VARIOUS FACTORS AFFECTING RECOVERY AND GROWTH RATE OF TRANSPLANTED MUSSELS *Perna viridis* (Linne)*

by

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ABSTRACT

One hundred twenty thousand green mussel, *Perna viridis* Linne spats ranging in size from 15 to 21 mm in length were collected at Sapian Bay, Capiz. They were transplanted in Cañas Bay, Ajuy municipality, Iloilo Province, Philippines and suspended from a raft using four different types of substrates, namely: Abaca or Manila rope (Musa textilis), cabo negro *(Arenga saccharifera),* sasa or nipa *(Nipa fruticans)* and polypropylene blue rope. Five stocking densities: 100, 200, 300, 400 and 500 mussels per meter rope were evaluated. The experiment was conducted from January 8 to April 23, 1978. Growth rate, recovery, optimum stocking density, optimum water depth and rope durability were determined.

Results show the feasibility of farming mussels in areas without natural spatfall by spat transplantation. For a 12 mm diameter rope, a stocking density of 200 to 300 mussels per meter rope gave a standardized production of 0.66 kg, per 100 mussels stocked, recovery rate of 52.7 to 54.42 per cent and a growth rate of 9.8 mm per month in 100 days culture period. Marketable size mussels over 50 mm in length with condition index of 47 per cent were obtained which compared favorably with those from natural spawning grounds.

INTRODUCTION

Mussels constitute one important fishery resource found in Philippine marine waters. It is a highly nutritive fishery resource which could help satisfy the protein requirement of the country.

There are two types of commercially exploited mussels in the Philippines, namely: the green bay mussel which consists of one species, *Perna viridis* (Linne) and the brown mussel which consists of *Modiolus metcalfei* and *M. philippinarum.* The green mussel was formerly referred to as *Mytilus smaragdinus.* Recent literature show that it is more properly classified as *Perna viridis,* Soot-Ryen, 1955 and Tan, 1974. Both the green bay and brown mussels are locally called *tahong* in Tagalog, *tahong* or *amahong* in Visayan, *dalig* and *saytil* in Ilocano. The green bay mussel, however,

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is the only species being cultivated due to its ability to settle on vertical substrates, unlike the brown mussels which settle only on their own kind and form a dense mat on the muddy bottoms of shallow bays (Yap, 1978).

Mussel culture was started in the Philippines in 1962 by the technical personnel of the Binakayan Demonstration Oyster Farm, Bureau of Fisheries in Bacoor Bay, Binakayan, Cavite, Luzon. Prior to this, mussels were considered as fouling organisms by oyster farmers due to their tendency to form dense settlement on oyster cultches and stakes, thus, competing with the oysters for space. Once its commercial value was recognized, its cultivation in Cavite became intensified.

Most mussel farms in the Philippines, notably in Bacoor Bay, Cavite, use bamboo stakes as culture substrate. This system of farming is popularly known as the "tulos" method. Modifications such as the provision for horizontal bamboo poles or "balag" and propping several bamboo poles against each other forming a wigwamlike structure had also been tried. Recently, in Sapian Bay, Capiz, rope webs tied in each corner to bamboo poles have been tried successfully. All of the farming techniques now in use, however, have two characteristics: (1) they are adaptable and easy to use only in areas where natural spatfall is found, (2) they are fixed to the bottom and tend to retard water flow and increase siltation.

The green mussel is found only in very few places: Bacoor Bay, Manila Bay, Luzon; Tinagong Dagat, Ibisan, President Roxas, Batan and Sapian municipalities, Capiz province; Banate Bay, Banate, Iloilo province; Hinigaran and Himamaylan municipalities, Negros Occidental province; Maqueda Bay, Samar Island; and Juban municipality, Sorsogon province. With the extensive Philippine coastline, there are probably many other areas where mussel could grow with proper introduction.

Mussel farming in Bacoor Bay, Cavite, Luzon has been greatly affected by pollution and siltation which are perhaps caused by rapid urbanization in surrounding areas. Due to these factors, a pressure has been felt to find an alternative site in Luzon. The Bureau of Fisheries and Aquatic Resources (BFAR) has had a long interest in transplantation and introduction of green mussels to areas outside Bacoor Bay. All past attempts, however, were based on transplantation of breeders with the idea of establishing breeding population in various places but had been unsuccessful.

