water column. Fertilized eggs hatch within one day into free-swimming larvae which remain in planktonic stage for 2-3 days before settling. Planktonic abalone larvae are dispersed by current. Following metamorphosis, juvenile abalones are light sensitive and seek habitats in cracks and underside of rocks. As the juveniles grow older, they migrate up to their preferred food sources which are mostly seaweeds.



**Figure 1** The life cycle of Donkey's ear abalone, *H. asinina*.

**Source:** Adapted from Cox (1962)

#### 1.4 Distribution

Donkey's ear abalones are occurring in all major oceans of the world and mostly found along outer coastline. They appear to be more abundant in tropical zones. Generally, abalones prefer shallow, turbulent water with high levels of dissolved oxygen. Abalones are usually most common off exposed rocky headlands in tropical seas. They show a very clear nocturnal behaviour in both the field and the hatchery. During the day they shelter under rocks or in crevices, dead coral heads or provided shelters, they emerge in the evening and hide again at dawn (Norris and Preston, 2003). Donkey's ear abalones are found on the islands along the eastern coasts of the upper Gulf of Thailand and tropical oceans (Gruenthal *et al.*, 2007; Shepherd, 1986). Individual Donkey's ear abalones are usually confined to one contiguous piece of coastline and associated Islands. The range of distribution is likely to be restricted to about along of coastline.

### 1.5 Habitat

The abalone used its foot to crawl from place to place in a typical snail-like manner. They are attaching to firm (rocky) substrate in waters with high salinity and some wave or current action. The abalones can be easily turned over and make food for predators such as octopus, sunflower star, wolf eel and sea otter in subtidal, and for man, birds, otter and mink in intertidal. As a consequence, abalones are generally found only in areas of hard rock and coral (Daume *et al.*, 2000). They are planktonic larvae dispersed by currents, tend to settle in recently grazed areas, attracted by chemicals secreted by colonizing algae, adults often colonize kelp beds. Abalones avoid the light so that, while there are some exceptions to the rule, in daylight, abalone usually found hiding in crevices on rocky reefs and under rocky overhangs.

### 1.6 Feeding

Wild abalones are herbivores. The diet changes during the different phases of their development, very young feed on diatoms and attached microalgae, juveniles feed on attached algae, adults feed on kelp fragments. They use a radula, an organ with many sharp teeth, in order to munch down their salty meal. When they are ready, larvae settle onto the sea bed and become spat and adulthood their changes larges seaweeds (Dunstan *et al.*, 2007). They eat many kinds of seaweeds but do have preferences. It is dangerous to try to make generalization, but it seems that wild abalones, as a group, prefer red algae, tolerate some brown algae and accept only very few types of green algae. Abalones are stimulated to feed when the surrounding water, moving susceptible to predation and increases the chances of seaweeds being washed past (Pirker and Schiel, 1993).

## **2. Ecology**

Abalones are herbivores. They prefer eating pieces of kelp, large brown algae. However, they may also feed on phytoplankton and diatoms if there is nothing else to eat. They use a radula, an organ with many sharp teeth. Abalones have to watch out for greedy sea urchins. The urchins will compete for food and space against the abalone, and usually the urchins win. Adult abalones also have to be wary of predators such as octopus, crab, lobsters, seastars and otters. The muscular foot of the abalone makes a tasty and high-caloric snack for these hungry animals. Abalones found in a sea otter range are often smaller, on average, more restricted to cracks and crevices. Although their foot is good to eat, it unfortunately cannot move quickly enough for a fast escape (Jarayabhand and Newkirk, 1989).

Abalone are slow growers and long-lived. In addition, their recruitment rates are often very unpredictable. Unfortunately, these characteristics make abalone very susceptible to over-harvesting. The "protection" link describes the rapid demise of the pinto abalone population and of populations of abalone around the world (FAO/UNDP, 1999).

## **3. Present status of fisheries and abalone production in Vietnam**

### **3.1 The wild catch of abalone landing in Vietnam**

In recent years, further review shows that the overall Vietnam supply of abalone, as a result of continuing increases in cultured production, combined with an unfortunate continued increase in the illegal wild catch was approaching the historical abalone abundance of the before 2000s.

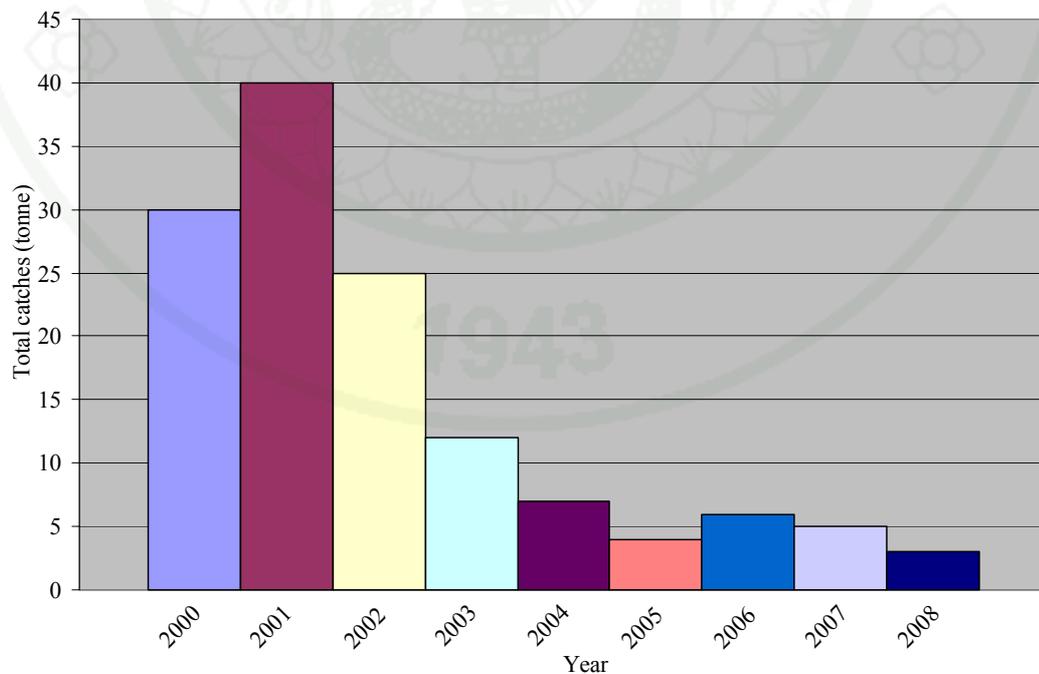
Intense fishing by locals using free diving methods has led to sharp decline in catches, and abalone stock is presently regarded as over fished. It was well known that over fishing, diseases, habitat loss and failed governing body management of the wild catch have all contributed to the decline of the abalone fisheries wild catch

over the past decades. Abalone in the wild has decreased yield and almost not to exploit more.

Figure 2 illustrates Vietnam fisheries landings for the year 2008 as compared with low to high range averages for wild catch abalone fishery in the decade following 2000s.

Certainly there was some wild catch of abalone decades ago, however it pale in comparison with the massive wild take from the late 2000s to the present. Despite a myriad of laws and penalties in many locals, the illegal catch continued in current year at an unprecedented pace.

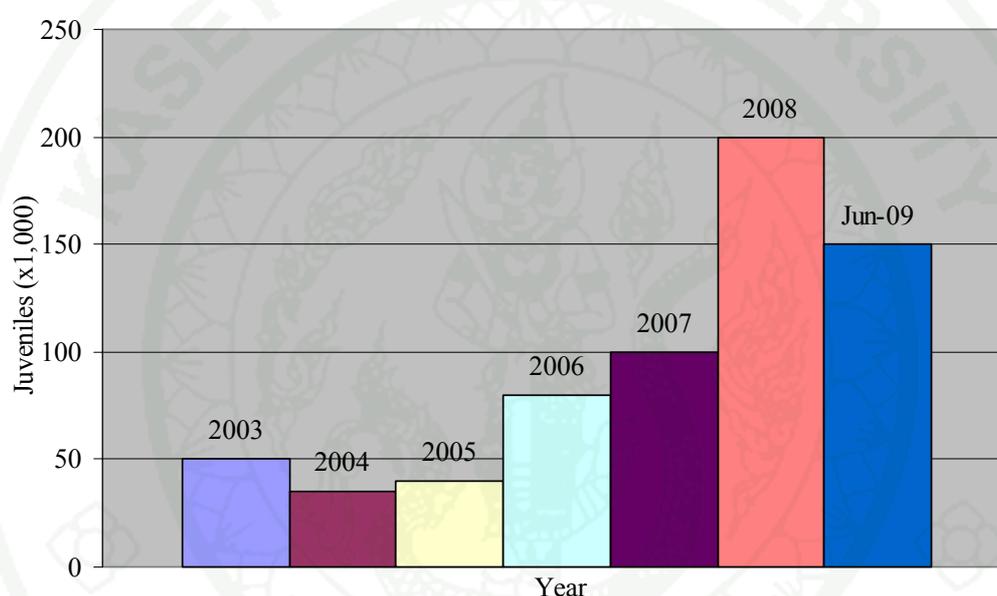
Nowadays, Fisheries Department considered closing down any form of abalone harvesting once current rights expired. It was estimated that if poaching continued at the current rate, abalone would be fished to extinction in some more year.



**Figure 2** Total catches (tonne) data in the Vietnam abalone fishery (MoFI, 2008).

### 3.2 Seed of abalone production in Vietnam

Figure 3 illustrates the total juvenile's production as reported within Vietnam. The phenomenal growth of the Vietnam Juveniles cultured abalone were evident when comparing the  $2 \times 10^5$  juveniles for the year 2008 with just  $5 \times 10^3$  juveniles 5 years earlier, but only one factor experiments and not yet developed a mass production of juveniles and supply to farmer.



**Figure 3** Total juveniles data in the Vietnam abalone production (RIA 3, 2009).

Specific hatchery techniques need to be developed or adapted for each abalone species. The aquaculture of *H. asinina* in Vietnam was investigated in a series of projects since 2004, the resources of which are available in several internal and unpublished reports, but have not appeared in the peer reviewed literature. This paper reviews the progress of the abalone aquaculture trials in Vietnam, with emphasis on the development of the culture facilities, hatchery and handling techniques, and constrains to the culture of *H. asinina*.

Recent increases in the hatchery production of abalone show an inverse relationship to decline in wild catches. The number of juveniles in the shell has increased over the rate yielded commercial fishing of abalone from wild catches.

Hatchery production for commercial culture and for enhancement of over exploited stocks is the most promising means of increasing abalone production in the long term of Vietnam.

It has been shown that the abalone can be cultivated in Vietnam, at least in closed system and that proposals for cultivated in captivity are promising. Vietnam has definite economic advantages for the development of such project, learn about with other countries in region. In the final decision to introduce an exotic species, environmental and social considerations are integral parts of the assessment process. Such initiatives should be supported by legal measures that incorporate administrative procedures as well as methodologies to evaluate the environment impact. In that way, we will not only protect our marine ecosystem, but we will also promote the development of human enterprises involved in those ventures.

The culture system will accommodate 50,000 seed abalone in the 2003 year and increasing that production during the fifth year. A hatchery for production of abalone seed was planned for Vietnam.

While abalone aquaculture will most probably expand several folds during the next decade in the region, much of this expansion will be in Vietnam. The prevailing attitude of seed production in hatchery restricting the development of the abalone in Vietnam, the more limited and kelp distributions in the wild will most probably inhibit the growth of abalone aquaculture in the region.

## MATERIALS AND METHODS

### Experiment I: Embryonic and larval development and early growth of hatchery-produced *H. asinina*

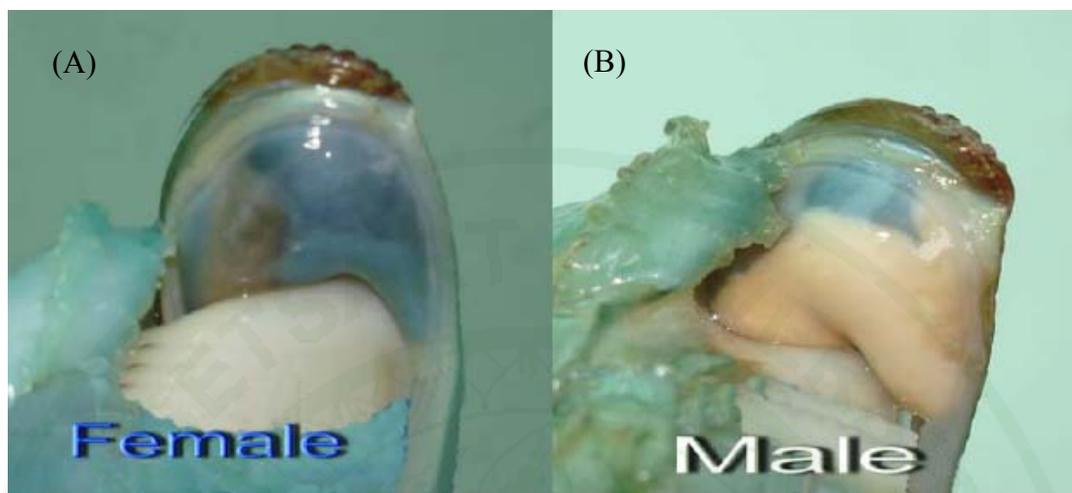
#### 1. Broodstock preparation



**Figure 4** Conditioning tanks for abalone broodstock.

*H. asinina* broodstock were obtained from Sichang Island, Chonburi province, Thailand. They were brushed to get rid of fouling organisms and maintain in broodstock conditioning tanks (Figure 4). Between 50-100% of 5  $\mu$ m filtered seawater at ambient temperature and salinity were changed daily.

## 2. Spawning induction



**Figure 5** Mature female abalones showing its green ovary (A) and male with a milky whitish gonad (B).

In September, 2008, mature male and female abalones with high gonad index (Figure 5) were selected and put separately into 1x0.5x0.5 m spawning tanks (Figure 6). As abalones usually spawn during 1-3 a.m., an opposite day and night light controlling system was used. This was aimed to obtain sperms and eggs in the afternoon instead of an early morning. Desiccation and thermal shock was chosen for spawning induction.



**Figure 6** Spawning tanks for abalone broodstock.

Three to four days after conditioning and spawning induction male and female abalones started to release their gametes. Release of eggs or sperms by animals usually triggers the spawning of many gravid animals nearby. Eggs and sperms were siphoned out and kept separately in 50 l bucket for fertilization.

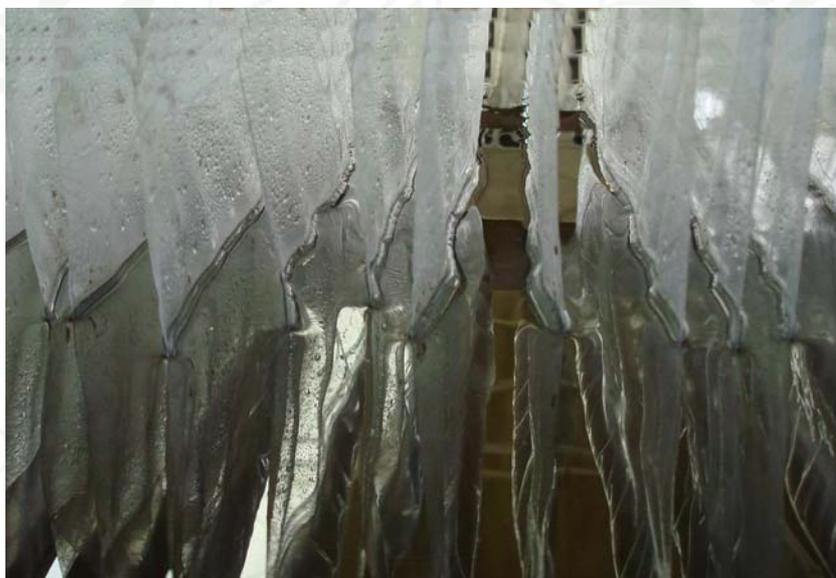
### 3. Fertilization and larval rearing

Fertilizations were conducted by mixing appropriate concentration of sperms into unfertilized eggs. They were left for 10 minutes. Then they were filtered through 500 and 50  $\mu\text{m}$  sieves. These were done to remove unwanted matters and excess sperms. Clean fertilized eggs were transferred into 1  $\text{m}^3$  fiberglass larval rearing tanks. During this period stages of abalone embryonic and larval development were monitored under a microscope, where the pictures were taken by a digital camera for further investigation.

After 24 hours the larvae were gently washed and passed through an outlet tube leading to the larval rearing tank. Thus no handling of the larvae takes place.

#### 4. Settlement tanks

The settlement tanks of size 1x4x1 m were used with an open water system. The gently aeration from the central column of tank was used to increase water movement. These settlement tanks were prepared a week before to allow the culture of epiphytic diatoms to grow on the shelter transparent film plates (Figure 7). This was done to allow the creeping larvae to set on these plates. To keep the tank clean, fresh 1  $\mu\text{m}$  filtered seawater was supplied continuously. Dead larvae and debris at the bottom of tank were siphoned out daily.



**Figure 7** Settling tanks for abalone with transparent film plates covered with epiphytic diatom.



**Figure 8** 40-60 days old juveniles abalone set on a transparent film plate.

The newly-settled postlarvae were reared about 60 days at which size the juveniles were ready to feed on macro-algae (Figure 8). Juvenile abalones were rinsed to remove abalones from transparent film plates and kept on the bottom of tank. The shelters plates made from PVC roof cut into 30x45 cm were put on bottom of the rearing tanks to serve as substrates for juvenile abalones.

