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Status of Abalone Fishery and Experiential Mariculture as a Resource Conservation Strategy in Carot, Anda, Pangasinan

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ABSTRACT

The study describes the abalone fishery in Carot, Anda, Pangasinan to develop mariculture and to reseed a part of the harvest as a resource conservation strategy. The abalone fishery of Anda is artisanal or small-scale, typified by fishers gleaning or free-diving on shallow rocky areas which are the typical habitat of abalone. Low densities of 1.67 to 8 individuals per 250 m^2 were observed. Local fishers have knowledge of productive fishing areas. Hence, cage culture of abalone in these areas could be a viable resource conservation strategy as they serve as reproductive reserves to supply larvae for continued productivity of the fishing grounds. Abalone mariculture following the Farmer Field School (FFS) concept was explored to address both resource management and economic needs. As a resource enhancement activity, mariculture guarantees that cultured abalone are allowed to grow to maturity before harvested, while some are retained to restock a marine sanctuary. Since mariculture makes possible the aggregation of individuals, the probability that fertilization would take place is increased. As supplemental source of livelihood, abalone is a high-value commodity and its culture can help augment the income of fishers. Small abalone (3-4 cm) can be cultured further for 3-4 months to increase their size and weight. Mariculture should be done from November to May to avoid the rainy season and improve survivorship. The experiential activity was successful because it became a means for the fishers to experience resource management. Under the FFS, the researcher became a facilitator and mentored the cooperators in learning from their experience. The lessons sharpened the fishers' skills in observation, problem-solving, decision-making, and critical thinking. This enabled them to gain an appreciation of their resource.

Keywords: Abalone fishery, mariculture, Farmer Field School, conservation, resource management, experiential activity

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INTRODUCTION

Fisheries of all kinds in the Philippines have surpassed their sustainable levels of catch or are overfished (Green and others 2003). The sea urchin fishery in Bolinao, Pangasinan is one example showing the disastrous effects of unregulated harvesting of marine invertebrates (Juinio-Meñez and others 2001). Commercial harvesting started in the 1970s but lasted only a few years due to heavy exploitation. The scenario was aggravated by the practice of collecting small urchins even before they had the opportunity to reproduce. The University of the Philippines Marine Science Institute embarked on seed production to enhance the recovery of wild urchin populations through reseeding in marine protected areas, and the promotion of community-based grow-out culture. Results were promising, with juvenile recruitment pulses recorded beginning in 1999 (Juinio-Meñez and others 2008a, b). At present, the sea urchin industry in Bolinao is seen to have been revived and is thriving very well. This strategy could also work well with other highly exploited species like abalone.

Abalone can be found in Carot, Anda in Pangasinan but is now believed to be overfished. The area is being degraded due to overharvesting and other destructive fishing practices such as destroying rocks to collect cryptic abalone and cyanide fishing, among others. Abalone is a high-value commodity with a big potential for export. The life history traits of abalone make them especially vulnerable to overfishing, which poses a great challenge to fishery management. In areas where the abalone are found to be very few and widely apart, chances of successful fertilization are low.

Unless the direct users and the policy makers are educated about the status and proper management of the abalone fishery, it may eventually collapse. Hence, sustainable alternatives to overharvesting need to be explored and promoted in coastal fisher communities to mitigate the prevalent trend of ever-decreasing catches. One possible option is to educate coastal fisherfolk communities to help them become resource managers and promote community-based abalone mariculture as a resource conservation strategy (Capinpin 2012).

The abalone fishery of Anda is artisanal or small-scale, typified by fishers gleaning or free-diving on shallow rocky areas which are the typical habitat of abalone. In promoting resource management to the coastal fisherfolk, it must be harmonized with their immediate need for daily subsistence (Bangi and Juinio-Meñez 2001). If the aim is to reduce pressure on marine resources, the fisherfolk must have other means of livelihood. Thus, mariculture was explored to address both resource management issues and the need for development of sea-based livelihood. As a resource enhancement activity, mariculture guarantees that the cultured organisms with economic value can be allowed to grow to sexual maturity before they are harvested, while retaining some for reseeding. Since mariculture makes possible the aggregation of individuals, the probability that fertilization would take place is increased. As supplemental source of livelihood, abalone is a high-value commodity that can help augment the income of the communities. Moreover, by taking care of the abalone stocks in cages, the fisherfolk will gain an appreciation of, and eventually care for, their unique but important resource. This study is envisioned to become an entry point in heightening the ecological awareness of local communities on sustainable management through hands-on, experiential, resource management activities.