In most other countries where mussel farming is practised, the system used involves collection of spats in one area and growing them at controlled ... through transplantation, regular thinning, and

transplantation and continuous culling. This is the system used in Spain, now the world's top producer of farmed mussels. By adapting these technologies under Philippine conditions and using locally available materials, it is hoped that potential areas could be tapped for mussel farming.

The objectives of this study are:

General objective

1. To test the feasibility of growing mussel spats outside of their natural spawning grounds by transplantation technology.

Specific objectives

1. To compare the use of four locally available ropes for mussel farming.
2. To determine the optimum stocking density of mussels for transplantation, using ropes as substrates.
3. To determine the water depth that will give the highest yield.

REVIEW OF LITERATURE

The first transplantation work on mussel using the raft method started in the later part of World War II in northwest Spain and could be credited to Spanish mussel farmers (Mason, 1971; Bardach *et al*, 1972; Maclean, 1972). Spats were obtained from the Atlantic Coast and transplanted to Galician Bay. From a series of bouchot method which is homologous to the stake method in the Philippines, the first mussel raft was introduced (Eversen, 1968; Field, 1922). The raft was simple and made of remains of old ships where rope hangings were suspended. At present, rafts are made out of molded fiberglass floats and buoys to increase their carrying capacity. An average size raft of 400 m^2 can accommodate about 500 rope hangings of mussels.

Two or more rafts are utilized during the culture period. A small raft with suspended tarred ropes made of locally woven sparto grass or one-half-inch diameter nylon rope, criss-crossed with one-half-inch square and one-foot-long wooden peg is set near the shore during spring for spat collection (Andrew, 1968). Four to six months later, the collectors are gathered, thinned and bound to growing ropes by very fine, large mesh rayon nettings (Anon, 1968; Andrew, 1968). The ropes are then suspended from bigger rafts located in deeper water where they are allowed to grow to marketable sizes (Figueras, 1976; Tortell, 1976; Bardach, Ryther and McLarney, 1972; Mandelli and Acuña, 1975; Macfarlane, 1971). During the growing period a second or third thinning is usually done to prevent over-crowding of the mussels. The method has been very successful and has made Spain the leading mussel producing nation in the world since 1968 with an estimated annual production of approximately 154,000 metric tons (Maclean, 1972).

The success of Spain in mussel farming using the suspended rope method stimulated various workers in other countries to further investigate the potential of such culture technique in several north European countries where the conventional sea bottom culture was impractical due to sudden changes of temperature, turbulence and strong waves (Dare & Davies, 1975).

In Venezuela, a slightly modified raft for the green mussel, *Perna perna*, transplantation gave encouraging results. Young mussels, 2.5 to 3.5 cm in length were bound to polypropylene rope, sisal ropes or wooden sticks or guatacaro by rayon nettings, ranging from 4.5 to 6.5 meters in length then hung on rafts varying in size from 35 to 400 m^2 and anchored in deep waters. When the mussels are about 4 to 5 cm in length, they are redistributed to additional ropes to prevent losses due to detachment and over crowding (Mandelli and Acuña, 1975; Tortell, 1976).

In Norway where the hydrobiological condition is sometimes unfavorable during summer due to rise in temperature, young mussels are gathered during spring and placed in polypropylene fiber net bags with mesh size of 6.5 mm x 12 mm and diameter of 3.0 cm and subsequently suspended from rafts in areas with favorable growing conditions (Bohle, 1971).

The use of other suspended materials for transplanting mussels such as plastic mesh cylinders tied at regular intervals with or without rope substrate and perforated plastic cones attached to ropes at 30 cm intervals, all designed to increase mussel production have been reported (Bohle, 1971; Mandelli and Acuña, 1975; Moeller and Giordano, 1975; MacFarlane, 1971; Tortell, 1976 and Chen, 1977).

The work on mussel transplantation is not limited to the off-bottom type. Work is also being done on the on-bottom system of mytiliculture. The British method is a unique example. Young mussels are manually collected from seeding grounds and sowed on artificial beds. Transplantation areas are usually on flats with plenty of sand and gravel covered with rich mud which is conducive to growth of planktonic organisms (Field, 1922).

In Holland, the world's second largest producer of mussels with an annual harvest of about 100,000 tons (Mason, 1971), the young mussels are gathered by dredge from natural spawning grounds with poor growing conditions and are planted in areas with abundant food (Korringa, 1976; Havinga, 1956).