#### 5. Diatom diets

Generally, spat start to feed on epiphytic diatoms as soon as they set on the plates (Gapasin and Polohan, 2004; Evans, 2000). The major feed items for abalones at the early juvenile stages were various benthic species of diatom. We cultured diatoms in laboratory and outdoor (Figure 9). The most common form of microalgae used on feeding plates was various species of diatoms, but in this study we used mass culture of *Nitzschia sp.* a benthic diatom species. It seems probable that many other species could be used as well. Stocks of the benthic diatom were monocultured under the laboratory condition. When diatoms were necessary, subculture of the stock was

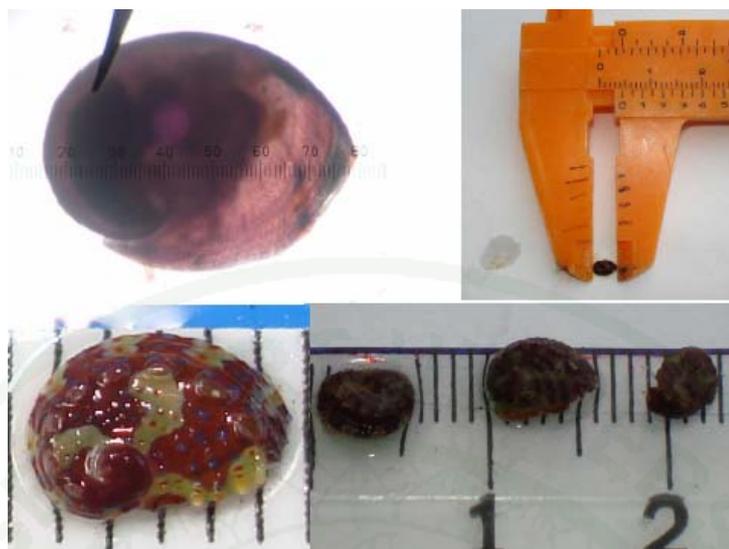
propagated to grow to a larger volume and transferred to outdoor tank where the culture plastic plates were kept. There appears to be an increasing appreciation to the virtues of the microalgae as a food source for nursery abalones. Spat collection tanks were usually used for this purpose. Three bundles of culture plate were immersed in 500 litres spat collection tank containing propagated diatoms 4-5 days prior to the introduction of creeping larvae. In addition, sufficient light and the right amount of nutrient should be made available to enhance diatom growth. It was suggested that diet of microalgae provide the juveniles with suited nutritional requirement.



**Figure 9** Laboratory culture of the diatom *Nitzschia sp.* (A), Outdoor mass culture of diatom *Nitzschia sp.* (B).

#### 6. Determination of early growth and survival rate of *H. asinina*

Abalone length, width and weight were measured every five days during experiments. Mean weights were determined using a precision scales and taking the biomass total weight of all animals divided by the total number of animals. Shell length and width were obtained to the less than 1 mm using digital camera (Figure 10).



**Figure 10** Measurements for shell length and shell width of abalone spat by vernier calliper and digital camera.

## 7. Data analysis

### Measurement of embryonic and larval development of *H. asinina*

Embryonic development, larval development and newly settled abalone to 3 months old abalones were monitored. Shell length data was analyzed in Excel. To assess the change over time, a series of photograph were taken using a compound microscope equipped with camera. The data for the settlement experiment during the nursery period with the overall mean and variance were measured at the prominent stages by an ocular meter equipped with microscopes.

## Experiment II: Effects of stocking density on growth and survival of *H. asinina* grown within plastic cages

### 1. Experimental animals and conditions

*H. asinina* broodstock were collected from NinhHoa District and kept in a local abalone farm in NinhTho. In November, 2008, 110 males and females broodstock were brought back to NinhTho Experimental Station, KhanhHoa Province, Vietnam.

The abalone used for the experiments were juveniles *H. asinina* originated from an artificial spawning. Four stocking densities were used i.e. 40, 60, 80 and 100 pcs/cage. Three initial size different range of 4-5, 7-8 and 10-11 mm were cultured in plastic cages with measuring 30x40x30 cm (Figure 11). The plastic cages were suspended to the depth of 0.8 m in a 15 m<sup>3</sup> indoor tank that continuously received sand-filtered sea water at a supply rate of 20 l/min. Water depth in the tank was maintained at 1m and aeration was provided through the tank bottom.



**Figure 11** Abalones culture in plastic cage.

During the experiment, pre-determined amount of seaweeds *Ulva sp.* (Figure 12) was added to feed the animals once in every 2-3 days. Uneaten seaweed was siphoned out and weighed prior to the next feeding time.



**Figure 12** Seaweed diets of abalone culture.

The abalones were reared in constant darkness with light only being turned on during feeding, surveillance and measurement. Water quality measurements were taken weekly and mortality rate of abalone was observed in the morning.

## 2. Growth of abalone

Abalone length, width and weight were measured every month during experiments. Mean weights were determined using a precision scales and shell length and widths were done by using vernier calliper and ruler (Figure 13).



**Figure 13** Measurements for shell length and shell width of abalone by rulers.

Two separate experiments were carried out using abalones of different stocking density per plastic cage and different initial mean shell lengths.

The first experiment was carried out for 6 months with four densities i.e. 40, 60, 80 and 100 pcs/cage with ten replicates. The initial sizes of abalones per experiment were between 7 to 8 mm in shell length.

The second experiment was carried out over 6 months for three initial shell length which are 4-5, 7-8 and 10-11 mm. The stocking density used for this experiment was 60 pcs/cage with ten replicates as well.

### 3. Data Analysis

#### 3.1 Data processing and statistical analysis for grow-out experiment

The length, width, body weight and survival rate data, monthly growth rates in terms of shell length (L), shell width (R), body weight (W) and survival rates (S) were determined as follows:

$$L = (L_f - L_i)/Dn$$

$$R = (R_f - R_i)/Dn$$

$$W = (W_f - W_i)/Dn$$

Where:  $L_f$  and  $L_i$  were shell length at final and initial shell length, respectively.

$R_f$  and  $R_i$  were shell width at final and initial shell width, respectively.

$W_f$  and  $W_i$  were body weight at final and initial body weight, respectively.

$Dn$  was days of rearing.

Biomass ( $\text{kg/m}^2$ ) = Total wet weight of abalone culture/ Area squared culture of abalone.

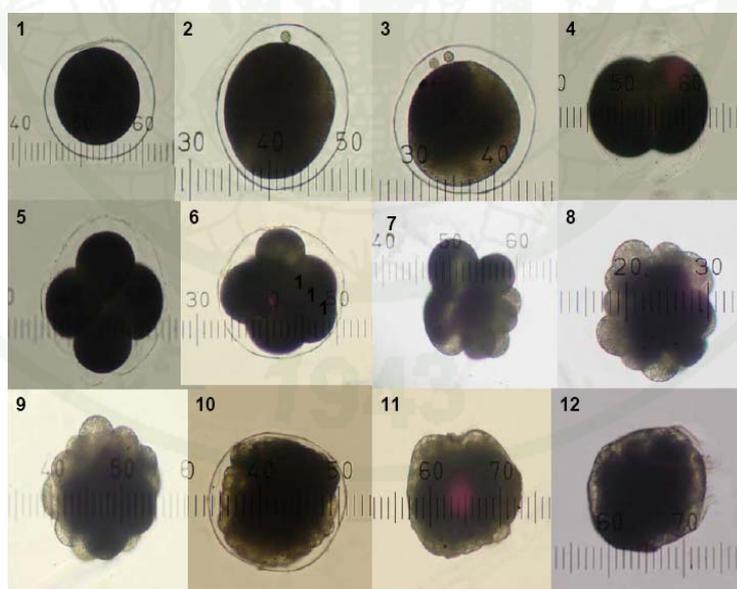
All statistical analyses were performed with SPSS 15.0. The relationship between growth and survival rate was analysed by using a paired t-test at 5% probability level. Percentage data were arcsine-transformed prior to statistical analysis.

## RESULTS AND DISCUSSION

### Experiment I

#### 1. Embryonic developments of hatchery-produced abalone

In September, 2008, thirty males and females in the broodstock tanks were collected and spawned to produce juveniles in the hatchery. The broodstocks were kept alive in spawning tanks filled with filtered seawater, with no diet. Three to four days after conditioning, male and female abalones were housed in separate tanks while they spawn. Desiccation and thermal shock method was chosen for this experiment at 11.30-12 a.m. Spawning was begun at 1:30-2:30 hrs after the induction. After male abalones released sperms, they were transferred into the tank where female abalones have laid eggs. Fertilization occurs quickly within these tanks and after 30 minutes fertilized eggs were removed, thoroughly rinsed and placed into new tanks.



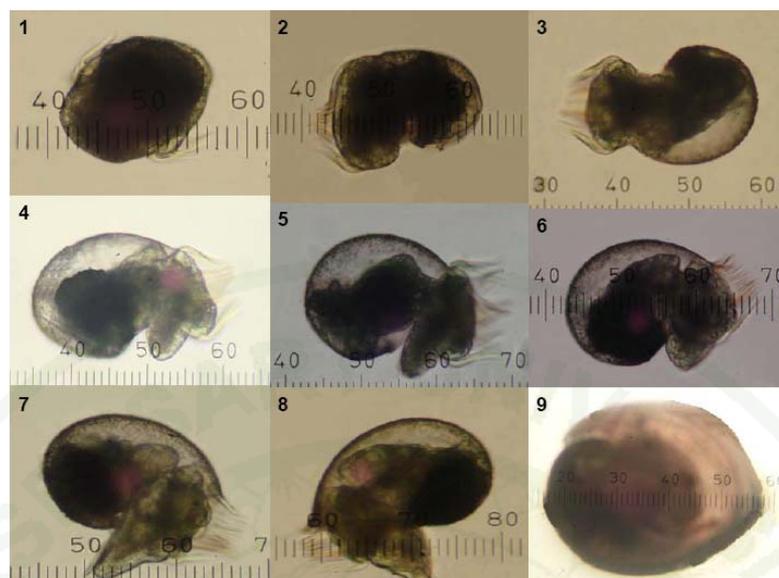
**Figure 14** Developmental stages of *H. asinina*: (1) Fertilized egg, (2) First polar bodies, (3) second polar bodies appear on the fertilized egg, (4) 2-cells stage; (5) 4-cells stage, (6) 8-cells stage, (7) 16-cells stage, (8) 32-cells

stage, (9) 64-cells stage, (10) Gastrula stage, (11) Trochophore, (12) Newly hatched trochophore.

The diameters of fertilized egg were about 170-180  $\mu\text{m}$  (Figure 14-1). At 10-15 minutes after fertilization, first and second polar bodies were formed at seawater temperature of 30°C (Figure 14-2, 3). At 20-30 minutes after fertilization, the fertilized eggs spent the first cleavage, the embryo was now at the two-cells stage (Figure 14-4) and then followed by second cleavage taken place 30-40 minutes after fertilization was now at the four-cells stage (Figure 14-5). At 40-50 minutes the third cleavage taken place, the embryo was at eight-cells stage (Figure 14-6). And then, the embryo developed continuously from the fourth, fifth until they reached the sixth cleavage appropriate for 60, 75 and 90 minutes the embryo becomes 16, 32 and 64 cells (Figure 14-7, 8, 9).

Approximately 3.30 hours later, the embryo become slightly elongated having reached the gastrula stage with the characteristic blastopore (Figure 14-10). At 4:45 hours later, the ciliary belt appeared on the developing embryo. It began to actively rotate within the egg membrane with the aid of the ciliary belt and the apical hairs (Figure 14-11) and 6 hours later the membrane become thinner, until it finally bursts (Figure 14-12) the embryo was newly hatching into swimming trochophore larvae.

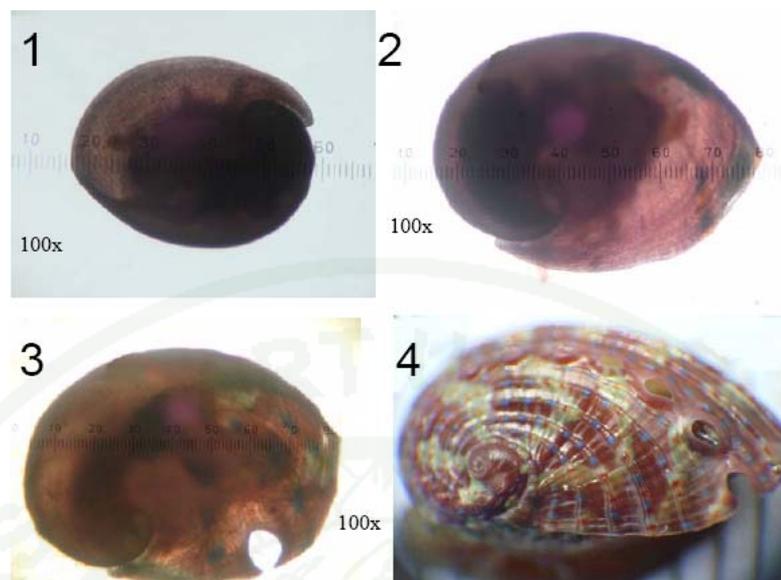
Approximately 9-10 hours later, the larva develops into the early veliger larval stage, the swimming cilia were now borne by a distinctive collar of cells, surrounding the developing head (Figure 15-1, 2). At this stage the larva was 220-230  $\mu\text{m}$  long. Within 12-14 hours, the late veliger develops an eye spot, foot, operculum and a protoconch similar to that of a snail (Figure 15-3, 4, 5). The larvae were active swimmers and can often being seen swimming in tornado-like formations in the water column with the help of the velum. After 24-26 hours, while approaching the settling stage, the foot grows bigger and the velum degenerates and disappears (Figure 15-6, 7, 8).



**Figure 15** Developmental stages of *H. asinina*: (1) Early veliger, (2) Veliger, (3) Late veliger, (4) Peristomal stage, (5) Early larvae, (6) 24-hrs larvae, (7) 30-hrs larvae, (8) Creeping larvae, (9) 10 days-old juvenile.

Ten days later, the juveniles reach 420-570  $\mu\text{m}$  in shell length (Figure 15-9) and fifteen days growth up 650-790  $\mu\text{m}$  in shell length (Figure 16-1, 2).

The larvae metamorphosed into juveniles within 2-3 days after fertilization. First respiratory pore stage was seen in 18-20 days after fertilization and this juvenile was  $1.19 \pm 0.15$  mm long (Figure 16-3). At this stage the juvenile abalones were called "spat" and were ready to settle on a transparent film plates.



**Figure 16** Developmental stages of *H. asinina*: (1) 14 days old juvenile, (2) 16 days old juvenile, (3) juvenile with first respiratory pore, (4) 45 days old juvenile.

**Table 2** Embryonic and larval development stage of *H. asinina*.

Stage	Time after fertilization
Fertilized egg	0 min
First polar bodies	10 min
Second polar bodies	15 min
2-cells stage (first cleavage )	20-30 min
4-cells stage (second cleavage)	30-40 min
8-cells stage (third cleavage)	40-50 min
16-cells stage (fourth cleavage)	60 min
32-cells stage (fifth cleavage)	75 min
64-cells stage (sixth cleavage)	90 min
Gastrula stage	3-4 hrs
Trochophore	4-5 hrs

**Table 2** (Continued)

Stage	Time after fertilization
Newly hatch trochophore	6 hrs
Early veliger	8 hrs
Veliger	10 hrs
Late veliger	12-14 hrs
Peristomal stage	18 hrs
Early larvae	22 hrs
Larvae	24-26 hrs
Creeping larvae	30 hrs

The spats of this *H. asinina* can be produced at a commercial scale and supplied all year round to farmers (McShane, 1991).

Fertilized eggs of *H. asinina* were smaller (180  $\mu\text{m}$ ) when compared to that of *H. iris* (230  $\mu\text{m}$ ; Harrison and Grant, 1971) and *H. midae* (222  $\mu\text{m}$ ; Genade *et al.*, 1988). It was the same range as in subtropical species *H. ovina*, *H. varia* (Tsvetnenko and Taylor, 2004; Oleh, 2005).

The trochophore and early veliger larvae of *H. asinina* were positive phototactic as described in other Haliotids (Singhagraiwan and Doi, 1993). Our larval rearing period ranged from 2 to 3 days and settlement in rearing tank nearly 3 months at mean temperature at 9 a.m. being  $28.13 \pm 0.82^{\circ}\text{C}$ , at 3 p.m. being  $29.98 \pm 1.04^{\circ}\text{C}$ , and the salinity ranged from 29 to 33 ppt (Table 3).

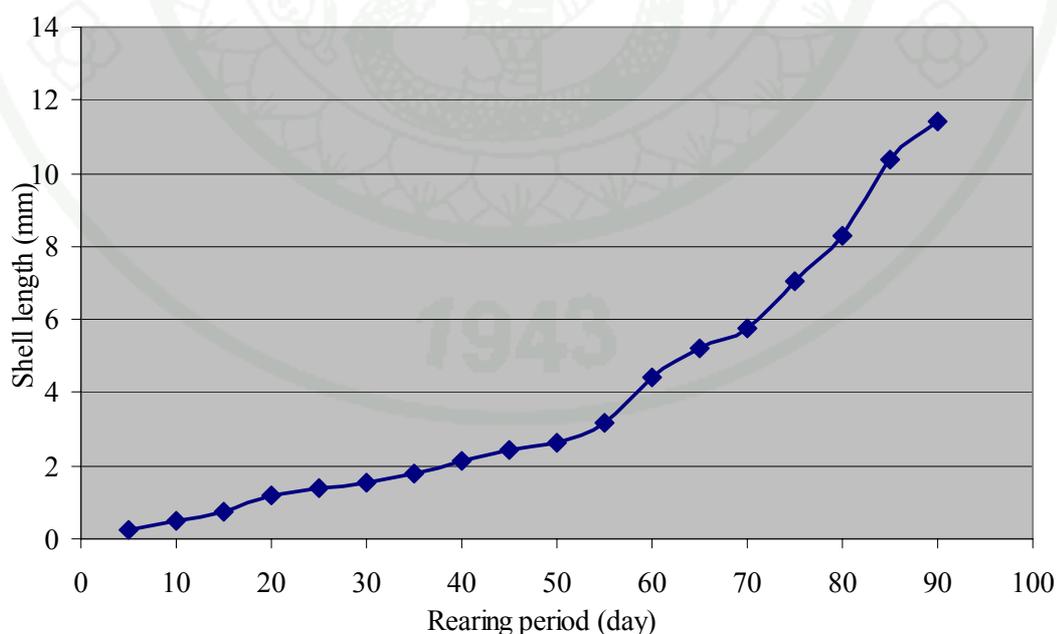
**Table 3** Temperature and salinity of seawater in larval rearing tanks.