The present study aims to assess (1) the status of the abalone fishery in Carot, Anda, Pangasinan to justify the establishment of abalone mariculture primarily as a resource conservation strategy and as a supplemental source of livelihood; (2) the growth and survival of abalone in cages; and (3) the efforts to reseed a part of the harvest of the mariculture cooperators for resource conservation.

MATERIALS AND METHODS

Study Area

The study was conducted in Barangay Carot in Anda, Pangasinan, northern Philippines where the target species is naturally available. Only about 30 fishers – both daytime and night-time fishers – are actively fishing for abalone in Carot. This small number is due to the fact that it requires experience to be able to harvest the cryptic abalone. To these fishers, abalone fishing comprises a large part of their income.

Assessment of Abalone Fishery

Group and Individual Interviews

A focus group discussion was conducted among abalone gatherers to collect data on abalone gathering and collection methods, abalone species caught, average catch per day, time of collection, marketing, biology and ecology, and historical trends in fish catch. Additional information was collected via individual interviews with abalone gatherers who were also identified as possible cooperators in the experiential activity/Farmer Field School (FFS) activity.

Transect and Actual Catch Data

Transect surveys were done in Carot (Banlag and Purod Wilda) and in barangay Tondol on December 18 and 19, 2012, respectively. Tondol was included as a basis for comparison as abalone can also be found in that area. Three replicate 50m x 5m belt transects were established in each site and all abalone within the belt were counted. In addition, on March 14, 2011, the catch composition of two cooperators was examined to validate data gathered from the interviews and actual survey.

Abalone Mariculture Using the Farmer Field School (FFS) Concept

The FFS is a group-based learning process that involves actual interactions with and among gatherers/farmers (Gallagher 2003). In this process, the participants carry out experiential learning activities that help them understand the ecology of abalone. In this particular study, these activities involved growth experiments, regular field observations, and group analysis. Likewise, the local research partners/ cooperators were involved in this undertaking through experiential (participatory) experimentation concerning culturing abalone in cages as a way to enhance the recovery of abalone stocks and as a possible supplemental source of livelihood.

Identification of Cooperators

Six abalone gatherers were chosen to implement the project based on the following criteria:

1. Must be an active member of the community, preferably a group leader;
2. Has attended a basic seminar on the biology and culture of abalone;
3. Interested in conducting experimental/trial grow-out of abalone in cages;
4. Has time for the activity; and
5. Has time to attend monthly regular meetings as well as emergency meetings, especially when problems arise during the course of the activity.

The tasks of the cooperators included: participation in the mentoring sessions; setting up of cage culture sites; stocking, monitoring the growth and development of stocked individuals; cleaning and maintenance of the cages; feeding; and recording any unusual observations. Cage materials were provided by the researcher. The labor and maintenance were provided by the cooperators as their contribution in the experiential activity. It was also agreed with the cooperators that they should harvest only stocks that had attained a shell length of 50 mm — mature abalone that have already spawned many times and have already contributed to the replenishment of the population. It was made clear to them that there should be no immediate expectations of profit, but it was hoped that the practice could serve as reproductive reserves to further replenish natural stocks. It was emphasized that abalone or *H. asinina* attains sexual maturity at 35 mm and spawns at 13-15 day intervals (Capinpin and others 1998). It was also an agreed policy to leave or retain a part of the harvest in the cages to be released in a nearby marine protected area.

Source of Abalone

For stock conservation and resource management purposes, it was best to use native stocks rather than those coming from another region since the latter might have a different genetic structure that could pose a threat to the genetic diversity of the local stocks. However, local stocks were difficult to find in large numbers so only a few small wild abalone were used.

Grow-out Experiments

Net cages measuring 50 X 50 X 20 cm were constructed using polyvinyl chloride (PVC) pipes fitted together and covered with nets similar to that used by Capinpin and others (1999). Two pieces of PVC gutter were placed inside each cage as shelters. The cages were suspended and tied to bamboo poles set at depths of about 1.5 m. It was ensured that the cages were not exposed during the lowest tides. Two trials were conducted, with each trial consisting of three replicate cages. The stocking densities, initial sizes, and date of stocking of small wild abalone are shown in Table 1.