All the above-mentioned mussel transplantation techniques applied were within the same body of water as the spawning ground. The first documented transplantation involving two different localities was done by Dare and Davies (1975) in eastern Irish Sea, England. Spats were collected on ropes from Morecambe Bay, Northwest England with high and regular spatfall throughout the year with the peak in May to July resulting to a heavy density settlement of about 100,000 to 200,000 spats per meter rope in spring. The collected seedlings were transplanted in Menai Strait, North Wales, an area with a very irregular and undetermined spatting season but with conditions favorable for shellfish growth. Despite the great mortality due to over crowding, fast current and turbulence during the experimental period, marketable mussels with an average length of 61 mm were harvested after six months.

In the Philippines, attempts by technical men of the Bureau of Fisheries and Aquatic Resources (BFAR) to develop a breeding population of mussels outside Bacoor Bay, Cavite, and other natural spawning grounds have not given encouraging results. Tortell (1975) attributed this to inadequate knowledge and resources. Researchers of the Southeast Asean Fisheries Development Center (SEAFDEC), Aquaculture Department conducted preliminary studies on mussel transplantation such as in Igang Bay, Aklan, and a milkfish pond in Leganes, Iloilo. The binder used was a plastic continuous stocking net known as "netlon" which turned out to be unsuitable. A more suitable netting material made out of abaca fiber was later on developed. The work on transplantation was not carried further (Yap, personal communication).

MATERIALS AND METHODS

Duration of the Study

This two-phased study was conducted in Cañas Bay, Ajuy, Iloilo from July 13, 1977 to April 23, 1978. The first phase was the survey and testing of the site for growth and survival of mussels from July 15 to September 10, 1977. The second phase was the setting of the main series of the experimental ropes and data collection from January 8 to April 23, 1978.

During the study period water temperature and dissolved oxygen were measured using a YSI model 55 DO meter, water transparency by a secchi disc, and salinity by AO T/C Goldberg refractometer. Plankton samples were collected by a Kitahara quantitative plankton net hauled vertically from a depth of 2 meters. Water samples were analyzed at the SEAFDEC Chemistry Laboratory at Tigbauan, Iloilo for phosphate, nitrite-N, ammonia-N and suspended organic matter using standard methods (Strickland and Parsons, 1968; APHA-AWWA-WPCF, 1975).

The Study Area

Cañas Bay is approximately 20 hectares in area, situated between 11°01'18"N and 11°04'12"N latitutdes and 122°54'48"E and 122°56'30'E longitudes (Figure 1). About 74 kilometers north of the city of Iloilo and accessible by land transportation, it is bounded by sitio Bay-ang, Ajuy, Iloilo at the eastern part, Bay-ang Point and sitio Santiago, Barotac Viejo at the western part. The bay opens to the south. Several freshwater streams from the surrounding watershed drain into the bay. Only five of these streams, however, are flowing during February to May each year.

The bay is an important fishing ground for the coastal populace. Common fishing gears used are hook and line, gill nets, push nets, fish corrals and crab pots. Fishes caught are goatfish, slipmouth, swordfish, nemipterids, *Sardinella,* anchovies, mullets, *Therapon spp.,* sole and flatfish and other marine species that are of minor importance.

The seabed is basically flat, the bottom consisting of gravel and sand with plenty of coral fragments near and at the seashore. Approaching the shoreline, the bottom tends to be of fine sand mixed with mud, decaying organic matter and silt.

Tidal range is from 0.6 to 1.75 meters. The deepest portion is at the mouth towards the middle of the bay which is 12 meters. Surface current velocity measured 23 cm per second during calm weather as measured by a current flow meter. The water of the bay is bluish-green at the middle becoming greenish as it approaches the shore. The physico-chemical parameters of the bay is presented in Figure 2. Salinity ranged from 25 to 33 parts per thousand (o/oo); dissolved oxygen from 6.3 to 9.8 parts per million (ppm) at the surface; water temperature average 28°C; phosphate from 0.0025 to 0.1680 ppm; nitrite-N from 0 to 0.0744 ppm; and suspended matter from 0.0136 to 0.054 milligrams per liter (mg/1). Water parameters are similar to that of Sapian Bay, Capiz, the source of spats for the study (Yap, 1976).