Sample	Water quality		Remark
	Salinity (ppt)	Temperature ( $^{\circ}\text{C}$ )	
9 a.m.	29-33	$28.13 \pm 0.82$	
3 p.m.		$29.98 \pm 1.04$	

## 2. Growth and survival rates of juvenile *H. asinina* in hatchery

In the rearing tank, the spats settled onto plates, which the settling plates were covered in benthic diatoms such as *Nitzschia sp.* the favourite food of juvenile abalone. Two to three hundreds tiny abalones settled on each plate, where they remained for 3 months, feeding on benthic diatoms and juveniles possessed shell length ranging average 6.3-15.4 mm, with mean  $\pm$  standard variation of  $11.44 \pm 2.6$  mm and with survival rate of 4.16 %. A summary of embryonic, larval development and early growth of *H. asinina* were shown in Table 2 and 4.

Abalone mean shell length was measured  $0.25 \pm 0.026$  mm when the experiment began. They grew with an average of  $11.44 \pm 2.6$  mm in shell length over the 90 days rearing (Figure 17) for juveniles fed with *Nitzschia sp.* The abalones obtained growth rate of  $49.55 \mu\text{m}/\text{day}$  during initial rearing period. A growth point may be useful in determining age at which abalone should be harvested for grow-out, since growth rate drop off beyond the growth point on the standard curve.



**Figure 17** Relationship between the shell length (mm) and rearing time (day) of juvenile *H. asinina*.

**Table 4** Survival rate of juvenile *H. asinina* after 3 months period.

Laboratory larvae estimation data			
Eggs fertilized (Eggs)	After 24hr/Put in tank (Eggs)	After 3 months (Juveniles)	Survival rate (%)
2,313,300	1,202,900	50,000	4.16

In *H. asinina*, complete larvae rearing were achieved within the 2 days after fertilization. Larval settlements were begun on the 3<sup>rd</sup> day after fertilization at 28<sup>o</sup>C. This result was the same as has been reported by Stott *et al.* (2004). Both embryonic and larval development stages rates obtained from this study were in the same ranges as this same species by Jarayabhand *et al.* (1995).

The larval rearing period of *H. asinina* was 2-3 days, they generally grow faster than *H. varia* (4-6 days), which reduces the possible risks associated with long periods of larval rearing. All of the other procedures were similar to the hatchery techniques of most of the other commercially important species of abalone (Proudfoot *et al.*, 2008).

Previous studies (Najmudeen and Vitor, 2004) suggested that the early juvenile stage of abalone fed on various species of benthic micro-algae. In this experiment, juveniles of *H. asinina* were fed excessively with monoculture of diatoms such as *Nitzschia sp.* The stocks of diatoms were monoculture in the laboratory and then mass cultured out door to sunlight and regularly filled in nursing tanks. This was necessary to help maintaining good diatom films (Jardillier *et al.*, 2008).

It was generally known that growth and survival rates of post-larvae were affected by many factors, taking a very good care of juvenile abalone at this stage was very important.

Survival rates during the post-settlement period were generally very low. In this experiment the survival of abalone juveniles was about 4.16 % after 3 months of

rearing. In our experiment, 3 month-old juveniles of *H. asinina* can be fed on various diatom species such as *Nitzschia sp.* After 3 months the juvenile abalones were rinsed and taken off the transparent film plates. The animals were then put on the bottom of the tank, where artificial diets given (Olin, 1994).

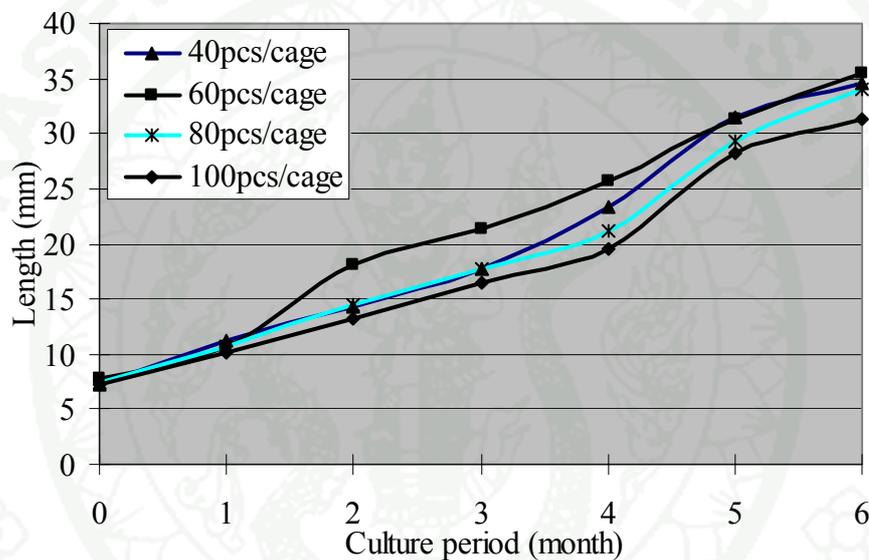
This experiment, growth rate of 3 months old *H. asinina* was faster than most of the tropical species such as *H. varia* (Hobday *et al.*, 2001; Webb *et al.*, 2004). Growth curve obtained in this experiment was shown in Figure 17.

Ideally, growth should be constructed from data over the entire commercial production cycle of the abalone. Anyhow, this information could be applied by hatchery managers, who wish to make “age to length” projections for various stages of abalone growth to facilitate management decisions.

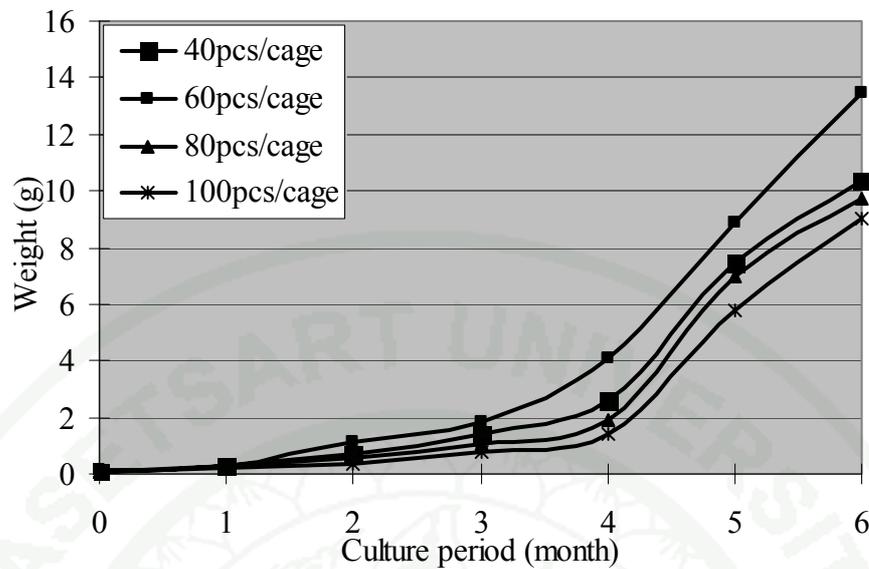
## Experiment II

### 1. Growth and survival rate with different stocking density of abalone

During the first 3 months growth rate in term of shell length and wet body weight (Figure 18, 19) among three stocking densities were not significantly different. At the end of 6 months, the results showed that at low density (40-60 pcs/cage) abalones grew significantly faster than the higher stocking density (80-100 pcs/cage).



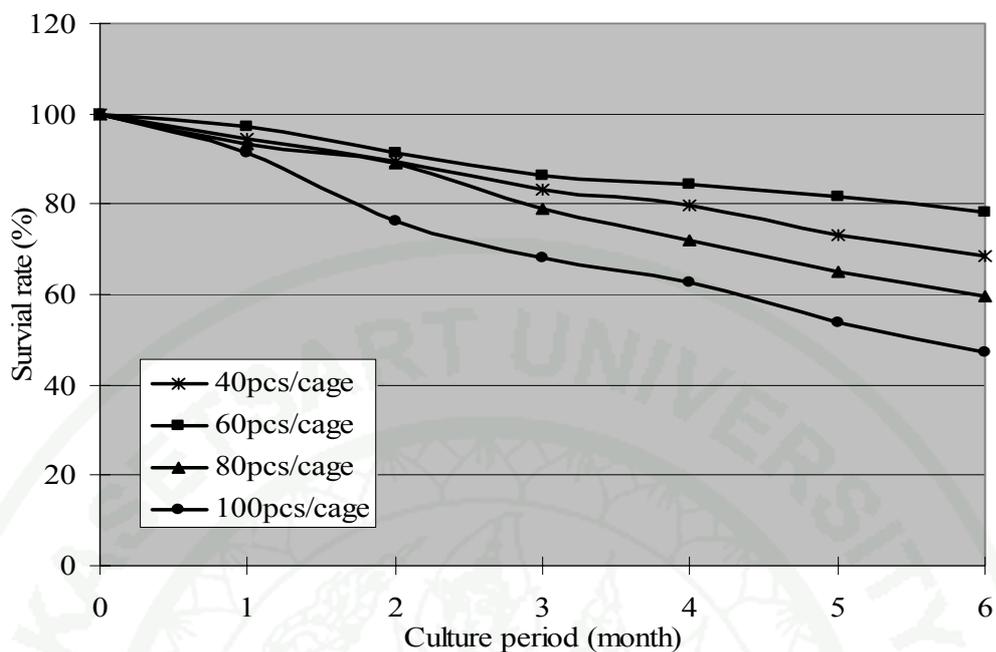
**Figure 18** Growth in term of shell length (mm) under four different stocking densities of abalone.



**Figure 19** Growth in term of weight (g) under four different stocking densities of abalone.

There were significant differences ( $P=0.001$  and  $P=0.01$ ) in abalone length and weight, and also in survival when taken over different time periods. After 6 months culture, there were significant differences ( $P=0.001$  and  $P=0.02$ ) in shell length and in weight of abalone growth with stocking density at 40 pcs/cage, between the two stocking densities at 80 and 100 pcs/cage ( $P=0.001$  and  $P=0.02$ ).

In addition, the stocking at 60 pcs/cage were found to have higher growth than those with stocking density at 80 and 100 pcs/cage ( $P=0.01$  and  $P=0.001$ ). Alternatively, there were no significant differences ( $P=0.358$ ) in growth rates of length among stocking density at 40 with 60 pcs/cage, and also no significant differences ( $P=0.289$ ) in growth rates of length between experiment stocking density at 80 with 100 pcs/cage.



**Figure 20** Survival rates with different stocking density of *H. asinina* reared in plastic cages.

Figure 20 was shown the survival rates of *H. asinina* fed by *Ulva sp.* at different stocking densities. Growth rates decreased as stocking density increased and survival rates varied greatly throughout the experiment. The curves, shown in Figure 20, might serve as a guide for determining the amount of *Ulva sp.* for effective management of survival.

Generally, slower and higher survival growing juveniles had month's mortality rates that were relatively higher than larger individuals. The highest survival rate of experiments were found to be at stocking density 60 pcs/cage and followed by those of 40, 80 and 100 pcs/cage. Abalones stocked at stocking densities 40-60 pcs/cage were also observed to have higher survival rates than those stocked at high densities with 80-100 pcs/cage.

In plastic cages, the growth of individual abalone decreased as stocking density increased. Similar results were reported in other studies on abalone in net

cages and other culture systems (Capinpin and Corre, 1996) and other shellfish (Jackson *et al.*, 2005).

The inverse relationship between growth and stocking density suggests that there is density dependent competition for space. Stocking density in the plastic cage would make it difficult for abalone at the bottom of the stack to move and activities, thus affecting their growth and survival rate even though there were optimum stocking densities (Shepherd *et al.*, 1992).

Abalones were tending to stack especially at high densities due to lack of primary attachment space. However, stacking restricts movement during culture, especially in confined areas such as plastic cages. Hence, stocking density limitation was probably one of the main factors affecting abalone growth at high densities.

The mean shell lengths, wet body weights (Figure 18, 19) monthly growth and survival rates (Figure 20) of abalone reared in plastic cages with different stocking density were significantly different as the 6<sup>th</sup> month of grow-out experimental period was reached.

A previous experiment also indicated that abalone stocked at low densities appeared to have higher growth and survival rates than those stocked at higher densities. There were significant differences in abalone length and weight, and also in survival when taken over different time periods. After 6 months culture, there were significant differences in shell length and in weight of abalone growth with stocking density at 40 pcs/cage and also at 60 pcs/cage in comparison to the two stocking densities at 80 and 100 pcs/cage.

The present study showed sustained growth of *H. asinina* throughout the experiment, implying the eminent suitability of stocking densities of 40-60 pcs/cage as an adequate growth for tropical abalone culture. The high stocking density of 80-100 pcs/cage in the grow-out appears to be unsuitable for this tropical abalone culture.

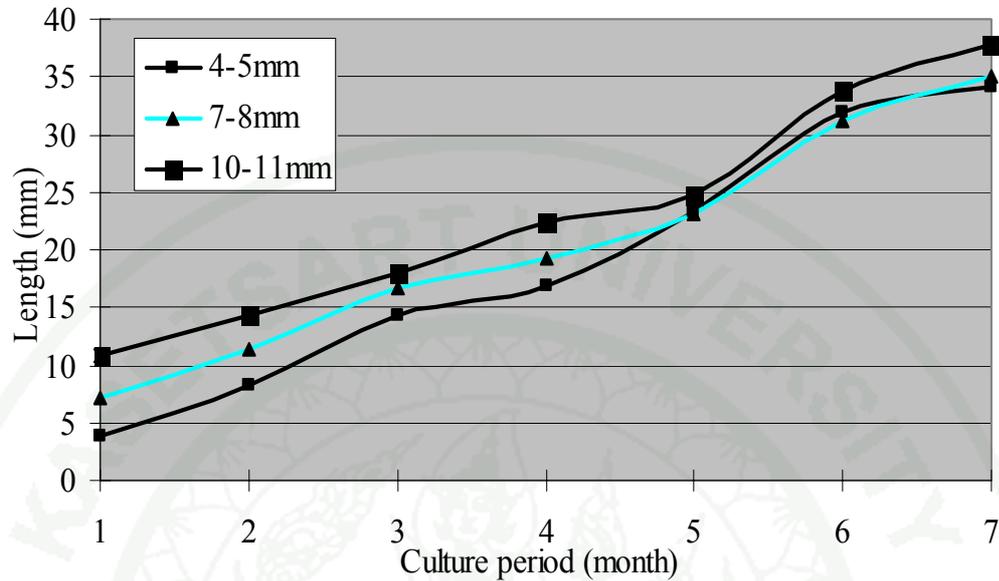
At high stocking density, abalone might have more difficulty to interfere with each other when they move out from cover to reach food. This may have affected their feeding and living conditions, growth and survival rate (Huchette *et al.*, 2003).

Another important factor that may affect abalone growth is the high density stocking. Since stocking density was done at time periods, those at higher densities received higher loads of fed *Ulva sp.* which could lead to dissolved oxygen competition and restricted water movement within the plastic cage. Growth of abalone is inhibited by increased levels of metabolic wastes, disease and reduced dissolved oxygen (Gorki and Nugegoda, 2006; Takami *et al.*, 1997). From there, high water exchange rate is important to maintain water quality as stocking densities increase (Steinarsson and Albert, 2003).

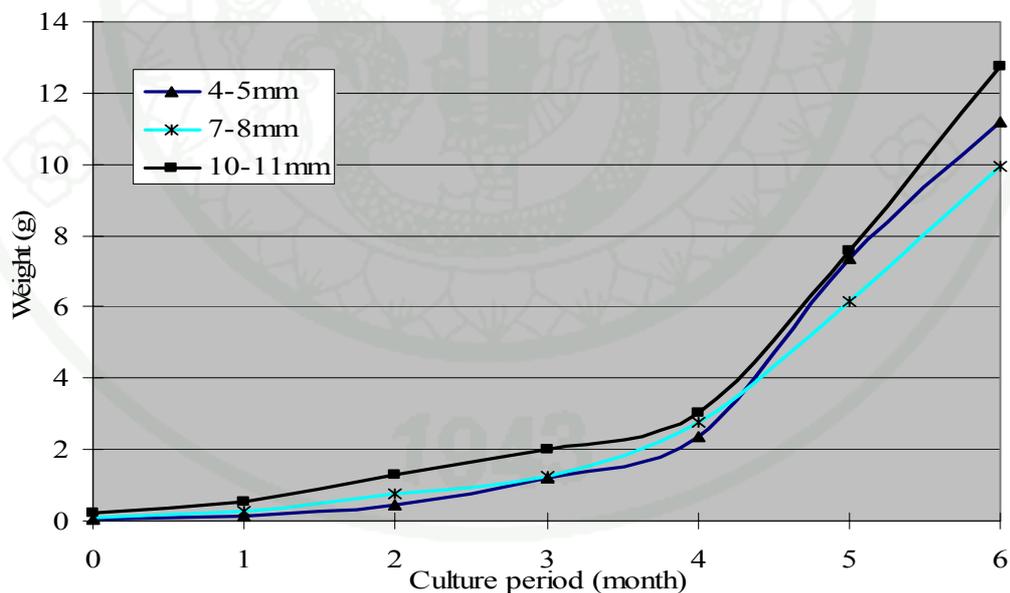
The highest survival rate of experiments were found to be at stocking density 60 pcs/cage (78.2 %) and followed by those of 40, 80 and 100 pcs/cage (68.7, 59.5 and 47.2 %). Abalones stocked at stocking densities at 40 and 60 pcs/cage (78.2 % and 68.7 %) were also observed to have higher survival rates than those stocked at high densities with 80-100 pcs/cage (59.5 % and 47.2 %).

The results shown that plastic cages set in the tank are appropriate for culture of tropical abalone. The high growth rate of *H. asinina* achieved in the experiment study shows its strong potential for culture. An economic analysis was important for the choice of optimum stocking density to maximize the production schedule and market potential.