Table 1. Stocking densities, initial sizes and date of stocking of abalone grown in sea cages

Trial	Stocking Density (Abalone/Cage)	Initial Size (cm)	Initial Weight (g)	Date of Stocking
1	25	42.74±0.54	16.60	April 8, 2011
2	50	40.99±0.80	14.39	May 30, 2011

Mean of 3 replicates
Mean±SE

The abalone mariculture was conducted for 3-4 months or up to 120 days. Feeding was done at weekly intervals by providing a pre-determined amount of the algae found in the area, preferably *Hydropuntia edulis* (=*Gracilaria coronopifolia*) using the established daily feeding scheme as a guide (Capinpin and others 1999).

The grow-out area (N 16°20’52.8" E 119°59’38.9") for pilot culture was accessible to the cooperators and visible from their residences, allowing them to guard the site against poaching. The site is also a natural seagrass area, dominated by *Enhalus acoroides* and *Thalassia hemprichii*. Water depth is about 1.5 m during the lowest tide, and water circulates freely. There are no freshwater tributaries in the vicinity.

Growth Evaluation

Abalone length and weight were measured every 15 days. Shell lengths were measured using a Vernier caliper and weights were measured using a kitchen weighing balance. Mean weights were determined by taking the biomass (total weight of the sample) divided by the total number of animals. Mean shell lengths were taken from all the stocked individuals.

Daily growth rates in terms of weight (DG_W) and shell length (DG_{SL}) were also calculated as follows:

$$DG_W\,(\text{g day}^{-1}) = G_W/n$$

$$DG_{SL}\,(\mu\text{m day}^{-1}) = G_{SL}/n$$

where G_W is increase in weight (g) calculated as final weight minus initial weight, G_{SL} is increase in shell length (µm) calculated as final length minus initial length, and *n* is days of culture.

Physico-chemical Parameters

Physico-chemical parameters such as temperature, salinity, pH, ammonia, and nitrite were recorded weekly.

Assessment of Reseeding as a Resource Conservation Strategy

To reiterate, it was agreed upon at the start of the mariculture activity that a portion of the harvest will be set aside for reseeding in a nearby marine protected area. Prior to the release, the abalone were tagged using Dymo and glue and placed in cut PVC pipes adapted from McCormick and others (1994). This method allows the easy transport of abalone and affords protection from predation immediately after transfer. Upon reaching the reseeding site, one end of each pipe was lodged in crevices or between boulders where the abalone can avoid exposure and exit safely. The site was revisited after one day to observe movement and/or presence of empty shells.

Statistical Treatment and Data Analysis

Frequencies, means and percentages were computed to summarize and describe the results. Additional data were presented in descriptive form as narrated by the subjects.

Cost and Return Analysis

A simple cost and return analysis was done based on the following assumptions:

1. The farmers would use indigenous materials such as bamboo for cages instead of PVC materials, which was provided to them in the present study; and
2. The sale of abalone would be at PhP 400/kg, which is the current farm gate price (Encena and Bayona 2010).

RESULTS AND DISCUSSION

Assessment of Abalone Fishery

There are two abalone species found in Anda, Pangasinan, namely *Haliotis asinina* and *H. planata*. Of the two species, only *H. asinina* was gathered as *H. planata* was rare. *H. asinina* has the potential for culture because of its large size and body weight and fast growth rate (Capinpin and Corre 1996, Capinpin and others 1999).

There were two types of abalone gatherers: the daytime and the night-time gatherers. The daytime collectors used a face mask and an improvised hook to collect abalone. The night-time collectors used a face mask, hook, and a lighting device (Petromax). Both types of fishers used rafts in order to move around the fishing ground and improvised nets (nylon or bamboo) to hold collected abalone.

Of the 12 abalone gatherers interviewed, 67% were regular day time gatherers and 33% were regular night-time gatherers. They also gleaned other commercially important invertebrates such as sea cucumbers, sea urchins, and other shellfishes. All of them have more than ten (10) years experience in abalone gathering.

Interviewees claimed that night-time gatherers collected more abalone than daytime gatherers. Night-time gatherers harvested up to 10 kg each of abalone. This is not surprising as abalone are nocturnal animals. They hide under rocks and in crevices at daytime and move out at night to feed on seaweeds. Night divers need not overturn the rocks since abalone are out searching for food or spawn when they are gravid during new and full moon periods (Capinpin and Hosoya 1995, Counihan and others 2001). Ready-to-spawn abalone are active, with their foot relaxed and flabby (Breen and Adkins 1981, Setyono 2006). Setyono (2006) observed that they do not retract their foot when touched, and would even crawl freely onto one's hand when handled. Night divers noted that abalone were easy to catch at this time; describing them (abalone) as *maamo* (tame) and *madulas* (loosely attached to the substratum).