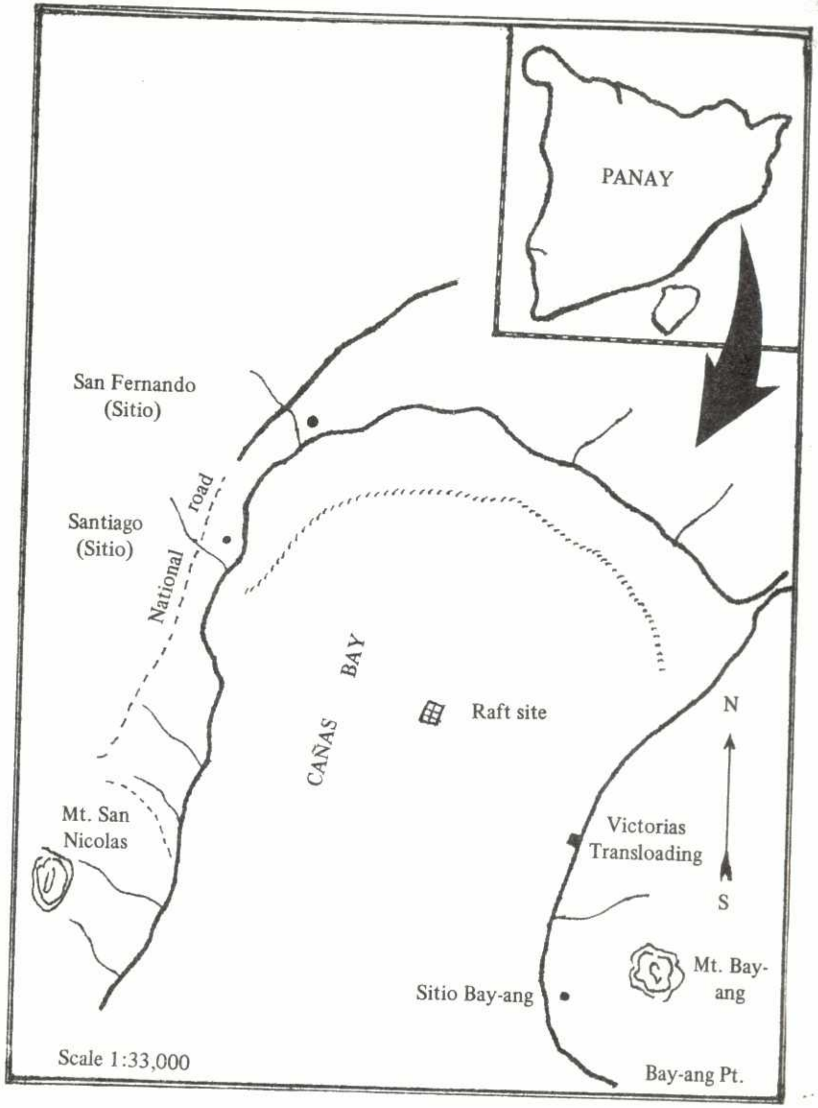


Figure 1. The study area, Cañas Bay, Ajuy, Iloilo showing the location of the raft.

Of the bivalves present, the oyster, *Crassostrea spp.* is the most abundant. It is, however, not farmed. Empty shells of cockles, *Arca sp.* and *Anadara sp.*; "kapis" or window pane oyster, *Placuna placenta;* clams, "paros" *Mya sp.;* venerids and scallops, *Amussium sp.* are found along the shore.

Swimming crabs, *Portunus sp.* are found in abundance in the Bay.

Barnacles are found in abundance attached to fish corrals, stones and other substrates in the intertidal and sublittoral zones.

Source of Spats

One hundred twenty thousand pieces of mussel spats ranging in length from 15 to 21 mm were procured from the mussel plots of the Bureau of Fisheries and Aquatic Resources and a private farm at Sapian Bay, Capiz, on January 6, 1978. The spats were transported in sacks to the SEAFDEC