## 2. Growth and survival rate with different initial size of abalone



**Figure 21** The changes of length abalone during culture.

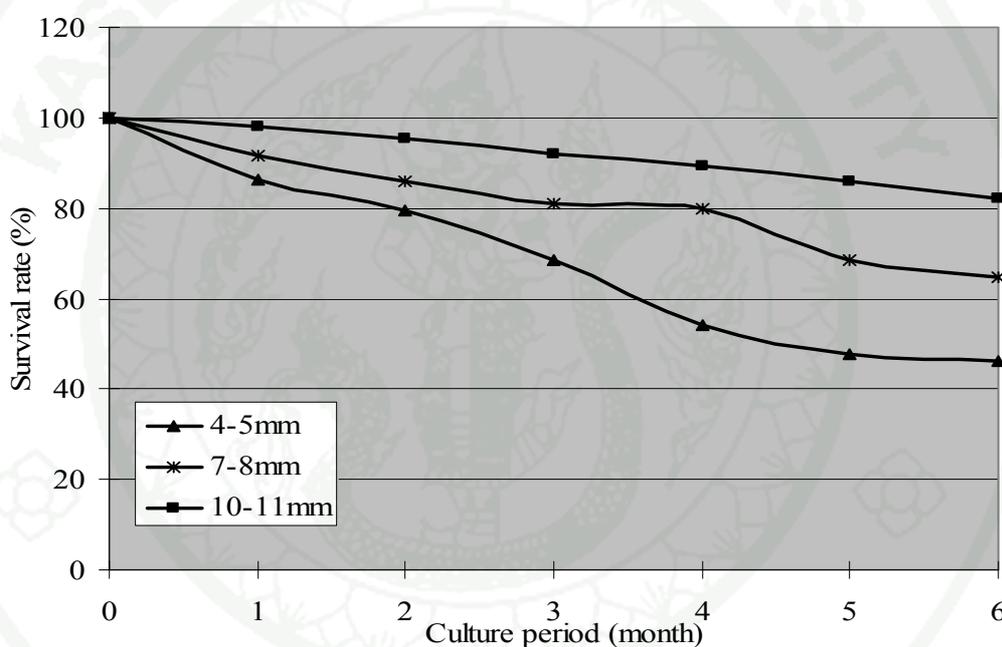


**Figure 22** The changes of weight abalone during culture.

Average monthly growth increments were calculated from measurements in 6 months. The average daily growth rate for 180 days ( $D_n=180$ ) of shell length and weight of group 4-5 mm with density 60 pcs/cage as  $L=167 \mu\text{m}\cdot\text{day}^{-1}$  and  $W=62 \text{mg}\cdot\text{day}^{-1}$  was highly variable growth rate within groups 7-8 mm as  $L=154 \mu\text{m}\cdot\text{day}^{-1}$ ,

W=55 mg.day<sup>-1</sup> and 10-11 mm as L=150 μm.day<sup>-1</sup>, W=70 mg.day<sup>-1</sup> of the experiments initial size.

The growth rate of group 4-5 mm with density 60 pcs/cage within experiments showed greater variation in length than both groups 7-8 and 10-11 mm over 6 months culture (Figure 21) but the weight and survival rate was lower (Figure 22, 23). The survival rate of groups 10-11, 7-8 and 4-5 mm were descending order as 82, 64.8 and 46.2%.



**Figure 23** Survival rate with different initial size of abalone *H. asinina* reared in plastic cages.

Interactions between the effect of initial size smaller and larger were found to significantly affect the growth rate and survival rate of the juvenile abalone.

**Table 5** Biomass with different initial size of abalone.

Culture period (month)	Stocking density (pcs/cage)	Trial	Biomass (kg/m <sup>2</sup> )
6	60	4-5 mm	2.58
6	60	7-8 mm	3.22
6	60	10-11mm	5.22

The overall average density 60pcs/cage at group initial size 10-11 mm with survival rate (82%), Biomass 5.22 kg/m<sup>2</sup> was highest among the groups 7-8 and 4-5 mm (Table 5). A higher group initial size 10-11 mm in density 60 pcs/cage significantly improved the growth of abalone. With limited initial size smaller in groups 4-5 and 7-8 mm, abalone stuck to confront living environment and restricted the movement and not enough diatom for feeding of the animal bottom. Thereby, affecting their growth, initial size for culture was one way to overcome the negative effects of stacking behaviour on the survival rate and growth of abalone in culture.

The growth and survival rate of abalone depends on initial size, season (temperature) and density (Pirker and Schiel, 1993; Capinpin *et al.*, 1998). Initial size was a major factor affecting growth and survival rates of gastropods.

Variations in growth and survival rates as a result of initial size of abalone weren't unusual as abalones known to sensitive to a number of environmental and physiological influences and food selective (Webber and Gisser, 1969; Lloyd and Bates, 2008).

However, growth and survival rates were remaining relatively constant among larger initial size abalone.

During the period grow-out of abalone offer important information to our own were interested in the growth rates that can achieved at different seasons and initial size of development abalone (Kawamura *et al.*, 1995; Degnan *et al.*, 2006). The

present experiment had high growth and survival rates (Figure 21, 23) even at large initial size and after 6 months culture.

The data shown that *H. asinina* fed *Ulva sp.* and cultured in plastic cages were reach size of 34-37 mm shell length in 6 months from initial size groups of 4-5, 7-8 and 10-11 mm.

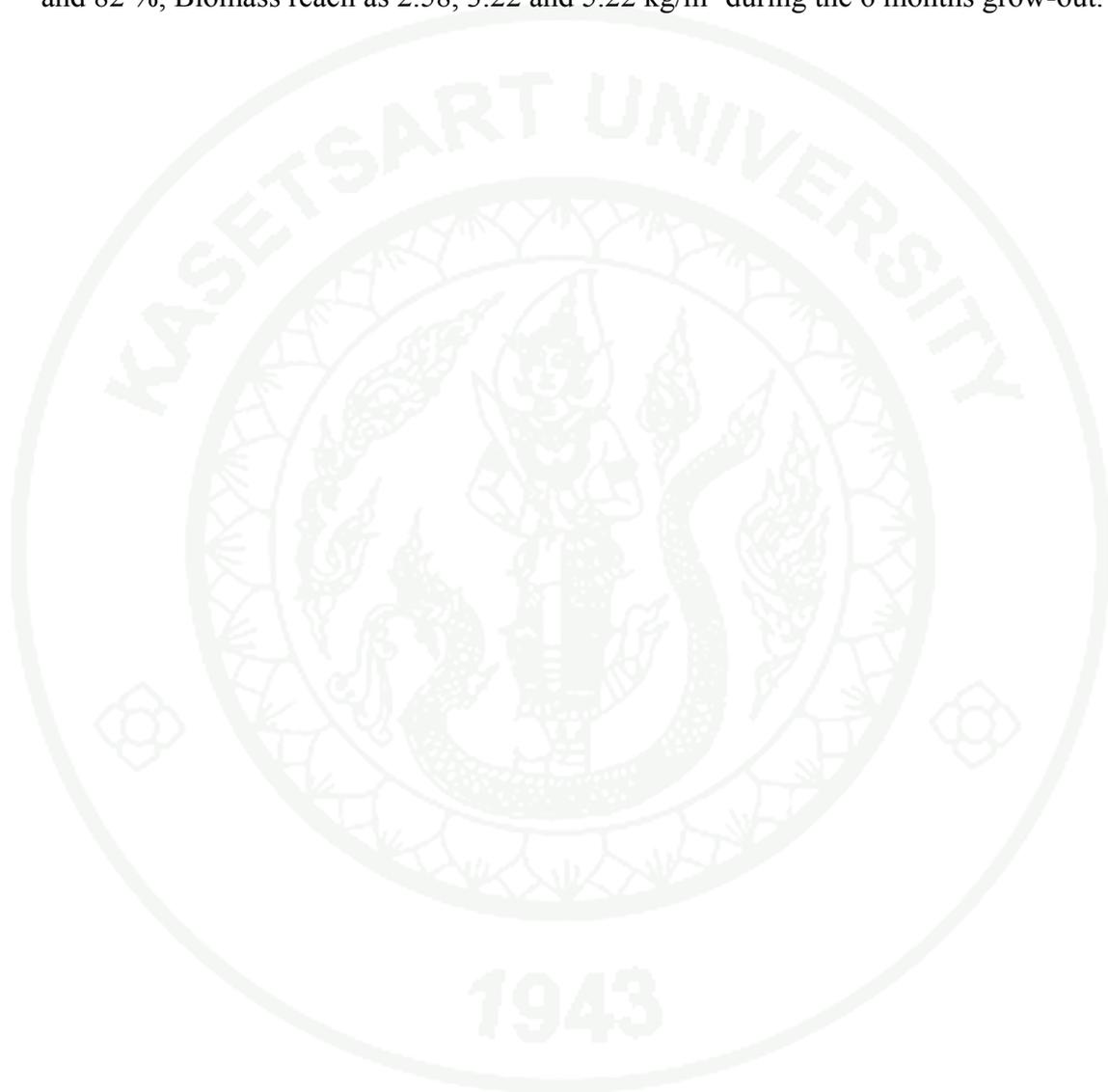
Generally, growth rates of abalones were higher in smaller and faster-growing juveniles than larger abalone. Average monthly growth increments were calculated from measurements in 6 months.

The growth rate of group 4-5 mm with density 60 pcs/cage varied largely than in groups 7-8 and 10-11 mm over 6 months culture, but survival rate was lower. The survival rate of groups 10-11, 7-8 and 4-5 mm were descending order as 82, 64.8 and 46.2%. Partitioning of the evidence interaction of period and initial size showed that initial size of the individual abalone affected their growth. The group 4-5 mm survival rate (46.2%) was lower, because during the first month culture of the experiment, not enough diatoms were available for this smaller initial size.

The study has demonstrated that abalones that survival rate slowly initially such as initial size with 4-5mm. It was therefore possible that the growth potential of the abalones in the present study may have been survival rate higher with initial size 10-11 mm by their optimal growth record. Nevertheless, since the abalones all had similar growth histories, it can be argued that the results correctly demonstrate how initial size optimum and growth potential were related to the shell length of the abalone.

The overall average initial size of abalone as 4-5, 7-8 and 10-11 mm, Biomass reach as 2.58, 3.22 and 5.22 kg/m<sup>2</sup> were different among the initial size. During the period experiment, Biomass were at harvest of group with largest initial size 10-11 mm highest (5.22 kg/m<sup>2</sup>) between group with smallest initial size 4-5 mm (2.58 kg/m<sup>2</sup>) and 7-8 mm (3.22 kg/m<sup>2</sup>) respectively.

In the present experiment, *H. asinina* with initial size of abalone as 4-5, 7-8 and 10-11 mm were attained a final weight of 11.18, 9.94 and 12.74 g. Results of plastic cage experiment showed that *H. asinina* with an initial size range of 4-5, 7-8 and 10-11 mm, stocked at 60 pcs/cage attained a harvest survival rates of 46.2, 64.8 and 82 %, Biomass reach as 2.58, 3.22 and 5.22 kg/m<sup>2</sup> during the 6 months grow-out.



## CONCLUSION AND RECOMMENDATIONS

### Conclusion

Desiccation and thermal shock methods were efficient in inducing spawning in ripen male and female *H. asinina*. It was simpler and more cost-effective to use than any other methods and can be applied to both individual and mass spawning experiments. This method was routinely used in the Research Centre to produce gametes of *H. asinina* for other larval experiments.

The trochophore and early veliger larval stages of *H. asinina* were reared within 2 to 3 days after fertilization. However, further experimentation should give due attention to environmental requirement to obtain optimize larval survival and improve larval quality.

The growth and survival of postlarvae were affected by the ingestibility and digestibility of the diatom which, in turn, depended on the species dominated in the biofilm. Survival rates during the post settlement period were generally low and variable, experiments recorded about 4.16 % survival rates and mean shell length  $11.44 \pm 2.6$  mm through 90 days of rearing on the diatom *Nitzschia sp.*

The tropical Donkey's-ear abalone *H. asinina* can be stocked from 40-60 pcs/cage for better survival rate, grow-out rearing in suspended plastic cages with a size of 30 x 40 x 30 cm.

Initial size was a major factor affecting growth rates of *H. asinina*. The average daily growth rate over 180 days of rearing period with density 60 pcs/cage obtained shell length and weight of group 4-5 mm as  $L=167 \mu\text{m}\cdot\text{day}^{-1}$  and  $W=62 \text{mg}\cdot\text{day}^{-1}$ , in group 7-8 mm as  $L=154 \mu\text{m}\cdot\text{day}^{-1}$ ,  $W=55 \text{mg}\cdot\text{day}^{-1}$  and in group 10-11 mm as  $L=150 \mu\text{m}\cdot\text{day}^{-1}$ ,  $W=70 \text{mg}\cdot\text{day}^{-1}$ , respectively.

There were differences in the survival rate between initial size groups reared at the density 60 pcs/cage. The survival rate of groups 10-11 mm was the highest followed by groups 7-8 mm and 4-5 mm with descending order as 82 %, 64.83 % and 46.16 % respectively.

Currently, the abalone culture is highly feasible. Experimental Station has produced successful commercial abalone but not in mass production, replication.

At present, abalone culture was adopted in cement tanks, pen, cage and pond in favourable environment sites. Abalone farming must pass two stages, i.e. hatchery induces larvae breeding and spats raising to commercial size. Breeding stage larvae takes 3 months. When abalone reaches sizes 4-5 mm they started commercial farming. This phase takes six months grow-out, when the size abalone reach 40-50 mm and the weight can reach at 30 abalone/kg.

## Recommendations

In Vietnam, most of abalones were exploited from the wild by fishermen resulting in the decline of abalone production. Therefore, the study and application of technical advances in seed production and breeding abalone is very necessary. It is for abalone artificial breeding and step assay, not the farmer attention. If produced, the economic effects from this farmer are very high.

More variables in food, including the size and species of diatoms, will likely to improve the success of juvenile rearing. 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.

Surface area is remaining a potential if we thrive vocational aquaculture in general, abalone farming in particular. According to research results, the sea in central Vietnam has high biological diversity, closed wind and water with stable salinity as 30-34 ‰, and especially there are many species of algae and seaweeds. These conditions are favorable for the development of abalone farming. Besides the coastal area, over 5 thousand hectares of tidal land in the province are great potential sites for tiger prawns culture as well as abalone farming.

Currently, abalone for restaurants, hotels and exporting were mainly collected from wild catch. The products will be exhausted if they are not renewable. Abalone production methods of creating the experimental are a matter of very necessary and meaningful to the problem of biodiversity marine environment of Vietnam and improve economic efficiency in aquaculture in Vietnam particularly in the Central. Abalone farming is a prospect.

Uncontrolled exploitation, no planning and methods to exploit the explosive, anesthetic original cyanide are the cause of environmental pollution and declining resources for abalone in particular and other biological resources in general in the region.

Need to strengthen the propaganda, farmer often recommends for fishermen community awareness right about the importance of the protection and sustainable use of marine resources. Research technique breeding abalone production in hatchery, the model applies in technique abalone farming community.

Need to promote research and technology transfer for reproduction abalone to farmer, providing the seed and rehabilitation resources and restore the rare species at risk of extinction in economic development areas.

Implementation of research applications to techniques seed and grow-out produced abalone for protecting, developing abalone and species of high economic value are exploited excessively such as abalone (*H. asinina*) and other mollusks.

The region quickly established grow-out farming in several different models, is one of the most effective solutions and active part in economic development and management of animal resources in the particular piece of bark and sources benefit marine life in general.

Improved grow-out techniques males and females with high gonad index to enhance fertility, increased survival rate of larvae. Need to improve seed production technology of abalone in the hatchery to provide seed for farmer.

## LITERATURE CITED

- Bryan, P.J. and P.Y. Qian. 1998. Induction of larval attachment and metamorphosis in the abalone *Haliotis diversicolor* (Reeve). **Journal of Experimental Marine Biology and Ecology**. 223: 39-51.
- Capinpin, J.C.E. and K.G. Corre. 1996. Growth rate of the Philippine abalone, *Haliotis asinina* fed an artificial diet and macroalgae. **Aquaculture**. 144: 81-89.
- , V.C. Encena and C.B. Nestor. 1998. Studies on the reproductive biology of the Donkey's ear abalone, *Haliotis asinina* Linne'. **Aquaculture**. 166: 141-150.
- , J.D. Toledo, V.C. Encena and M. Doi. 1999. Density dependent growth of the tropical abalone *Haliotis asinina* in cage culture. **Aquaculture**. 171: 227-235.
- Cox, K. W. 1962. California abalones, family *Haliotidae*. **California Fish and Game**. 118: 1-133.
- Daume, S., S.B. Gardner and W.J. Woelkerling. 1999. Settlement of abalone larvae (*Haliotis laevigata* Donovan) in response to non-geniculate coralline red algae (Corallinales, Rhodophyta). **Journal of Experimental Marine Biology and Ecology**. 234: 125-143.
- Daume, S., A. Krsinich, S. Farrell and M. Gervis. 2000. Settlement, early growth and survival of *Haliotis rubra* in response to different algal species. **Journal of Applied Phycology**. 12: 479-488.

- Degman, B.M., M.J.P. Selvamani and S.M. Degnan. 2001. Microsatellite Genotyping of Individual Abalone Larvae: Parentage Assignment in Aquaculture. **Mar. Biot.** 3: 478-485.
- Degnan, S.M., T. Lucas and M. Macbeth, W. Knibb, B.M. Degnan. 2006. Heritability estimates for growth in the tropical abalone *Haliotis asinina* using microsatellites to assign parentage. **Aquaculture**. 259: 146-152.
- Dunstan, G.A., N.G. Elliott, S.A. Appleyard, B.H. Holmes, N. Coned, M.A. Grubert and M. A. Cozens. 2007. Culture of triploid Greenlip abalone (*Haliotis laevigata* Donovan) to market size: Commercial implications. **Aquaculture**. 271: 130-141.
- Evans, D. 2000. Abalone Aquaculture in South Australia. **Primary Industries and Resources South Australia**. pp6.
- Fallu, R. 1991. Abalone Farming. **Fishing New Book**. Blackwell Science Ltd. Oxford. pp196.
- FAO/UNDP. 1990. Training Manual on Artificial Breeding of Abalone (*Haliotis discus hannai*) in Korea DPR. **Training Manual 7**, FAO/UNDP Regional Seafarming Project. pp105.
- FAO/UNDP. 1999. Year Book of Fishery Statistics for 1997. **Food and Agriculture Organization of the United Nation**. Italia. pp198.
- Fermin, C.A. and S.M. Buen. 2002. Grow-out culture of tropical abalone, *Haliotis asinina* (Linnaeus) in suspended mesh cages with different shelter surface areas. **Aquaculture International**. 9: 499-508.