Night divers go fishing during the new and full moon periods because they can collect more abalone during these times. The divers would fish for about 2-3 consecutive nights without missing any particular night. Depending on sea conditions, all the night divers would fish until dawn, i.e. up to 6-7 hours at a time.

For *H. asinina*, spawning episodes coincide with new and full moons for recently captured abalone held in tanks (Capinpin and Hosoya 1995, Counihan and others 2001).

Actual Catch Data

Figures 1 and 2 show the size distribution of the catch of the two fisher-cooperators.

For the first cooperator, the 34 pieces of abalone caught in a 4-h fishing operation had a total weight of 1.2 kg with an average weight of 35.29 g. This corresponds to a catch per unit effort (CPUE) of 300 g/h. The biggest number (41%) of the catch fall under the 5.1-5.5 cm size category. Overall, 68% of the catch was over 5 cm in size and within the agreed legal size limit among the cooperators (Fig. 1). On the

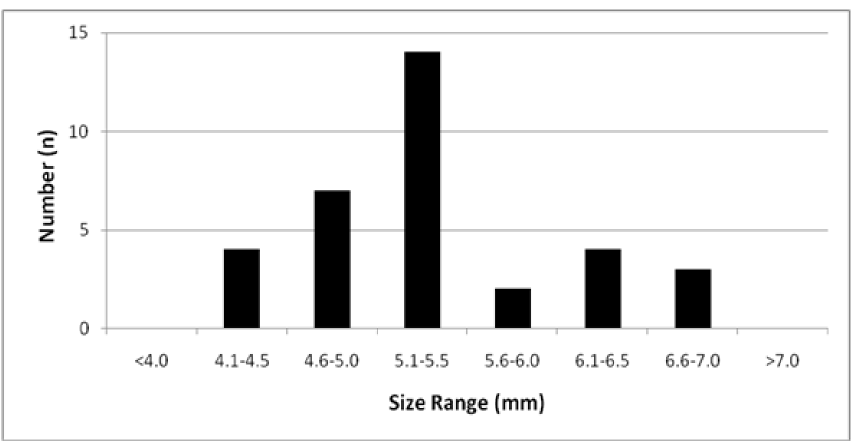

Figure 1. Size frequency distribution of abalone catch (n=34) of Cooperator #1 off the coast of Cabungan near the sanctuary in a 4-h fishing operation.

other hand, the total catch of the second cooperator (Fig. 2) in a 3-h fishing operation off Cangaluyan Island consisted of 29 pieces for a total weight of 1.15 kg or a mean weight of 39.65 g. The biggest number (45%) of the catch fell in the 6.1-6.5 cm category. The computed CPUE was 383 g/h. Overall, 83% of the total catch was over 5 cm in size, which was considered as legal size limit.

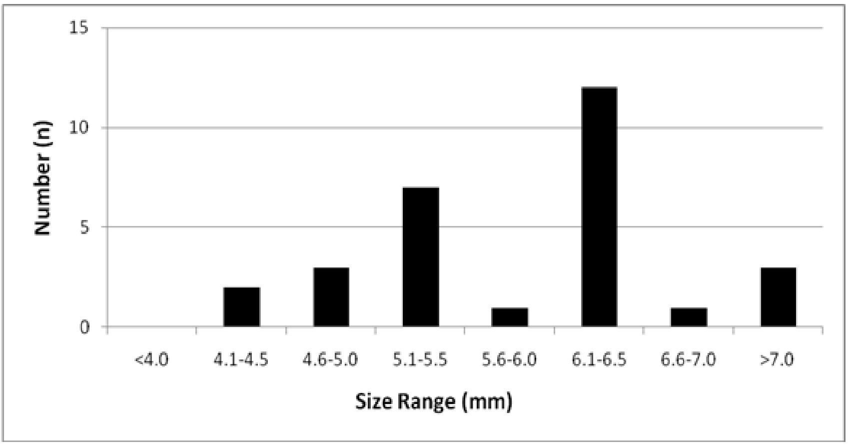

Figure 2. Size frequency distribution of abalone catch (n=29) of Cooperator #2 off Cangaluyan Island in a 3-h fishing operation.

Sungthong and others (1993) surveyed the distribution of wild *H. asinina* around Samet Island in Thailand in 1989 and reported the number of abalone collected by divers per hour (CPUE) from 5.79-6.00 in Hin Khan Na and 9.5-10.25 in Ao Thien Reefs. The CPUEs of the two fishermen of 8.5-9.7 abalone per hour in the present study was comparable to that in Ao Thien Reef (9.5-10.25 abalone per hour) in Samet Island.