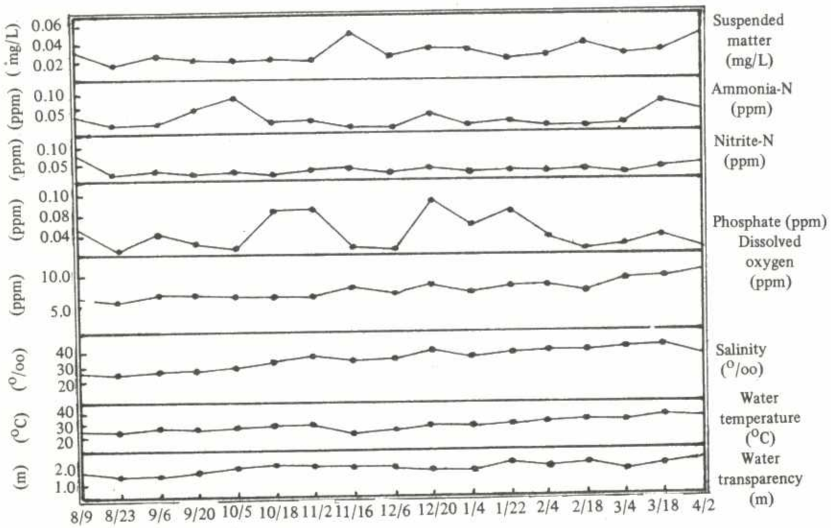


Figure 2. Hydrographic parameters of Cañas Bay, Ajuy, Iloilo during the

Laboratory in Tigbauan, Iloilo, where they were conditioned for one day in two wooden tanks with flowing seawater. During the conditioning process they were fed with cultured chlorella and diatom in the morning and afternoon.

Bamboo Raft

A bamboo raft, 8 meters long and 7 meters wide, consisting of three layers of bamboos lashed together with nylon monofilament line no. 150 was used in the study (Figure 3). The bamboos were set one-half meter apart. The culture ropes were suspended from the bottom most layer of bamboos.

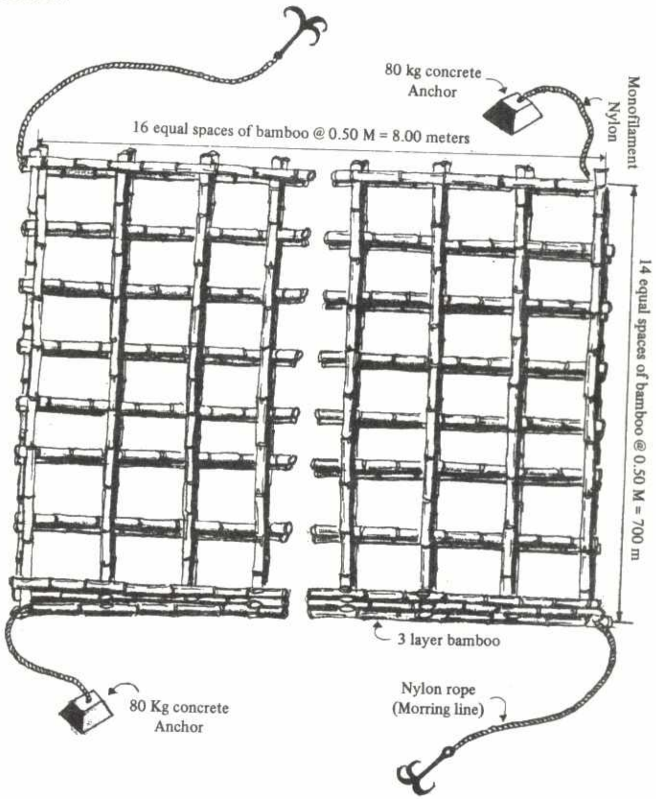
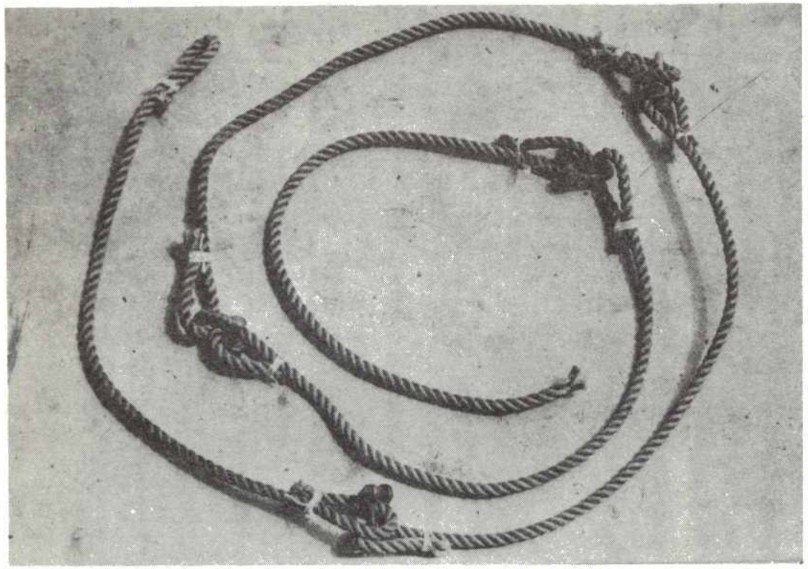