- Gallardo, W. G. and S. M. Buen. 2003. Evaluation of mucus, Navicular, and mixed diatoms as larval settlement inducers for the tropical abalone *Haliotis asinina*. **Aquaculture**. 221: 357-364.
- Gapasin, R.S.J. and B.B. Polohan. 2004. Induction of larval settlement and metamorphosis in the donkey-ear abalone, *Haliotis asinina* Linnaeus, by chemical cues. **Hydrobiologia**. 519: 9-17.
- Genade, A.B., A.L. Hirst and C.J. Smith. 1988. Observations on the spawning, development and rearing of the South African abalone *Haliotis midae* Linnaeus. **S. Afr. J. Mar. Sci.** 6: 3-12.
- Gibson, T.S., G.L. Allan, G. File, J.D. Mullen and H. Scottorr. 2007. Priorities and Principles for Investment in Aquaculture Research by NSW Department of Primary Industries. **Economic Research Report**. 36: 1-122.
- Gordon, H. R. and P. Cook. 2001. World abalone supply, markets and pricing: historical, current and future. **Journal of Shellfish Research**. 20: 567-570.
- Gorski, J. and D. Nugegoda. 2006. Toxicity of Trace Metals to Juvenile Abalone, *Haliotis rubra* Following Short-Term Exposure. **Environ Contam.** 77: 732-740.
- Gosling, E. 2003. Bivalve Molluscs. **Fishing New Book**. Oxford. pp443.
- Gruenthal, K. M., L.K. Acheson and R.S. Burton. 2007. Genetic structure of natural populations of California red abalone (*Haliotis rufescens*) using multiple genetic markers. **Mar. Biol.** 152: 1237-1248.
- Harrison, A.J. and J.F. Grant. 1971. Progress in abalone research. **Tasman. Fish. Res.** 5: 1-17.

- Hobday, A.J., J. T. Mia and L.H. Peter. 2001. Over-exploitation of a broadcast spawning marine invertebrate: Decline of the white abalone. **Reviews in Fish Biology and Fisheries**. 10: 493-514.
- Huchette, S.M.H., C.S.Koh and W.D. Rob. 2003. Growth of juvenile blacklip abalone (*Haliotis rubra*) in aquaculture tanks: Effects of density and ammonia. **Aquaculture**. 219: 457-470.
- Huner, J. V. and E.E. Brown. 1985. Crustacean and Mollusk Aquaculture in the United States. **AVI Publishing Company**. America. pp476.
- Jackson, D. J., N. Ellemor and B.M. Degman. 2005. Correlating gene expression with larval competence, and the effect of age and parentage on metamorphosis in the tropical abalone *Haliotis asinina*. **Mar. Biol.** 147: 681-697.
- Jarayabhand, P. and G.F. Newkirk. 1989. Effect of Intraspecific Competition on Growth of the European Oyster, *Ostrea edulis* Linnaeus, 1750, **J. of Shellfish**. 8: 359-365.
- Jarayabhand, P., H. Kojima and P. Menasveta. 1995. Embryonic larval development and early growth of hatchery produced abalone (*Haliotis ovina* Gmelin, 1971) seed. **Thai Journal of Aquatic Science**. 1: 194-202.
- Jarayabhand, P. and N. Paphavasit. 1996. A review of the culture of tropical abalone with special reference to Thailand. **Aquaculture**. 140: 159-168.
- Jardillier, E., M. Rousseau and A. Gendron-Badou. 2008. A morphological and structural study of the larval shell from the abalone *Haliotis tuberculata*. **Mar. Biol.** 154: 735-744.

- Kawamura, T., T. Saido, H. Takami and Y. Yamashita. 1995. Dietary value of benthic diatoms for the growth of post-larval abalone *Haliotis discus hannai*. **Journal of Experimental Marine Biology and Ecology**. 194: 189-199.
- Lloyd, M.J. and A.E. Bates. 2008. Influence of density-dependent food consumption, foraging and stacking behaviour on the growth rate of the Northern abalone, *Haliotis kamtschatkana*. **Aquaculture**. 227: 24-29.
- McShane, P. E. 1991. Density-dependent mortality of recruits of the abalone *Haliotis rubra* (Mollusea: *Gastropoda*). **Mar. Biol.** 110: 385-389.
- MoFI. 2008. The fisheries of abalone landing in Vietnam. **Agriculture Publisher**. pp231.
- Mottet, M. G. 1978. A review of the fishery biology of abalones. Washington Report. **Fish. Tech.** Report 37.
- Najmudeen, T.M & A.C.C. Vitor. 2004. Seed production and juvenile rearing of the tropical abalone *H. varia* Linnaeus 1758. **Aquaculture**. 234: 277-292.
- Norris, B.J. & N. P. Preston. 2003. Triploid induction in the tropical abalone, *Haliotis asinina* (Linnaeus), with 6-dimethylaminopurine. **Aquaculture Research**. 34: 261-263.
- Oleh. 2005. Abalone (*Haliotis asinina* L): 5. early juvenile rearing and on growing culture. **Oceana**. 2: 1-10.
- Olin, P. 1994. Abalone culture in Hawaii *Haliotis fulgens* and *Haliotis diversicolor supertexta*. **Center for Tropical and Subtropical Aquaculture**. 3: 1-6.
- Pirker, J. G. and D.R. Schiel. 1993. Tetracycline as a fluorescent shell-marker in the abalone *Haliotis iris*. **Mar. Biol.** 116: 81-86.

- Proudfoot, L.A., S. Kochler and C.D. Mcquaid. 2008. Using growth band auto fluorescence to investigate large-scale variation in growth of the abalone *Haliotis midae*. **Mar. Biol.** 153: 789-796.
- RIA 3. 2009. Seed of abalone production in Vietnam. **Agriculture Publisher**. pp156.
- SEAFDEC. 2000. Abalone Seed Production and Culture. **Tigbauan, Iloilo. Philippines**. pp25.
- Shepherd, S. A. 1986. Studies on Southern Australian abalone (Genus *Haliotis*) VII. Aggregative behaviour of *H. laevigata* in relation to spawning. **Mar. Biol.** 90: 231-236.
- Shepherd, S. A., M.J. Tegner and S.A. Guzman del pro'o. 1992. Abalone of the World. **Fishing New Book**. Oxford. pp609.
- Singhagraiwan, T. and M. Doi. 1993. Seed Production and Culture Abalone, *Haliotis asinina* Linne. **The Research Project of Fisheries Resource Development in the Kingdom of Thailand**. pp32.
- Spencer, B. E. 2002. Molluscan Shellfish Farming. **Fishing New Book**. Oxford. pp271.
- Steinarsson, A. and K.I. Albert. 2003. Size dependent variation in optimum growth temperature of red abalone (*Haliotis rufescens*). **Aquaculture**. 224: 353-362.
- Stott, A.E., T. Takeuchi, Y. Koike. 2004. An alternative culture system for the hatchery production of abalone without using livefood. **Aquaculture**. 236: 341-360.

- Takami, H., T. Kawamura and Y. Yamashita. 1997. Survival and growth rates of post-larval abalone *Haliotis discus hannai* fed conspecific trail mucus and/or benthic diatom *Cocconeis scutellum varparva*. **Aquaculture**. 152: 129-138.
- Tsvetnenko, E. and M.H. Taylor. 2004. A growth assessment of juvenile abalone *Haliotis laevigata* fed enriched macroalgae *Ulva rigida*. **Aquaculture International**. 12: 467-480.
- Webb, E.L., R.J. Maliao and K.R. Jensen. 2004. A survey of stock of the Donkey's ear abalone, *Haliotis asinina* L. in the Sagay Marine Reserve, Philippines: evaluating the effectiveness of marine protected area enforcement. **Fisheries Research**. 66: 343-353.
- Webber, H. H. and A.C. Gisser. 1969. Reproductive cycle and gametogenesis in the black abalone *Haliotis cracheroidii* (Gastropoda: *Prosobranchiata*). **Mar. Biol.** 4: 152-159.
- Westaway, C. and J. Norriss. 1997. Abalone Aquaculture in Western Australia. **Fisheries Western Australia**. pp24.



**Appendix**

**Appendix Table 1** Data of water quality.

Sample	Laboratory water quality data (weekly)												Remark
	1 <sup>st</sup>	2 <sup>nd</sup>	3 <sup>rd</sup>	4 <sup>th</sup>	5 <sup>th</sup>	6 <sup>th</sup>	7 <sup>th</sup>	8 <sup>th</sup>	9 <sup>th</sup>	10 <sup>th</sup>	11 <sup>th</sup>	12 <sup>th</sup>	
pH	8.0	8.2	8.2	8.1	8.1	8.2	8.2	8.3	8.2	8.4	8.0	8.3	
Temp (°C)	25.2	27.3	28	28.2	28.5	29.2	28	25	26	24	24	23	
Salinity (ppt)	32	32	31	30	30	31	30	30	32	31	30	32	
DO (mg/l)	5.2	5.5	5	5.5	5.5	5	5.3	5.3	5.6	5.9	6	5.2	
NH <sub>3</sub> -N (mg/l)	0.01	0.01	0.01	0.02	0.01	0.02	0.02	0.02	0.03	0.02	0.01	0.02	
NO <sub>2</sub> -N (mg/l)	0	0	0	0	0	0	0	0	0.001	0	0	0	
PO <sub>4</sub> <sup>3-</sup> (mg/l)	0	0	0	0.02	0.01	0.01	0	0	0	0.01	0.02	0	
H <sub>2</sub> S (mg/l)	0	0	0	0	0	0	0	0.001	0	0	0	0.002	
Alkalinity (mg/l)	115	115	115	115	115	125	125	125	125	130	130	130	

**Appendix Table 1 (Continued)**

Sample	Laboratory water quality data (weekly)												Remark
	13 <sup>th</sup>	14 <sup>th</sup>	15 <sup>th</sup>	16 <sup>th</sup>	17 <sup>th</sup>	18 <sup>th</sup>	19 <sup>th</sup>	20 <sup>th</sup>	21 <sup>st</sup>	22 <sup>nd</sup>	23 <sup>rd</sup>	24 <sup>th</sup>	
pH	8.4	8.1	8.3	8.4	8.2	8.0	8.4	8.3	8.4	8.0	7.8	7.8	
Temp (°C)	25	28	29	28	30	31	26	24	26	28	27	29	
Salinity (ppt)	30	32	32	30	31	32	32	32	32	31	32	31	
DO (mg/l)	5.4	5.5	6	5.4	5.5	4.9	4.5	5	5.5	5.5	5	5.5	
NH <sub>3</sub> -N (mg/l)	0.03	0.03	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.02	
NO <sub>2</sub> <sup>-</sup> N (mg/l)	0.001	0	0	0	0	0.001	0	0	0	0	0	0.001	
PO <sub>4</sub> <sup>3-</sup> (mg/l)	0	0	0	0.02	0.02	0.01	0	0	0	0.02	0.01	0	
H <sub>2</sub> S (mg/l)	0.003	0	0	0	0.002	0.004	0	0	0	0	0	0.001	
Alkalinity (mg/l)	130	125	125	125	125	125	125	125	125	125	115	115	

**Appendix Table 2** Length and weight of abalone growth at different initial size at 4-5 mm (60pcs/cage).

№	0 month			1 <sup>st</sup> month			2 <sup>nd</sup> month		
	Length(mm)	Width (mm)	Weight (g)	Length(mm)	Width (mm)	Weight (g)	Length(mm)	Width (mm)	Weight (g)
1	3.9	2.34	0.032	9.32	5.43	0.122	14.54	8.2	0.47
2	3.5	2.54	0.026	8.4	5.14	0.12	15.32	8.9	0.7
3	3.69	1.65	0.028	8.32	5.6	0.13	13.21	7.32	0.35
4	4.01	2.45	0.03	8.45	5.32	0.11	13.98	7.54	0.36
5	4.56	1.34	0.04	7.8	4.32	0.09	12.89	4.89	0.18
6	3.87	2.45	0.02	8.96	5.34	0.14	14.67	8.54	0.44
7	3.91	2.4	0.026	7.89	4.2	0.12	13.43	7.42	0.37
8	3.98	2.3	0.03	6.98	3.45	0.08	14.89	8.54	0.44
9	4.01	2.2	0.03	8.9	5.45	0.108	14.21	8.65	0.46
10	4.02	2.34	0.031	8.32	5.67	0.09	13.45	8.43	0.47
11	3.4	2.43	0.019	6.32	4.32	0.12	12.98	4.87	0.17
12	4.89	1.98	0.024	6.34	4.67	0.14	17.21	9.5	0.7
13	3.6	2.34	0.025	8.43	5.43	0.11	14.21	8.65	0.48
14	3.98	2.34	0.027	9.43	5.6	0.14	14.67	8.32	0.49
15	4	2.12	0.029	6.2	3.2	0.08	14.65	8.76	0.47
16	3.95	2	0.024	9.32	5.87	0.16	13.54	7.54	0.37
17	3.88	2.88	0.034	7.56	4.56	0.09	12.98	4.78	0.1

1943

Appendix Table 2 (Continued)

№	0 month			1 <sup>st</sup> month			2 <sup>nd</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
18	4.23	2.3	0.032	8.54	5.43	0.13	13.54	7.67	0.36
19	3.1	2.1	0.03	9.21	6.7	0.16	14.57	8.43	0.47
20	3.86	2.1	0.02	8.32	5.43	0.13	14.68	8.2	0.47
21	4.2	1.86	0.039	10	6.78	0.18	13	7.54	0.35
22	3.9	2.33	0.016	7.32	4.6	0.09	14	8.64	0.41
23	3.9	2	0.032	6	3.1	0.08	14.79	8.76	0.48
24	3.9	1.98	0.027	9.54	5.78	0.14	14.23	8.42	0.46
25	5	1.56	0.029	8.32	5.67	0.13	14.32	8.43	0.41
26	3.48	1.87	0.026	8.43	5.3	0.13	17.59	10.6	0.85
27	4.2	2.8	0.034	7.56	4.32	0.09	13	8.53	0.49
28	3.5	2.45	0.03	8.43	5.67	0.12	12.98	4.98	0.24
29	3.9	2.14	0.02	9.43	5.8	0.15	17.21	9.65	0.89
30		1.95	0.034	8.56	5.67	0.13	14.56	9.65	0.48
<b>Mean</b>	<b>3.94</b>	<b>2.18</b>	<b>0.028</b>	<b>8.22</b>	<b>5.13</b>	<b>0.12</b>	<b>14.31</b>	<b>8.01</b>	<b>0.446</b>
<b>SD</b>	<b>0.39</b>	<b>0.34</b>	<b>0.005</b>	<b>1.07</b>	<b>0.90</b>	<b>0.02</b>	<b>1.24</b>	<b>1.44</b>	<b>0.17</b>

Appendix Table 2 (Continued)

№	3 <sup>rd</sup> month			4 <sup>th</sup> month			5 <sup>th</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
1	19.42	12.21	3.87	25.06	13.45	3.02	31.87	17.34	7.85
2	16.21	10.01	1.09	24.94	13.21	3.01	32.01	16.29	6.43
3	17.89	9.78	0.9	23.12	12.07	2.48	32.89	17.34	7.49
4	16.76	10.32	1.04	23.43	11.87	2.11	36.4	18.21	8.94
5	16.89	10.43	0.98	22.45	12.34	2.14	29.04	16.34	7.43
6	15.65	8.54	0.8	25.56	13.65	3.34	29.04	16.32	6.32
7	16.31	10.45	1.34	22.67	12.43	2.94	30.48	17.42	7.54
8	16.79	9.34	0.94	25.78	13.45	3.32	36.97	20.34	9.89
9	18.43	11.49	1.21	23.65	12.65	2.45	30.47	16.37	6.43
10	16.21	8.1	0.34	23.21	11.78	1.98	29.48	16.11	6.77
11	18.65	9.34	1.21	23.54	11.21	2.49	27.48	15.92	5.06
12	17.32	11.34	0.98	24.98	11.23	1.48	35.31	19.56	5.09
13	18.65	10.43	0.97	26.97	13.65	3.72	28.49	16.98	6.46
14	16.32	10.56	1.02	24.87	12.45	2.56	34.59	18.45	7.65
15	15.43	9.98	0.98	21.78	9.99	1.02	29.58	16.93	6.75
16	16.78	10.32	1.45	23.97	10.34	2.09	31.45	17.43	7.33
17	16.87	9.56	0.98	19.69	9.89	1.09	36.05	20.34	8.65

Appendix Table 2 (Continued)

№	3 <sup>rd</sup> month			4 <sup>th</sup> month			5 <sup>th</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
18	17.87	10.34	0.9	23.01	12.34	2.31	33.59	18.32	8.65
19	19.12	11.43	2.8	27.86	15.23	4.12	32.57	17.32	7.86
20	16.87	10.45	0.6	22.12	11.24	1.89	34.58	18.43	8.64
21	10.21	8.32	0.95	19.98	10.78	1.22	32.58	17.56	7.6
22	17.43	10.34	1.34	23.68	12.35	2.34	32.59	16.85	6.79
23	17.21	9.34	0.95	28.48	13.24	3.45	31.43	16.89	6.43
24	16.43	10.41	0.67	22.07	12.34	2.31	29.48	15.89	5.04
25	18.56	13.1	0.78	21.68	11.24	2.87	33.59	17.45	7.43
26	16.32	8.34	0.87	22.21	12.34	2.58	31.48	17.03	8.7
27	18.42	10.12	0.8	23.69	10.23	1.89	34.59	18.45	9.53
28	11.77	9.21	0.54	22.49	12.45	2.49	37.03	19.43	9.65
29	16.87	9.34	0.98	23.56	11.98	2.43	28.43	16.67	5.02
30	18.32	9.21	1.43	21.49	10.23	1.32	28.4	16.09	5.67
31	18.78	10.34	3.19	16.78	10.45	1.09	28.31	17.01	8.76
<b>Mean</b>	<b>16.93</b>	<b>10.08</b>	<b>1.19</b>	<b>23.38</b>	<b>12.00</b>	<b>2.37</b>	<b>31.94</b>	<b>17.45</b>	<b>7.35</b>
<b>SD</b>	<b>1.91</b>	<b>1.11</b>	<b>0.75</b>	<b>2.35</b>	<b>1.27</b>	<b>0.79</b>	<b>2.81</b>	<b>1.22</b>	<b>1.38</b>