Abalone smaller than 5 cm represented 25% (16/63) of the combined catches. Fishers typically include small abalone (<5 cm) when they sell their catch. As much as 1/4 of abalone caught in local waters may be grown further to a larger size for better profit, as well as allowing them to reproduce many times before harvest.

Transect Surveys

Table 2 shows the estimated density from the transect surveys at Carot (Banlag and Purod Wilda) and Tondol. There were more abalone collected in Banlag than in Purod Wilda and Tondol. Abalone were cryptic during daytime when the survey was done and the distribution was highly dependent on the presence of suitable rocky substrates.

The observed densities of abalone were 8.00, 1.67, and 3.33 per 250 m^2 of surveyed area in Banlag, Purod Wilda, and Tondol, respectively. The observed densities in Banlag (3.2 per 100 m^2) were similar to the study of Maliao and others (2004) on selected open access areas in Sagay, Negros Occidental. The densities in Purod Wilda and in Tondol were lower (0.67-1.33 per 100 m^2). Maliao and others (2004) reported higher mean abalone densities in MPA areas in Sagay, implying that a properly enforced no-take MPA can promote recovery of local stocks.

Table 2. Actual density of abalone inside the 250 m^2 belt transect

Site		Coordinates	Number (per 250 m^{-2})
Banlag in Carot	Transect 1	N 16° 21’33.2" E 120°00’06.6"	10
	Transect 2	N 16° 21’34.3" E 120°00’06.4"	10
	Transect 3	N 16° 21’45.6" E 120°00’06.6"	4
		Mean	**8.00**
Purod in Carot	Transect 1	N 16° 21’26.5" E 120° 00’04.4"	1
	Transect 2	N 16° 21’23.9" E 120° 00’01.6"	0
	Transect 3	N 16° 21’17.5" E 120° 00’01.5"	4
		Mean	**1.67**
Tondol	Transect 1	N 16°19’24.8" E 120° 00’04.7"	1
	Transect 2	N 16°19’09.2" E 120°01’21.7"	3
	Transect 3	N 16°19’12.5" E 120°01’23.0"	6
		Mean	**3.33**

Catch Data Based on Interview

Based on interviews, the current catch of daytime fishers ranges from 1 to 2 kg in a typical fishing trip lasting about 4-6 h, from about 8 am to about 2 pm. On the other hand, night-time gatherers can collect as high as 7-10 kg each during the whole night but at a much limited time, depending on sea conditions as well as on the phase of the moon. Comparing the actual catch data and what the fisherfolk revealed in the interview, it can be inferred that the data from interviews were valid and approximated the actual data. This implies that, with validation, the information gathered from interviews can be a useful companion to standard scientific approaches.

Local Trade and Market

Abalone fishers currently have two buyers in the area. One of them buys their catch at PhP130/kg. The other buyer, a Korean, buys abalone at a higher price of PhP190-200/kg. The Korean reportedly transferred to Balingasay, Bolinao and entrusted the buying of abalone to a local resident from Barangay Cabungan. However, this person would not pay cash upon delivery. Hence, some fishers are forced to sell their catch to the local buyer in Carot at a much lower price in exchange for immediate cash. Thus, there is the need to find an alternative market for abalone collected in Anda, as abalone is an expensive food item in luxury restaurants.

The fishers stated that they sell their abalone catch live or fresh to the buyers. The buyer from Carot processes the abalone catch by salting and boiling them before these are delivered to Manila. The Korean sells live abalone directly to restaurants in nearby Dagupan City, Angeles City, or Baguio City or directly to other Koreans. Abalone has a traditional place in Asian societies particularly China, Japan, and Korea as an item of prestige, and is considered customary in banquets and traditional feasts (Oakes and Ponte 1996).