Appendix Table 2 (Continued)

№	6 <sup>th</sup> month			6 <sup>th</sup> month			6 <sup>th</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
1	34.98	18.32		32.44	17.54	11.23	38.39	21.48	14.12
2	30.56	17.98	10.89	33.45	18.64	11.49	<b>34.047</b>	<b>18.373</b>	<b>11.180</b>
3	34.19	18.43	12.01	34.56	18.65	12.23	<b>2.332</b>	<b>1.534</b>	<b>1.716</b>
4	33.98	17.39	11.2	29.14	15.95	9.32			
5	34.56	18.48	11.03	36.89	19.65	12.34			
6	35.32	19.84	11.98	34.86	18.54	11.23			
7	34.69	18.37	12.39	28.89	16.79	8.02			
8	33.21	17.89	10.09	33.46	18.49	11.32			
9	33.45	17.89	11.03	33.59	17.39	11.32			
10	36.54	19.87	13.09	32.35	17.97	10.32			
11	32.11	16.39	8.54	35.46	19.9	12.34			
12	32.11	16.43	8.68	36.46	20.12	12.89			
13	33.94	16.49	9.43	35.49	19.23	12.94			
14	29.45	15.89	7.21	36.94	20.49	12.4			
15	32.14	16.49	8.85	37.49	20.98	13.89			
16	33.45	17.54	11.21	36.48	20.39	12.45			

**Appendix Table 3** Length and weight of abalone growth at different initial size at 7-8 mm (60pcs/cage).

№	0 month			1 <sup>st</sup> month			2 <sup>nd</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
1	7.34	5.01	0.12	11.67	6.54	0.25	16.43	8.54	0.74
2	7.89	5.32	0.11	11.98	6.43	0.28	19.08	10.34	0.76
3	7.01	4.98	0.13	11.09	6.02	0.26	13.78	6.43	0.89
4	6.98	4.54	0.14	10.23	4.78	0.19	16.76	9.54	0.9
5	5.93	4.02	0.09	10.23	5.32	0.21	16.32	8.34	0.56
6	5.48	4.93	0.089	9.43	4.22	0.19	19.43	11.34	0.96
7	6.94	4.9	0.089	9.85	4.12	0.18	19.54	10.34	0.87
8	6.49	4.02	0.08	8.09	4.34	0.19	13.89	6.43	0.55
9	7.43	5.03	0.11	8.09	4.34	0.17	13.56	5.63	0.56
10	7.032	5.82	0.13	13.09	7.42	0.32	15.65	8.54	0.49
11	7.9	5.65	0.14	13.43	8.54	0.34	15.87	8.65	0.49
12	7.33	4.98	0.081	12.45	6.98	0.25	17.43	10.34	0.85
13	6.93	3.98	0.078	12.45	6.94	0.29	17.94	9.45	0.78
14	6.59	4.02	0.082	12.43	6.94	0.27	18.54	9.56	0.79
15	5.2	4.38	0.089	11.23	5.43	0.19	18.54	10.45	0.94
16	7.89	5.98	0.12	11.89	6.78	0.24	16.54	8.54	0.75
17	7.91	5.04	0.11	11.34	5.68	0.22	16.57	8.23	0.73

Appendix Table 3 (Continued)

№	0 month			1 <sup>st</sup> month			2 <sup>nd</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
18	9.38	6.09	0.14	13.89	8.54	0.32	19.54	10.45	0.98
19	6.49	4.93	0.087	14.32	8.54	0.32	19.45	9.56	0.86
20	7.93	4.39	0.083	14.93	9.11	0.4	15.76	8.55	0.78
21	7.49	4.02	0.088	13.89	8.54	0.3	16.43	9.45	0.86
22	8.01	5.02	0.13	12.34	6.43	0.27	14.67	7.54	0.68
23	6.9	4.56	0.089	10.23	5.42	0.21	14.78	7.54	0.65
24	9.03	5.96	0.12	10.56	5.86	0.2	15.67	8.46	0.73
25	7.21	5.02	0.1	10.11	5.31	0.2	16.94	9.67	0.87
26	8.94	5.78	0.13	9.212	5.01	0.2	16.43	8.64	0.76
27	6.95	4.93	0.089	9.54	4.69	0.19	15.46	7.54	0.67
28	5.77	4.77	0.079	8.45	4.32	0.19	15.78	8.54	0.76
29	7.99	5.4	0.11	12.56	8.53	0.32	17.32	9.45	0.89
30	6.95	5.04	0.11	11.45	5.89	0.19	14.89	7.54	0.56
<b>Mean</b>	<b>7.24</b>	<b>4.95</b>	<b>0.105</b>	<b>11.348</b>	<b>6.234</b>	<b>0.245</b>	<b>16.633</b>	<b>8.787</b>	<b>0.755</b>
<b>SD</b>	<b>0.973</b>	<b>0.618</b>	<b>0.021</b>	<b>1.84</b>	<b>1.522</b>	<b>0.059</b>	<b>1.760</b>	<b>1.331</b>	<b>0.139</b>

Appendix Table 3 (Continued)

№	3 <sup>rd</sup> month			4 <sup>th</sup> month			5 <sup>th</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
1	19.02	10.12	1.22	23.07	11.93	2.4	31.07	16.17	6.21
2	16.7	7.8	0.69	25.42	13.39	1.5	28.79	15.15	4.76
3	21.34	12.44	1.75	20.72	10.47	3.3	33.35	17.19	7.66
4	20.43	11.93	1.56	23.45	11.11	3.01	33.54	18.09	6.34
5	20.43	12.23	1.76	23.67	12.65	3.23	33.45	17.44	7.01
6	21.45	12.95	1.82	23.65	13.2	3.45	32.65	17.31	7.12
7	21.45	13.45	1.98	22.34	11.69	3.22	32.65	18.09	7.98
8	19.45	10.95	1.23	22.67	11.33	3.12	31.56	16.13	6.32
9	19.54	12.04	1.56	21.56	10.11	2.1	31.56	16.8	6.34
10	18.58	10.68	1.23	21.66	11.1	2.45	31.96	17.64	6.98
11	18.59	10.19	1.34	20.56	9.89	1.34	30.54	16.09	6.14
12	17.48	8.98	0.98	20.45	9.12	1.34	30.56	15.6	5.78
13	17.49	9.19	0.98	19.56	7.22	1.23	29.56	14.9	5.01
14	16.89	8.29	0.95	19.54	6.62	1.2	29.45	14.02	5.02
15	16.42	7.52	0.62	24.56	14.02	3.6	29.54	13.87	4.35
16	16.9	8.3	0.76	24.56	13.22	3.65	28.45	12.78	3.01
17	16.38	8.28	0.78	25.79	15.36	3.89	28.65	13.22	3.05

Appendix Table 3 (Continued)

№	3 <sup>rd</sup> month			4 <sup>th</sup> month			5 <sup>th</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
18	16.3	8.4	0.75	25.01	14.34	3.21	28.54	12.09	3.03
19	17.43	8.33	0.85	24.56	14.35	3.54	28.39	11.96	3.01
20	18.56	9.96	0.83	24.54	14.09	3.76	29.35	15.9	5.45
21	19.45	11.15	1.45	23.45	13.22	3.43	30.12	16.56	6.54
22	20.56	11.86	1.34	23.46	12.01	2.32	31.34	17.89	7.56
23	20.34	11.54	1.56	25.69	14.04	3.76	32.45	17.02	7.54
24	21.45	12.55	1.76	25.48	14.03	3.76	33.45	19.67	8.54
25	21.45	12.85	1.79	24.67	14.22	3.65	34.54	18.87	8.65
26	22.34	13.94	1.74	19.54	9.11	1.22	34.32	18.65	8.67
27	21.34	12.74	1.34	19.38	8.15	1.12	33.23	17.55	7.33
28	20.34	12.04	1.23	25.43	15.10	3.90	31.23	15.22	6.54
29	19.45	10.85	1.22	25.97	13.63	3.30	31.03	15.36	6.67
30	19.04	10.44	1.22	23.10	10.65	2.31	28.34	12.67	6.67
<b>Mean</b>	<b>19.220</b>	<b>10.733</b>	<b>1.276</b>	<b>23.117</b>	<b>11.979</b>	<b>2.777</b>	<b>31.122</b>	<b>15.997</b>	<b>6.176</b>
<b>SD</b>	<b>1.841</b>	<b>1.870</b>	<b>0.393</b>	<b>2.120</b>	<b>2.353</b>	<b>0.971</b>	<b>1.936</b>	<b>2.082</b>	<b>1.661</b>

Appendix Table 3 (Continued)

№	6 <sup>th</sup> month			6 <sup>th</sup> month			6 <sup>th</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
1	35.02	17.43	9.78	32.54	15.14	7.53			
2	32.1	15.79	7.33	32.65	14.12	7.01			
3	37.94	19.07	12.23	37.65	20.12	12.39			
4	36.54	19.11	9.32	37.65	19.02	11.24			
5	36.43	18.89	11.34	36.54	19.24	12.95			
6	35.87	17.33	9.43	35.46	17.93	9.53			
7	35.32	17.37	9.45	34.56	18.17	9.45			
8	34.65	16.22	8.97	32.45	13.92	10.34			
9	34.71	17.67	9.54	32.12	13.59	11.23			
10	33.65	14.7	7.43	31.95	13.43	11.24			
11	33.12	15.59	7.21	39.64	22.22	12.34			
12	32.56	15.07	7.12	37.54	20.14	12.34			
13	32.76	15.33	7.01	35.71	18.36	11.34			
14	37.9	21.56	12.34	31.95	14.42	7.53			
15	37.32	20.57	11.38	<b>35.028</b>	<b>17.391</b>	<b>9.945</b>			
16	36.54	20.2	12.02	<b>2.238</b>	<b>2.495</b>	<b>1.973</b>			

**Appendix Table 4** Length and weight of abalone growth at different initial size at 10-11 mm (60pcs/cage).

№	0 month			1 <sup>st</sup> month			2 <sup>nd</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
1	10.67	6.01	0.21	14.16	8.25	0.5	17.98	11.34	1.3
2	10.12	5.69	0.23	12.85	7.39	0.45	16.02	9.59	1.22
3	11.22	6.33	0.24	15.47	9.11	0.63	19.94	13.09	1.5
4	10.15	5.26	0.23	12.89	7.45	0.49	16.98	10.66	1.29
5	10.18	5.4	0.22	12.32	6.97	0.55	16.09	9.75	1.19
6	10.63	6.31	0.23	12.34	6.67	0.43	16.9	10.45	1.23
7	10.78	6.11	0.23	13.43	7.57	0.56	17.23	10.67	1.24
8	11.24	6.57	0.23	13.28	7.59	0.57	17.34	10.67	1.26
9	11.22	6.44	0.23	14.23	8.22	0.54	17.56	10.78	1.27
10	11.29	6.3	0.24	14.32	8.09	0.52	17.57	10.68	1.29
11	11.73	6.84	0.24	15.23	8.89	0.57	17.89	11.35	1.3
12	10.12	5.25	0.21	15.28	8.83	0.56	17.98	11.31	1.31
13	10.67	6	0.2	15.39	8.83	0.54	18.9	12.12	1.38
14	10.45	6.08	0.2	15.98	9.2	0.6	18.87	12.55	1.39
15	10.54	5.76	0.19	15.02	8.48	0.55	18.65	12.11	1.36
16	10.43	6	0.2	14.2	8.77	0.53	20.21	13.57	1.4
17	10.34	5.89	0.19	14.28	8.61	0.56	18.43	11.58	1.34

Appendix Table 4 (Continued)

№	0 month			1 <sup>st</sup> month			2 <sup>nd</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
18	11.24	6.68	0.21	14.98	9.2	0.59	18.32	11.42	1.35
19	11.49	7.17	0.22	13.89	8.57	0.67	19.08	12.66	1.42
20	11.36	7.14	0.23	13.21	8	0.54	17.65	11.2	1.31
21	11.2	6.31	0.23	15.29	9.95	0.6	19.5	13.18	1.34
22	11.29	6.97	0.23	12.24	6.64	0.45	19.34	12.89	1.45
23	11.92	7.25	0.24	14.56	8.02	0.51	19.23	12.45	1.43
24	10.32	6	0.21	15.34	8.91	0.57	19.23	13.02	1.5
25	10.54	5.77	0.19	15.25	8.58	0.52	17.6	11.04	1.32
26	10.76	6.33	0.22	12.24	6.81	0.47	17.54	10.65	1.26
27	10.87	6.66	0.23	12.34	6.56	0.49	17.56	11.13	1.37
28	10.98	6.2	0.22	14.32	9	0.6	17.87	11.66	1.37
29	10.21	5.54	0.19	15.89	10.77	0.7	15.8	9.01	1.1
30	11.39	7.11	0.25	15.89	10.11	0.66	16.21	9.56	1.19
31	10.56	5.87	0.19	15.89	9.35	0.6	16.22	9.68	1.1
<b>Mean</b>	<b>10.836</b>	<b>6.246</b>	<b>0.219</b>	<b>14.258</b>	<b>8.367</b>	<b>0.552</b>	<b>17.925</b>	<b>11.349</b>	<b>1.315</b>
<b>SD</b>	<b>0.506</b>	<b>0.562</b>	<b>0.018</b>	<b>1.240</b>	<b>1.046</b>	<b>0.064</b>	<b>1.185</b>	<b>1.196</b>	<b>0.099</b>

Appendix Table 4 (Continued)

№	3 <sup>rd</sup> month			4 <sup>th</sup> month			5 <sup>th</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
1	22.25	12.07	1.9	24.63	13.33	2.96	33.65	16.23	7.9
2	20.34	10.78	1.72	23.29	12.87	2.77	30.86	14.51	6.89
3	24.16	13.36	2.12	25.97	13.79	2.99	36.44	17.95	8.21
4	22.23	12.91	1.92	23.23	12.91	2.43	30.32	14.02	6.43
5	22.21	13.09	2.12	24.54	14.09	3.43	29.01	12.52	5.43
6	20.21	9.87	1.6	25.68	15.12	3.66	31.32	14.98	6.84
7	20.12	9.56	1.65	24.98	14.33	3.45	31.98	15	7.54
8	20.23	9.56	1.64	25.98	15.22	3.78	37.49	20.4	8.43
9	20.34	9.68	1.67	25.77	14.9	3.76	31.65	14.23	6.32
10	20.35	9.37	1.63	26.78	16.11	4.01	31.45	13.91	5.89
11	20.45	10.11	1.76	26.77	15.43	3.98	32.56	14.67	6.43
12	20.56	10.35	1.76	23.43	12.21	2.55	28.98	10.89	4.66
13	20.78	11.44	1.87	24.43	12.87	2.34	28.39	10.96	4.54
14	21.32	11.87	1.88	24.34	12.65	2.67	32.35	14.9	6.76
15	23.34	13.67	2.32	24.78	12.9	2.34	32.68	15.34	7.43
16	24.46	14.68	2.54	24.78	12.99	2.44	33.543	16.113	7.87
17	24.67	13.44	2.3	24.43	12.09	2.43	33.59	15.94	7.21

Appendix Table 4 (Continued)

№	3 <sup>rd</sup> month			4 <sup>th</sup> month			5 <sup>th</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
18	24.67	16.44	2.87	23.13	10.79	1.98	33.19	15.76	7.32
19	24.78	13.55	2.32	22.89	10.3	1.96	33.68	16.36	7.89
20	25.79	14.45	2.45	21.56	8.02	1.89	34.57	16.59	8.02
21	24.56	13.11	2.44	23.56	14.13	3.32	33.5	15.85	7.43
22	23.55	13.1	2.31	24.87	15.44	3.89	37.45	18.8	8.88
23	23.45	12.89	1.92	24.67	11.32	2.33	36.39	17.85	8.65
24	22.34	13.02	1.98	24.65	13.31	2.36	35.48	19.05	9.75
25	22.45	12	1.88	24.57	12.03	2.43	36.44	19.68	9.76
26	23.59	13.27	1.98	24.89	14.55	3.66	35.48	15.7	7.54
27	23.56	13.24	2.11	23.67	11.22	2.32	35.49	18.03	8.64
28	23.59	12.92	1.99	26.89	14.44	3.41	36.49	19	8.88
29	19.34	8.69	1.76	26.87	15.53	3.98	37.49	20.03	9.54
30	18.98	8.11	1.72	25.76	15.42	4.11	35.39	17.07	8.77
31	25.34	14.69	2.56	27.43	15.09	4.15	37.98	19.53	8.76
<b>Mean</b>	<b>22.387</b>	<b>12.106</b>	<b>2.022</b>	<b>24.814</b>	<b>13.400</b>	<b>3.025</b>	<b>33.719</b>	<b>16.189</b>	<b>7.568</b>
<b>SD</b>	<b>1.959</b>	<b>2.018</b>	<b>0.328</b>	<b>1.364</b>	<b>1.838</b>	<b>0.734</b>	<b>2.700</b>	<b>2.467</b>	<b>1.351</b>

Appendix Table 4 (Continued)

№	6 <sup>th</sup> month			6 <sup>th</sup> month			6 <sup>th</sup> month		
	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)	Length (mm)	Width (mm)	Weight (g)
1	39.54	18.27	13.45	35.18	17.75	12.37	<b>37.781</b>	<b>20.010</b>	<b>12.745</b>
2	35.98	16.62	10.32	36.4	21.01	12.45	<b>2.612</b>	<b>2.552</b>	<b>1.036</b>
3	43.1	19.92	12.33	36.38	20.95	12.56			
4	39.54	22.11	13.43	37.49	19.95	12			
5	39.54	21.98	12.32	37.5	18.96	12.98			
6	34.43	16.94	10.11	37.54	20.14	12.56			
7	41.34	23.4	14.45	38.45	19.81	12.88			
8	42.33	25.79	14.87	38.59	19.84	12.56			
9	39.54	23.11	13.87	39.65	22.22	12.76			
10	33.57	16.59	12.45	39.54	20.79	12.54			
11	33.5	15.96	11.34	38.54	19.9	12.67			
12	34.87	17.33	12.98	39.54	22.11	12.76			
13	34.56	16.69	12.24	39.54	22.11	13.98			
14	34.65	17.2	12.32	39.65	22.86	13.99			
15	34.55	17.01	12.32	40.54	23.78	14.34			
16	35.65	19.22	12.89	35.18	17.75	12.37			

**Appendix Table 5** Length and weight of abalone growth at different stocking density at 40 pcs/cage.

№	0 month		1 <sup>st</sup> month		2 <sup>nd</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
1	7.23	0.09	11.34	0.3	14.12	0.76
2	5.96	0.06	9.78	0.11	11.22	0.39
3	8.5	0.12	12.9	0.49	17.02	1.13
4	7.43	0.093	11.54	0.28	14.34	0.79
5	7.65	0.087	11.78	0.29	14.78	0.76
6	7.89	0.061	11.96	0.3	14.54	0.71
7	8.01	0.064	11.32	0.35	14.67	0.73
8	8.44	0.068	10.98	0.39	13.45	0.74
9	8.79	0.075	10.56	0.41	13.89	0.69
10	8.76	0.078	10.34	0.35	13.31	0.63
11	8.43	0.087	10.01	0.38	12.78	0.62
12	7.86	0.091	9.87	0.35	12.53	0.62
13	7.65	0.076	9.54	0.256	15.78	0.83
14	7.32	0.087	9.31	0.27	15.53	0.81
15	6.78	0.12	9.34	0.22	16.42	0.83
16	6.75	0.11	8.97	0.34	16.88	0.87
17	6.42	0.1	8.54	0.21	17.04	0.89

Appendix Table 5 (Continued)

№	0 month		1 <sup>st</sup> month		2 <sup>nd</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
18	5.67	0.1	12.98	0.23	17.03	0.92
19	5.89	0.093	12.67	0.22	15.42	0.71
20	5.54	0.098	12.54	0.19	14.78	0.74
21	8.54	0.119	12.43	0.15	14.75	0.76
22	8.56	0.116	12.32	0.24	13.89	0.69
23	7.89	0.123	11.89	0.26	13.02	0.68
24	5.01	0.06	11.32	0.22	13.23	0.61
25	9.21	0.054	11.67	0.28	12.32	0.66
26	4.78	0.089	11.39	0.26	12.01	0.6
27	4.65	0.092	12.89	0.41	11.21	0.51
28	7.32	0.096	12.68	0.49	11.43	0.52
29	7.65	0.089	12.68	0.46	11.92	0.51
30	7.98	0.0865	12.89	0.13	17.5	1.2
<b>Mean</b>	<b>7.285</b>	<b>0.089</b>	<b>11.281</b>	<b>0.295</b>	<b>14.227</b>	<b>0.730</b>
<b>SD</b>	<b>1.273</b>	<b>0.019</b>	<b>1.348</b>	<b>0.099</b>	<b>1.874</b>	<b>0.169</b>

Appendix Table 5 (Continued)

№	3 <sup>rd</sup> month		4 <sup>th</sup> month		5 <sup>th</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
1	17.18	1.34	23.15	2.57	31.03	7.92
2	13.16	0.66	19.18	1.64	25.62	3.91
3	21.2	2.02	27.12	3.5	36.44	11.93
4	22.43	2.09	23.45	2.65	31.34	7.63
5	21.32	2.05	23.98	2.79	31.54	7.78
6	21.45	2.05	23.21	2.3	36.43	11.67
7	21.78	2.04	23.65	2.78	36.08	11.34
8	20.43	2	23.32	2.6	36.75	11.76
9	20.21	2	22.43	2.75	30.54	7.76
10	19.54	1.98	22.56	2.84	30.43	7.32
11	19.68	1.92	21.89	1.84	29.78	5.12
12	18.54	1.95	21.56	1.98	29.54	4.89
13	18.43	1.91	20.43	1.92	28.54	4.32
14	17.19	1.36	19.56	1.93	28.54	4.76
15	17.43	1.32	18.89	1.83	27.54	4.22
16	17.01	1.36	19.54	1.94	27.21	3.89
17	17.04	1.3	18.45	1.76	26.43	3.78

Appendix Table 5 (Continued)

№	3 <sup>rd</sup> month		4 <sup>th</sup> month		5 <sup>th</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
18	17.3	1.29	25.89	2.89	26.78	3.76
19	16.89	1.3	25.67	2.87	25.67	3.78
20	16.42	1.34	26.75	2.94	25.42	3.33
21	14.89	1.09	28.89	3.65	32.56	7.89
22	13.6	0.89	29.54	3.89	32.85	8.02
23	13.89	0.62	27.89	3.56	33.46	8.11
24	14.65	0.73	19.54	1.76	33.68	8.24
25	13.78	0.69	28.54	3.56	34.69	8.67
26	13.7	0.61	27.53	3.84	34.21	8.86
27	13.67	0.66	27.53	3.54	35.56	10.76
28	22.89	2.02	24.65	2.81	35.56	10.45
29	17.43	1.36	19.43	1.71	36.85	11.23
30	17.32	1.43	18.54	1.53	36.54	11.15
<b>Mean</b>	<b>17.682</b>	<b>1.446</b>	<b>23.425</b>	<b>2.606</b>	<b>31.587</b>	<b>7.475</b>
<b>SD</b>	<b>2.928</b>	<b>0.526</b>	<b>3.473</b>	<b>0.733</b>	<b>3.839</b>	<b>2.920</b>

Appendix Table 5 (Continued)

№	6 <sup>th</sup> month		6 <sup>th</sup> month		6 <sup>th</sup> month	
	Length(mm)	Weight (g)	Length(mm)	Weight (g)	Length(mm)	Weight (g)
1	34.17	10.96	17	34.21	10.54	
2	28.2	6.24	18	33.34	10.21	
3	40.14	15.68	19	32.45	9.43	
4	34.67	10.43	20	33.68	9.68	
5	34.21	10.54	21	32.45	9.78	
6	34.89	10.6	22	38.54	11.23	
7	34.21	10.43	23	36.54	11.4	
8	34.54	10.22	24	39.65	14.21	
9	35.89	10.78	25	39.54	14.32	
10	35.32	10.89	26	40.65	15.31	
11	38.32	11.8	27	39.65	14.56	
12	28.21	5.43	28	38.65	14.56	
13	27.43	4.54	29	38.65	15.43	
14	29.43	5.12	<b>Mean</b>	<b>34.590</b>	<b>10.395</b>	
15	29.54	5.21	<b>SD</b>	<b>3.950</b>	<b>3.314</b>	
16	28.53	4.89				

**Appendix Table 6** Length and weight of abalone growth at different stocking density at 60 pcs/cage.

№	0 month		1 <sup>st</sup> month		2 <sup>nd</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
1	7.83	0.091	10.72	0.285	18.01	1.2
2	5.05	0.07	7.53	0.095	14.9	0.55
3	10.61	0.283	13.91	0.47	21.12	1.72
4	10.63	0.284	13.97	0.48	21.23	1.74
5	10.67	0.281	13.67	0.44	21.56	1.77
6	10.32	0.282	13.43	0.42	21.87	1.78
7	9.01	0.14	12.77	0.38	20.54	1.58
8	9.45	0.142	12.32	0.37	20.78	1.6
9	9.87	0.145	12.56	0.38	20.21	1.55
10	8.89	0.118	11.23	0.35	19.12	1.28
11	8.54	0.115	11.56	0.36	19.34	1.29
12	8.32	0.113	11.78	0.356	19.67	1.29
13	7.56	0.092	10.87	0.287	18.97	1.27
14	7.21	0.093	10.66	0.284	18.64	1.281
15	7.89	0.099	10.31	0.281	18.32	1.27
16	6.78	0.087	9.87	0.147	17.78	1.25
17	6.54	0.085	9.64	0.145	17.53	1.24

Appendix Table 6 (Continued)

№	0 month		1 <sup>st</sup> month		2 <sup>nd</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
18	6.32	0.088	9.32	0.14	17.31	1.24
19	5.12	0.072	8.78	0.118	16.23	0.75
20	5.45	0.074	8.54	0.114	16.56	0.78
21	5.78	0.077	8.23	0.11	16.78	0.79
22	5.32	0.073	7.78	0.092	15.42	0.55
23	6.65	0.085	7.65	0.09	15.56	0.56
24	7.67	0.094	7.32	0.09	15.78	0.59
25	8.65	0.115	10.54	0.284	14.78	0.48
26	9.76	0.144	10.43	0.28	14.65	0.46
27	5.32	0.073	10.43	0.28	14.32	0.42
28	5.67	0.076	11.32	0.35	18.65	1.27
29	5.21	0.073	11.78	0.36	18.54	1.26
30	9.87	0.143	11.67	0.36	18.56	1.26
31	8.56	0.115	11.63	0.367	18.64	1.27
<b>Mean</b>	<b>7.759</b>	<b>0.123</b>	<b>10.717</b>	<b>0.276</b>	<b>18.109</b>	<b>1.140</b>
<b>SD</b>	<b>1.869</b>	<b>0.067</b>	<b>1.924</b>	<b>0.125</b>	<b>2.198</b>	<b>0.426</b>

Appendix Table 6 (Continued)

№	3 <sup>rd</sup> month		4 <sup>th</sup> month		5 <sup>th</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
1	21.33	1.72	25.83	3.87	31.32	8.45
2	17.92	0.125	21.11	1.76	26.87	4.3
3	24.74	2.78	30.55	7.91	35.77	13.87
4	24.87	2.79	21.32	1.77	35.65	13.65
5	24.65	2.76	21.34	1.78	35.21	13.32
6	24.21	2.77	30.21	7.9	35.78	13.2
7	23.56	2.54	29.76	7.41	34.21	12.54
8	23.54	2.51	29.56	7.4	34.56	12.57
9	23.21	2.56	29.12	7.39	34.87	12.6
10	22.23	2.27	28.98	5.58	33.21	11.23
11	22.56	2.29	28.56	5.56	33.56	11.45
12	22.78	2.3	28.43	5.51	33.78	11.67
13	21.34	1.72	27.54	4.87	32.21	8.98
14	21.66	1.78	27.23	4.8	32.56	9.12
15	21.98	1.79	27.78	4.9	32.98	9.56
16	20.87	1.53	26.78	4.23	31.21	8.45
17	20.54	1.5	26.65	4.33	31.54	8.5

Appendix Table 6 (Continued)

№	3 <sup>rd</sup> month		4 <sup>th</sup> month		5 <sup>th</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
18	20.12	1.49	26.43	4.28	31.98	8.6
19	19.9	1.29	25.56	3.89	30.21	7.91
20	19.65	1.25	25.78	4.01	30.65	7.95
21	19.21	1.28	25.21	3.87	30.87	7.98
22	18.98	1.26	24.21	2.65	29.31	7.43
23	18.56	1.24	24.56	2.66	29.89	7.5
24	18.23	1.2	24.78	2.68	29.01	7.3
25	17.64	1.23	23.34	2.48	28.43	5.67
26	17.56	1.22	23.76	2.45	28.65	5.6
27	17.32	1.21	23.98	2.46	28.79	5.71
28	24.77	2.67	22.21	2.21	27.58	4.87
29	24.54	2.66	22.45	2.24	27.58	4.8
30	21.56	1.7	22.87	2.29	26.94	4.86
31	21.87	1.75	21.23	2.71	26.54	4.89
<b>Mean</b>	<b>21.352</b>	<b>1.845</b>	<b>25.714</b>	<b>4.124</b>	<b>31.346</b>	<b>8.856</b>
<b>SD</b>	<b>2.410</b>	<b>0.670</b>	<b>2.904</b>	<b>1.938</b>	<b>2.888</b>	<b>3.022</b>

Appendix Table 6 (Continued)

№	6 <sup>th</sup> month		6 <sup>th</sup> month		6 <sup>th</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
1	35.45	13.31	17	35.76	13.7	<b>Mean</b> <b>SD</b>
2	31.11	8.56	18	35.21	13.65	
3	39.79	18.24	19	34	12.56	<b>35.499</b> <b>2.752</b>
4	39.98	18.31	20	34.78	12.7	
5	39.54	18.1	21	34.21	12.3	<b>13.468</b> <b>3.282</b>
6	39.32	18.1	22	33.78	11.54	
7	38.78	17.24	23	33.54	11.6	
8	38.54	17.22	24	33.21	11.3	
9	38.21	17.21	25	32.98	9.12	
10	37.78	15.87	26	32.56	9.1	
11	37.65	15.78	27	32.12	8.91	
12	37.32	15.7	28	31.89	8.54	
13	36.78	14.87	29	31	8.45	
14	36.54	14.75	30	31.21	8.65	
15	36.21	14.7	31	35.45	13.67	
16	35.78	13.75				

1943

**Appendix Table 7** Length and weight of abalone growth at different stocking density at 80 pcs/cage.

№	0 month		1 <sup>st</sup> month		2 <sup>nd</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
1	7.2	0.09	10.46	0.281	14.27	0.45
2	5.3	0.073	8.79	0.112	11.45	0.354
3	9.1	0.14	12.13	0.39	17.09	1.23
4	7.23	0.092	12.43	0.392	17.54	1.2
5	7.43	0.093	12.67	0.401	17.98	1.25
6	7.76	0.097	12.87	0.41	17.32	1.23
7	7.89	0.098	11.23	0.342	16.87	0.78
8	8.54	0.112	11.45	0.35	16.76	0.72
9	8.43	0.11	11.78	0.356	16.43	0.73
10	8.76	0.112	10.43	0.276	16.43	0.73
11	8.3	0.112	10.54	0.281	15.68	0.55
12	9.12	0.14	10.65	0.287	15.32	0.54
13	9.11	0.14	10.87	0.289	14.67	0.46
14	7.65	0.093	9.43	0.145	14.32	0.47
15	7.89	0.095	9.67	0.146	14.54	0.48
16	6.98	0.082	9.46	0.142	14.67	0.49
17	6.75	0.089	9.34	0.143	14.89	0.48

Appendix Table 7 (Continued)

№	0 month		1 <sup>st</sup> month		2 <sup>nd</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length(mm)	Weight (g)
18	6.43	0.081	8.78	0.119	14.67	0.44
19	6.21	0.081	8.32	0.112	13.56	0.42
20	5.67	0.074	8.65	0.114	13.78	0.41
21	5.89	0.078	8.89	0.119	13.32	0.44
22	5.43	0.073	9.57	0.145	13.4	0.43
23	5.21	0.072	9.53	0.143	12.34	0.4
24	7.54	0.071	10.54	0.287	12.32	0.39
25	7.32	0.071	10.57	0.289	12.56	0.394
26	7.78	0.078	10.68	0.281	11.23	0.354
27	7.89	0.079	12.09	0.391	11.67	0.345
28	9.32	0.143	12.78	0.393	11.67	0.35
29	9.65	0.146	11.89	0.356	12.67	0.41
30	5.32	0.073	11.67	0.353	13.67	0.43
31	5.11	0.071	10.65	0.287	14.45	0.51
<b>Mean</b>	<b>7.36</b>	<b>0.10</b>	<b>10.61</b>	<b>0.26</b>	<b>14.44</b>	<b>0.58</b>
<b>SD</b>	<b>1.35</b>	<b>0.02</b>	<b>1.33</b>	<b>0.11</b>	<b>1.95</b>	<b>0.28</b>

Appendix Table 7 (Continued)

№	3 <sup>rd</sup> month		4 <sup>th</sup> month		5 <sup>th</sup> month	
	Length(mm)	Weight (g)	Length(mm)	Weight (g)	Length(mm)	Weight (g)
1	17.49	1.23	21.18	1.76	29.4	7.32
2	14.06	0.45	17.72	1.25	25.05	3.89
3	20.92	1.68	24.64	2.89	33.75	11.21
4	14.32	0.46	24.87	2.91	33.64	11.32
5	14.56	0.43	24.65	2.78	33.23	11.25
6	14.78	0.46	24.21	2.87	32.87	9.12
7	15.32	0.57	23.98	2.59	32.65	8.95
8	15.65	0.58	23.76	2.56	32.12	8.99
9	15.78	0.55	23.23	2.53	31.23	8.54
10	16.43	0.73	22.87	2.41	31.45	8.34
11	16.64	0.72	22.54	2.46	31.67	8.66
12	16.79	0.77	22.13	2.48	30.87	8.12
13	17.32	1.23	21.76	1.72	30.46	7.98
14	17.65	1.24	21.56	1.69	30.13	7.92
15	17.98	1.25	21.21	1.67	29.68	7.56
16	18.54	1.28	20.98	1.69	29.56	7.56
17	18.76	1.27	20.65	1.67	29.31	7.54

Appendix Table 7 (Continued)

№	3 <sup>rd</sup> month		4 <sup>th</sup> month		5 <sup>th</sup> month	
	Length(mm)	Weight (g)	Length (mm)	Weight (g)	Length(mm)	Weight (g)
18	18.98	1.28	20.23	1.66	28.35	5.56
19	19.43	1.3	19.23	1.29	28.43	5.67
20	19.55	1.29	19.56	1.29	28.34	5.87
21	19.98	1.31	19.98	1.29	27.46	4.87
22	20.43	1.67	18.98	1.28	27.13	4.95
23	20.65	1.71	18.65	1.28	27.98	4.82
24	20.76	1.69	18.23	1.27	26.67	4.54
25	17.54	1.24	17.43	1.25	26.45	4.57
26	17.87	1.25	17.89	1.25	26.32	3.98
27	17.98	1.25	17.21	1.25	25.67	3.94
28	16.89	0.73	23.65	2.55	25.53	3.89
29	18.21	1.28	22.56	2.43	25.45	3.88
30	18.54	1.29	21.43	1.65	29.45	7.5
31	17.45	1.25	21.34	1.66	29.65	7.4
<b>Mean</b>	<b>17.65</b>	<b>1.08</b>	<b>21.24</b>	<b>1.91</b>	<b>29.35</b>	<b>6.96</b>
<b>SD</b>	<b>1.94</b>	<b>0.40</b>	<b>2.32</b>	<b>0.61</b>	<b>2.59</b>	<b>2.28</b>