Growth and Survival of Cultured Abalone

First Trial

The first batch of small wild abalone was stocked on April 8, 2011 and the culture ended on July 8, 2011. Within three months of culture, the mean shell length increased from 42.74 ± 0.54 mm to 49.55 ± 0.30 mm (Table 3). On the other hand, the mean total weight increased from 16.60 ± 0.70 g to 24.78 ± 1.61 g. The harvest of the stocks was done after reaching an agreed size of about 50 mm. All of the harvested stocks were mature and had ripe gonads. Capinpin and others (1998) identified that sexual maturity of this species is reached at a size of 35 mm for both male and females and it is assumed they have spawned every 2 weeks following a lunar cycle. Thus, the cultured stocks had contributed to repopulating the

Table 3. Mean shell length (mm), mean weight (g) and survival rates (%) of the first batch of wild abalone cultured in net cages for 90 days (Trial 1)

Days	Mean Shell Length (mm)	Mean Weight (g)	Survival Rate (%)
0	42.7±0.5	16.6	100.0±0.0
15	43.3±0.6	17.2	100.0±0.0
30	44.2±0.6	18.9	100.0±0.0
45	44.4±0.6	19.8	100.0±0.0
60	45.3±1.1	20.2	96.0±2.3
75	47.2±0.8	21.2	92.0±4.0
90	49.6±0.3	24.8	92.0±4.0

Mean of 3 replicates
Mean±SE

surrounding areas. The survival rate of cultured abalone was high, ranging from 88-100% with a mean of 92.0 ± 4.0 %.

A total of about 1.7 kg was harvested from the 3 cages utilized in the first batch. The growth rates, however, were very low (Table 4) compared to the results obtained by Capinpin and others (1999), wherein the growth rates were above 100 μm d^{-1} in shell growth and above 0.20 g d^{-1} in weight for abalone stocked in sea cages with similar stocking densities. Likewise, the survival rates were lower at 92% in the present study compared to >95% in the previous study at similar stocking densities (Capinpin and others 1999).

Table 4. Mean growth rates in length (DG_{SL}) and weight (DG_w) of the first batch of wild abalone cultured for 90 days (Trial 1)

Replicate	DG_W (g d^{-1})	DG_{SL} (μm d^{-1})
1	0.12	79.44
2	0.11	88.89
3	0.04	58.67
Mean	**0.09**	**75.67±8.93**

Mean±SE

In contrast, the results of the present study were comparable to abalone cultured in tanks with limited water exchange (Capinpin and Corre 1996). In the latter, the researchers reported mean daily growth rates of 55.8 μm d^{-1} in shell length and 0.09 g d^{-1} in weight during the later part of the culture period when the abalone were larger. Further, they observed a decreasing trend in growth rates during the latter part of the feeding experiment. This reduction in growth rates of abalone was possibly due to the requirement for energy during gonad maturation. The slowing of growth rate following sexual maturity in abalone is well known and has been attributed to the channeling of energy into gonad development (Capinpin and Corre 1996, Mercer and others 1993).

Similar results were observed by Estepa and Meñez (2001)in their study on sea cucumbers. They observed the slowing of growth of sea cucumbers during the latter part of their 8-month culture in pens in Pilar, Bolinao. They speculated that growth slowed down when the samples reached mean weights of over 240 g, possibly as an indication that the species had reached its maturity stage.

Second trial

Table 5 shows the mean growth in length, weight, and survival rates of small wild abalone cultured for 105 days.

Table 5. Mean shell length (mm), mean weight (g) and survival rates (%) of the second batch of wild abalone cultured in net cages for 105 days (Trial 2)

Days	Mean Shell Length (mm)	Mean Weight (g)	Survival Rate (%)
0	41.0 ± 0.8	14.4	100.0 ± 0.0
15	41.4 ± 1.2	14.6	93.3 ± 4.7
30	41.7 ± 1.4	15.6	84.7 ± 3.7
45	43.3 ± 1.4	16.1	71.3 ± 2.4
60	45.4 ± 2.2	19.7	62.0 ± 7.0
75	46.0 ± 2.1	20.2	58.7 ± 8.7
90	48.8 ± 1.1	22.2	54.0 ± 10.1
105	49.7 ± 1.1	23.2	41.3 ± 15.5

Mean of 3 replicates
Mean±SE

The second batch of abalone grew from 40.99 mm to 49.71 mm in shell length and from 14.39 g to 23.17 g in weight after 105 days. The culture period took a longer time to complete because of the smaller initial size of the second batch (40.99±0.80 mm) compared to the first batch (42.74±0.54 mm). The computed growth rate was 83.02 µm day^{-1} in terms of shell length and 0.084 g day^{-1} in terms of weight (Table 6). These were comparable to that observed in the first batch, but also lower than earlier results of Capinpin and others (1999). Trial 2 survival rates were also lower compared to the first batch due to prolonged heavy rains. It began after one month from stocking up to the end of the culture period.