Appendix Table 7 (Continued)

№	6 <sup>th</sup> month		6 <sup>th</sup> month		6 <sup>th</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
1	33.38	11.21	17	33.56	11.25	
2	28.47	6.98	18	33.32	11.16	
3	28.3	7.21	19	33.78	11.29	
4	33.21	8.92	20	32.45	9.32	
5	32.55	9.21	21	32.67	9.23	
6	32.45	8.89	22	32.87	8.97	
7	37.65	15.82	23	31.23	8.56	
8	32.44	9.21	24	31.56	8.43	
9	36.88	14.76	25	31.56	8.51	
10	32.78	9.12	26	30.43	7.98	
11	32.76	8.98	27	30.43	7.91	
12	35.31	13.93	28	30.56	8.23	
13	28.43	6.97	29	29.34	7.45	
14	28.78	6.99	30	29.54	7.32	
15	34.56	12.57	<b>Mean</b>	<b>32.27</b>	<b>9.73</b>	
16	34.32	12.54	<b>SD</b>	<b>2.37</b>	<b>2.39</b>	

**Appendix Table 8** Length and weight of abalone growth at different stocking density at 100 pcs/cage.

№	0 month		1 <sup>st</sup> month		2 <sup>nd</sup> month	
	Length(mm)	Weight (g)	Length (mm)	Weight (g)	Length mm)	Weight (g)
1	7.14	0.09	10.12	0.28	13.17	0.4
2	5.47	0.04	7.67	0.09	10.41	0.28
3	8.81	0.13	12.57	0.39	15.93	0.64
4	7.12	0.09	12.54	0.38	12.54	0.28
5	7.45	0.089	12.43	0.39	12.67	0.28
6	7.89	0.09	12.21	0.37	12.54	0.27
7	7.65	0.088	11.23	0.31	12.78	0.28
8	7.54	0.085	11.34	0.32	12.54	0.28
9	8.65	0.125	11.98	0.34	13.65	0.35
10	8.43	0.122	11.67	0.33	13.76	0.34
11	8.79	0.128	10.23	0.289	13.87	0.36
12	6.76	0.084	10.5	0.287	11.234	0.34
13	6.89	0.088	10.67	0.267	11.67	0.36
14	6.54	0.085	10.79	0.291	11.65	0.32
15	6.32	0.083	9.54	0.112	11.45	0.35
16	6.56	0.089	9.43	0.113	10.34	0.28
17	5.46	0.078	9.21	0.14	10.56	0.28

Appendix Table 8 (Continued)

№	0 month		1 <sup>st</sup> month		2 <sup>nd</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
18	5.79	0.075	9.56	0.18	10.67	0.28
19	5.73	0.074	8.54	0.16	10.78	0.27
20	5.63	0.079	8.76	0.14	14.78	0.46
21	5.67	0.075	8.98	0.15	14.67	0.45
22	6.89	0.086	7.65	0.09	14.78	0.47
23	6.48	0.087	7.32	0.089	13.54	0.35
24	7.32	0.089	7.98	0.09	13.21	0.37
25	7.54	0.087	10.16	0.278	14.01	0.44
26	7.76	0.09	10.65	0.276	14.22	0.41
27	7.89	0.093	10.87	0.289	15.81	0.55
28	8.01	0.12	10.43	0.281	15.43	0.56
29	8.34	0.11	10.43	0.293	15.88	0.58
30	8.65	0.1	10.65	0.267	15.98	0.6
<b>Mean</b>	<b>7.172</b>	<b>0.092</b>	<b>10.204</b>	<b>0.243</b>	<b>13.151</b>	<b>0.383</b>
<b>SD</b>	<b>1.051</b>	<b>0.019</b>	<b>1.489</b>	<b>0.100</b>	<b>1.787</b>	<b>0.111</b>

Appendix Table 8 (Continued)

№	3 <sup>rd</sup> month		4 <sup>th</sup> month		5 <sup>th</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length (mm)	Weight (g)
1	16.28	0.72	19.37	1.29	28.23	5.72
2	13.1	0.34	15.46	0.65	23.91	2.93
3	19.46	1.29	23.28	2.92	32.55	8.91
4	18.58	1.28	19.87	1.29	23.54	2.81
5	18.54	1.28	19.43	1.24	23.67	2.91
6	17.48	1.25	19.21	1.22	24.54	3.22
7	17.49	1.12	19.65	1.25	24.67	3.32
8	16.44	0.79	15.78	0.67	25.56	3.89
9	16.45	0.74	15.43	0.65	25.87	3.96
10	15.56	0.69	16.78	0.69	26.43	4.13
11	15.78	0.68	16.48	0.72	26.67	4.32
12	14.56	0.47	17.58	1.12	27.55	4.87
13	14.57	0.45	17.54	1.14	27.78	4.92
14	13.45	0.36	18.54	1.18	28.76	5.76
15	13.85	0.37	18.89	1.2	28.98	5.97
16	13.02	0.33	19.43	1.28	28.54	5.32
17	15.89	0.61	19.65	1.28	28.21	5.12

Appendix Table 8 (Continued)

№	3 <sup>rd</sup> month		4 <sup>th</sup> month		5 <sup>th</sup> month	
	Length (mm)	Weight (g)	Length (mm)	Weight (g)	Length(mm)	Weight (g)
18	16.89	0.66	20.43	1.67	28.76	5.19
19	16.89	0.67	20.57	1.65	29.76	7.32
20	17.89	1.12	21.57	1.64	29.64	7.22
21	17.58	1.22	21.59	1.68	29.54	7.16
22	18.48	1.21	22.58	2.54	29.43	7.23
23	18.48	1.19	22.95	2.46	30.21	8.13
24	19.4	1.27	23.54	2.5	30.64	8.11
25	19.37	1.28	23.86	2.59	31.86	8.55
26	19.98	1.37	19.54	1.28	31.56	8.53
27	13.01	0.37	19.56	1.28	32.76	8.92
28	13.1	0.32	19.54	1.28	32.75	8.86
29	13.56	0.35	19.34	1.27	28.45	5.56
30	16.76	0.78	19.01	1.23	28.89	5.56
<b>Mean</b>	<b>16.396</b>	<b>0.819</b>	<b>19.548</b>	<b>1.429</b>	<b>28.324</b>	<b>5.814</b>
<b>SD</b>	<b>2.202</b>	<b>0.378</b>	<b>2.306</b>	<b>0.607</b>	<b>2.687</b>	<b>2.000</b>

Appendix Table 8 (Continued)

№	6 <sup>th</sup> month		6 <sup>th</sup> month		6 <sup>th</sup> month	
	Length(mm )	Weight (g)	Length (mm)	Weight (g)	Length(mm)	Weight (g)
1	31.34	8.43	17	31.98	8.78	
2	25.45	3.89	18	31.57	8.65	
3	37.23	16.12	19	32.67	9.12	
4	25.43	3.87	20	32.56	9.22	
5	25.67	3.91	21	33.21	11.13	
6	26.54	4.22	22	33.95	11.23	
7	26.78	4.32	23	34.65	12.45	
8	27.54	4.87	24	34.32	12.33	
9	27.54	4.98	25	35.44	13.81	
10	28.75	5.53	26	35.68	13.97	
11	28.79	5.67	27	36.43	14.78	
12	29.67	7.32	28	36.21	14.56	
13	29.75	7.43	29	37.54	16.01	
14	30.43	8.32	30			
15	30.65	8.43	<b>Mean</b>	<b>31.363</b>	<b>9.019</b>	
16	31.46	8.56	<b>SD</b>	<b>3.652</b>	<b>3.854</b>	

**Appendix Table 9** Survival rates at different stocking density of abalones.

№	40 pcs/cage		60 pcs/cage		80 pcs/cage		100 pcs/cage	
	Juveniles	(%)	Juveniles	(%)	Juveniles	(%)	Juveniles	(%)
1	400	100.00	600	100.00	800	100.00	1000	100.00
2	378	94.50	583	97.17	747	93.33	915	91.50
3	358	89.50	548	91.33	712	89.00	763	76.33
4	333	83.17	518	86.33	631	78.83	682	68.17
5	319	79.83	507	84.50	575	71.83	627	62.67
6	293	73.17	489	81.50	521	65.17	540	54.00
7	275	68.67	469	78.17	476	59.50	472	47.17

**Appendix Table 10** Survival rates at different initial size of abalones (60pcs/cage).

№	4-5 mm		7-8 mm		10-11 mm	
	Juveniles	(%)	Juveniles	(%)	Juveniles	(%)
1	600	100.00	600	100.00	600	100.00
2	517	86.17	549	91.50	589	98.17
3	478	79.67	516	86.00	572	95.33
4	410	68.33	487	81.17	553	92.17
5	325	54.17	479	79.83	536	89.33
6	286	47.67	412	68.67	515	85.83
7	277	46.17	389	64.83	492	82.00

**Appendix Table 11** Length of early juveniles rearing abalone.

№	5 <sup>th</sup> (mm)	10 <sup>th</sup> (mm)	15 <sup>th</sup> (mm)	20 <sup>th</sup> (mm)	25 <sup>th</sup> (mm)	30 <sup>th</sup> (mm)	35 <sup>th</sup> (mm)	40 <sup>th</sup> mm)	45 <sup>th</sup> (mm)
1	0.21	0.54	0.65	1.18	1.18	1.78	1.55	1.77	2.45
2	0.23	0.58	0.72	1.18	1.00	1.53	2.32	2.12	2.48
3	0.22	0.55	0.78	1.20	1.33	1.73	2.00	1.82	2.23
4	0.26	0.43	0.76	1.00	1.05	1.73	1.45	2.31	1.95
5	0.24	0.52	0.68	1.20	1.40	1.75	1.40	1.83	2.45
6	0.25	0.51	0.71	1.23	1.68	1.53	1.40	2.76	2.33
7	0.26	0.59	0.69	1.15	1.68	1.55	1.25	1.58	2.31
8	0.24	0.42	0.74	1.03	1.73	1.55	1.98	2.31	2.81
9	0.26	0.57	0.67	1.20	1.30	1.21	1.98	2.25	2.45
10	0.23	0.55	0.72	1.00	1.35	1.73	1.95	2.28	2.74
11	0.25	0.49	0.72	1.13	1.38	1.73	1.70	2.28	2.33
12	0.29	0.45	0.79	1.15	1.33	1.73	2.00	1.55	2.48
13	0.22	0.49	0.71	1.10	1.35	1.75	1.15	1.58	2.45
14	0.29	0.57	0.69	1.08	1.08	1.70	1.38	1.83	2.45
15	0.21	0.42	0.73	1.38	1.43	1.45	2.03	1.83	2.20
16	0.25	0.55	0.71	1.18	1.45	1.45	2.03	1.63	1.58

Appendix Table 11 (Continued)

№	5 <sup>th</sup> (mm)	10 <sup>th</sup> (mm)	15 <sup>th</sup> (mm)	20 <sup>th</sup> (mm)	25 <sup>th</sup> (mm)	30 <sup>th</sup> (mm)	35 <sup>th</sup> (mm)	40 <sup>th</sup> (mm)	45 <sup>th</sup> (mm)
17	0.26	0.51	0.89	1.13	1.50	1.33	2.03	1.58	2.87
18	0.29	0.55	0.77	1.15	1.48	1.33	1.77	2.45	1.53
19	0.24	0.58	0.72	1.15	1.48	1.55	1.75	2.30	2.76
20	0.27	0.51	0.68	1.63	1.43	1.20	1.72	2.50	2.75
21	0.28	0.48	0.69	1.68	1.45	1.48	2.00	2.40	2.45
22	0.27	0.47	0.65	1.40	1.36	1.03	1.75	2.30	2.63
23	0.26	0.57	0.69	1.18	1.39	1.45	1.78	1.98	2.90
24	0.29	0.55	0.75	1.18	1.38	1.33	1.88	1.98	1.88
25	0.22	0.54	0.76	1.17	1.45	1.33	1.83	2.46	2.45
26	0.23	0.57	0.77	1.16	1.35	1.75	1.75	2.54	2.72
27	0.27	0.42	0.79	1.19	1.38	1.70	2.25	2.21	2.78
28	0.23	0.57	0.79	1.15	1.32	1.52	2.25	2.56	2.98
29	0.29	0.55	0.72	1.20	1.37	1.51	1.45	2.73	2.74
30	0.29	0.51	0.78	1.17	1.35	1.33	1.31	2.75	2.42
<b>Mean</b>	<b>0.253</b>	<b>0.52</b>	<b>0.73</b>	<b>1.1955</b>	<b>1.378</b>	<b>1.522</b>	<b>1.767</b>	<b>2.147</b>	<b>2.45</b>
<b>SD</b>	<b>0.026</b>	<b>0.052</b>	<b>0.051</b>	<b>0.148</b>	<b>0.161</b>	<b>0.199</b>	<b>0.31</b>	<b>0.378</b>	<b>0.35</b>

Appendix Table 11 (Continued)

№	50 <sup>th</sup> (mm)	55 <sup>th</sup> (mm)	60 <sup>th</sup> (mm)	65 <sup>th</sup> (mm)	70 <sup>th</sup> (mm)	75 <sup>th</sup> (mm)	80 <sup>th</sup> (mm)	85 <sup>th</sup> (mm)	90 <sup>th</sup> (mm)
1	2.13	2.90	4.43	5.13	5.7	6.9	8.23	10.8423	11.43
2	2.18	3.30	5.3	5.9	7.1	6.78	8.45	10.45	11.54
3	1.98	2.70	4.2	5.23	5.7	6.54	8.9	10.54	15.4
4	2.31	2.50	4.33	5.8	5.6	6.98	10.3	7.87	13
5	2.18	3.42	4.32	5.1	7.4	6.77	6.8	8.76	15.3
6	2.50	3.34	4.45	4.5	4.7	7	9.7	7.54	12.43
7	2.62	3.43	3.56	5.2	4.65	8.5	8.43	8.78	12.34
8	2.48	3.50	3.45	4.4	5.7	6.9	6.4	9.43	15.3
9	2.32	3.40	4.53	5.5	4.5	5	7.4	9.67	12.56
10	1.95	3.80	4.3	5.23	4.8	7.4	7.5	11.834	11.76
11	2.31	4.41	4.55	4.5	4.4	6.9	6.3	12.43	11.65
12	2.35	3.90	3.45	4.5	7.3	6.4	8.5	11.834	6.3
13	3.48	3.65	5.5	4.6	4.3	6.8	7.44	12.45	6.4
14	3.50	3.32	3.45	5.4	5.7	6.9	9.42	13.432	11.78
15	3.78	3.82	3.8	4.9	5.2	9.4	6.4	7.843	6.4
16	3.75	2.50	5.2	5.4	5.5	7.3	10.23	10.834	15.21

Appendix Table 11 (Continued)

№	50 <sup>th</sup> (mm)	55 <sup>th</sup> (mm)	60 <sup>th</sup> (mm)	65 <sup>th</sup> (mm)	70 <sup>th</sup> (mm)	75 <sup>th</sup> (mm)	80 <sup>th</sup> (mm)	85 <sup>th</sup> (mm)	90 <sup>th</sup> (mm)
17	2.75	2.90	5.4	6.2	8.2	4.4	9.421	13.841	11.43
18	2.73	3.60	5.4	4.23	5.9	5.5	9.34	11.424	12.21
19	2.28	2.54	4.9	6.4	7.2	5.5	9.45	12.56	15.3
20	2.78	2.67	3.5	4.2	3.5	6.9	7.5	10.854	13.21
21	2.94	2.54	5.1	6.1	7.4	6.87	8.4	10.56	10.23
22	2.75	2.89	4.2	5.12	5.7	9.54	7.4	10.434	10.23
23	2.45	2.76	3.2	5.12	6.3	6.4	9.4	10.67	9.32
24	2.33	2.94	4.93	4.22	5.4	8.6	8.4	9.76	8.43
25	2.70	3.30	5.1	5.2	5.4	7.5	7.54	9.65	9.45
26	3.00	2.80	4.6	5.3	7.8	9.4	7.67	8.34	13.21
27	2.97	2.90	5.2	4.43	6.4	4.5	8.54	10.56	11.45
28	2.61	3.43	5.1	5.8	3.7	10.4	8.412	9.848	8.2
29	2.63	2.70	2.5	6.42	6.4	9.4	8.34	8.49	11.34
30	2.62	3.89	5.3	6.42	5.4	4.5	8.45	10.434	10.24
<b>Mean</b>	<b>2.644</b>	<b>3.192</b>	<b>4.442</b>	<b>5.215</b>	<b>5.765</b>	<b>7.063</b>	<b>8.289</b>	<b>10.399</b>	<b>11.435</b>
<b>SD</b>	<b>0.480</b>	<b>0.502</b>	<b>0.785</b>	<b>0.687</b>	<b>1.202</b>	<b>1.547</b>	<b>1.090</b>	<b>1.629</b>	<b>2.605</b>

## CURRICULUM VITAE

NAME: Mister Nguyen Duc Minh

BIRTH DATE: October 20, 1974

BIRTH PLACE: Binh Dinh Province, Vietnam

EDUCATION:	<u>YEAR</u>	<u>INSTITUTION</u>	<u>DEGREE</u>
	1998	University of Nong Lam in Ho Chi Minh City	B.Sc.(Aquaculture)

PROFESSIONAL STATUS: Researcher

OFFICE: Research Institute for Aquaculture No 2,  
116 Nguyen Dinh Chieu, District 1, Ho Chi Minh City,  
Vietnam.

FUNDING SOURCE: ACMECS (Ayeyawady-Chao Phraya-Mekong Economic  
Cooperation Strategy) scholarship of TICA (Thailand  
International Development Cooperation Agency)