Table 6. Mean daily growth rates in terms of length (DG_{SL}) and weight (DG_w) of small wild abalone cultured in sea cages for 105 days (Trial 2)

Replicate	DG_W (g d^{-1})	DG_{SL} (µm d^{-1})
1	0.06	78.00
2	0.08	82.48
3	0.12	88.57
Mean	**0.08**	**83.02±3.06**

Mean±SE

It is also a well-known fact that the growth of abalone and other shellfish decreases as stocking density increases. Consequently, it takes a longer time to reach harvest size (Capinpin and others 1999).

Similar mortalities were observed for sea urchins cultured in pens in Bolinao (Bangi and Meñez 2001). The death of balding sea urchins in cages was attributed partly to the occurrence of a phenomenon they called "kulaba" or water poisoning observed to occur annually during the rainy months, and partly due to high stocking density.

Physico-chemical Properties of Water

Water temperature and pH were in normal conditions and ranged from 29-33°C and from 8.0-8.6, respectively, throughout the culture period; whereas ammonia and nitrite were undetected and were always 0 mg/L and <0.3 mg/L, respectively, throughout the culture period. On the other hand, salinity ranged from 29.2 to 34.5 ppt (specific gravity, 1.022 to 1.026) during the whole of April up to June 14. It dropped to 23.9 from 26.6 ppt from June 29 to July 15 (specific gravity, 1.018 to 1.020) which corresponded to the time when typhoons Falcon and Goring ravaged northern Luzon. Even without typhoons, the continuous rain during this period lowered salinity levels that affected the cultured abalone. Normal seawater salinity is about 32-35 ppt. Salinity normalized from July 15 onwards until the end of the culture period, which allowed some of the abalone in Trial 2 to recover despite being exposed to prolonged heavy rains in an enclosed environment.

Cost and Return Analysis

Table 7 shows a simple cost and return analysis based on several assumptions such as the use of indigenous materials (e.g. bamboo) for the manufacture of cages and the increase of abalone price to PhP 400/kg, the current farm gate price for the species (Encena and Bayona 2010). Although a small net income was attained during the 3-month culture period, profitability can be increased on a larger scale (Encena and Bayona 2010) by improving survival rates and searching for new market opportunities.

Reseeding Into a Protected Area

Thirty six (36) abalone from the first harvest were tagged for reseeding; the rest were processed and sold. The tagged abalone were released into the Panacalan MPA (N 16° 16' 07.0" E 120° 01' 42.7") in Macaleeng, Anda on July 11, 2011. Macaleeng is about an hour of boat-ride from Carot.

Table 7. A simple cost and return analysis of abalone mariculture based on the results of Trial 1 using 3 cages with a stocking density of 25 abalone per cage and cultured for 90 days

Production (kg)	1.7
Survival Rate (%)	92
Farm Gate Price (PhP/kg)	400
Cost of Seed (PhP 2/abalone X 75)*	150
Cost of cage (PhP 75 X 3 cages)**	225
Gross Revenue (PhP)	680
Net Income (PhP)	305

*Cost of small abalone weighing an average of 15 g at PhP 130/kg, the actual price fishers sell their catch in the area
**Cage made of bamboo frame covered with net

Anda has five MPAs situated in Carot (13.3 ha), Cabungan (18 ha), Caniogan (9.8 ha), Magsaysay (14.8 ha), and Panacalan (48.59 ha). The MPAs in Carot and Cabungan were the earliest established (1998) while Panacalan was the most recent (2003) (Salmo and others 2005). However, according to the cooperators, the sanctuary in Carot is no longer operational. Even in 2004, Salmo and others (2005) reported that there had been problems in enforcement due to the weakening of people's organizations (POs) in the area, which is attributed to changes in leadership of these POs. The Panacalan MPA was chosen as the reseeding site because it is the most well-enforced MPA to date in the area. The 36 tagged abalone reflect the commitment made by the cooperators at the start of the mariculture activity.

The use of cut PVC pipes in reseeding minimizes handling stress and protects abalone from predation during and after their placement on the ocean floor. Tegner and Butler (1985) noted that abalone handled excessively produce mucus which then attracts predators. High mortalities often occur within hours of transplantation. Protection during the initial hours following placement allows the abalone to recover from handling and transport stress and become acclimated to the release site. In addition to providing a safe refuge during the initial acclimation period, the configuration of the planting module is such that one end can be lodged in crevices or between boulders. The abalone can thus avoid exposure and can exit safely. The site was revisited after one day and it was observed that all tagged abalone left the PVC pipes and took refuge in the surrounding crevices. A search for empty shells in the surrounding areas revealed no mortality due to reseeding and/or predation. It is assumed that the abalone were able to disperse into the surrounding areas safely.

Studies on the effect of abalone size at the time of release have indicated that, at least for some species, there is an optimal size for maximum survival. For instance, the survival of juvenile Madaka *(H. gigantea)* abalone after one year in the ocean increased from 10 to 70% as the size of the abalone planted was increased from 10 to 30 mm (Inoue 1976 as cited in McCormick and others 1994). In this study, though the number released was low (only 36), the abalone released was large (about 5 cm) and came previously from the wild, and had a strong chance to survive.

Experiential Mariculture Activity

The mariculture activity following the FFS concept was very interesting and meaningful to the local cooperators. It is because the FFS is particularly adapted to field study, where specific hands-on management skills are required (Gallagher 2003, Gallagher and others 2006). The cooperators were more comfortable in the field than in classrooms as there were no lectures and all activities were based on experiential, participatory, hands-on work. In the experiential activity/FFS, the field itself became the "teacher" as it provided most of the training materials such as the cultured animal, seaweeds as its food, its predators, pests and other real problems. The activities included in the experiential activity followed the natural cycle of their subjects. In this case, the cycle was from "abalone seed" to a "mature abalone" that contributed to the replenishment of its population. As much as possible, the approach allowed all aspects of the subject to be covered, in parallel with what was happening in the field. The lessons sharpened the cooperators' skills in the areas of observation, problem-solving, and decision-making, and helped develop their critical thinking (Gallagher 2003, Gallagher and others 2006). It was ensured that the activities were participatory and hands-on so as to encourage learning.

Being a hands-on activity, it was a new experience for the cooperators specifically on how to address both their resource management and economic needs. This activity was envisioned to contribute in enhancing abalone populations while heightening the fisherfolk's ecological knowledge of the life history of abalone and its culture. At the same time, it was viewed as a potential means to provide supplemental source of livelihood.

The experimental activity helped the cooperators to understand the importance of choosing a suitable site for the cultured species. They learned that mariculture should be done during fair weather (i.e. November to April or May) and that the cages are best located further out in the sea to avoid the lowering of the salinity during heavy rains. The experiments, though limited, reinforced what they learned in their lecture. They learned the importance of monitoring the growth and survival of the organisms as well as water quality parameters. This gave them an idea about how long it would take to culture the abalone and to determine the optimal time to harvest. The activity heightened their environmental awareness and understanding of the ecological principles and the rationale for resource management (Capinpin 2012).

In the experiential activity, the researcher became a facilitator who assisted the cooperators to learn from their experience towards sustainable practices and resource management. This is opposed to technology transfer wherein an extension staff is expected to be an expert conveying lessons from the research to farmers in a top-down approach, particularly when there are no hands-on activities.

During the experiments, several problems arose such as the low survival of abalone in Trial 2, and the need to reevaluate task and time allotment of each member for the different maintenance activities. Using the FFS concept in mariculture, the learners advanced because they were given a free hand to learn and to decide which problem-solving steps they would to take during the mariculture activity. In the process, the cooperators participated in providing solutions as well as refinements and adjustments to the techniques and time allotment schemes. They also suggested ways on how to grow the abalone faster based on their own observations and experiences. Thus, the activity provided them with a sense of ownership over the resource and responsibility towards their actions.

CONCLUSION

Mariculture is an excellent tool for the conservation of fishery resources particularly abalone. It is also a sustainable supplemental source of livelihood. The viability of abalone mariculture is favored by the biological attributes of this species. Specifically, the abalone has fast development and growth rates. Likewise, the use of cages entails low capital outlay and maintenance cost. The growing of small abalone in sea cages can increase their size and weight, which translate to better prices when they are sold. It is recommended to replicate the mariculture of abalone in other areas to create dense breeding populations which can help in enhancing the existing breeders and the periodic release of abalone in sanctuaries (Capinpin 2012). Through actually performing the culture of abalone in cages, the cooperators gained technical skills in selecting suitable sites for the culture of these organisms as well as in choosing cultured species that feed low in the food chain (e.g. abalone). The cooperators also gained capability in monitoring the development of stocked individuals, and improved their knowledge on the biology of the cultured organism.

Overall, the experiential mariculture was considered as a successful activity in terms of providing experience to the cooperators in resource management and of providing a venue for the study of abalone mariculture as a supplemental source of livelihood.

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