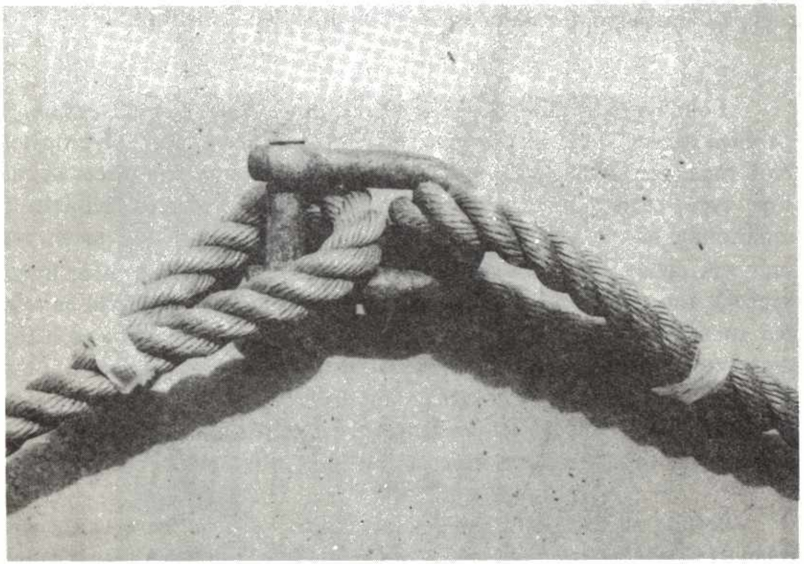
Figure 3. Detail of the bamboo raft used in the study.

The raft was moored at each end by two pronged iron anchors each weighing 20 kilograms and by two 80 kg. concrete blocks placed at opposite corners. Four 15 meters, 30 mm diameter polypropylene blue rope were used as mooring lines.

PLATE III



III-a. One rope unit composed of 5 segments (1 meter each).



III-b. Close-up shows how rope segments are joined by galvanized iron shackles.

taken using a top loading balance (sensitivity: 50 grams with maximum capacity of 10 kilograms).

The ropes were weighted down vertically underwater with cement sinkers weighing about one kilogram each.

The Experiment

Five stocking densities: 100, 200, 300, 400 and 500 mussels per meter segment of rope were tried. The total stocking per five meter rope unit were, therefore, 400, 800, 1200, 1600, and 2000 mussels respectively. For each density level three replicates were made. Additional two hangings for each density level were provided as source of mussels for shell length and weight measurement conducted fortnightly. Each rope was numbered accordingly from 1 to 25 using an embossed plastic tape tied with copper wire to the rope. The ropes were suspended from the raft using a randomized complete block design determined by drawing numbers.

Factors considered in the evaluation of data were: Rope Type (abaca, cabo negro, sasa or nipa and polypropylene blue ropes); Water Depth (1, 2, and 3 meters); and Stocking Density (100, 200, 300, 400 and 500 mussels per meter segment of rope).

Sampling of the Suspended Crops

Growth was monitored bi-weekly by individual shell length and live weight measurement of 25 mussels as well as by weighing each rope segment. A vernier caliper was used for shell length measurement, an Ohaus Dial-O-Gram for individual live weight determination, and a top loading commercial balance (capacity 10 kg, sensitivity 50 grams) for weighing the entire rope segments.

Survival was determined by actual count of the live mussel from each rope segment on April 23, 1978. This, however, could be done only on the polypropylene blue rope and cabo negro, all other rope types not having lasted through the study period. The highest production in biomass per rope segment in relation to stocking density was considered the best stocking rate for this particular study. In the evaluation and analysis, the lowest segment of the ropes (4 meter depth) was excluded because it was observed during the course of the study that they were touching the bottom and was subjected to mechanical abrasion resulting in severe losses. Ideally, in this type of culture the rope hangings should never be allowed to touch the bottom.

Table 1. Average number recovered and percentage recovery in relation to water dept, rope type and stocking density of transplanted mussels reared in Canas Bay, Ajuy, Iloilo from January 8 to April 23, 1978.

Rope Type	Water Depth (m)	STOCKING DENSITY 100 NR	100 %R	200 NR	200 %R	300 NR	300 %R	400 NR	400 %R	500 NR	500 %R
Polypropylene blue	1	46	46.0	98	49.0	119	39.76	155	38.8	170	33.93
	2	42	42.0	124	61.9	184	61.32	172	43.08	199	39.86
	3	35	35.0	125	62.66	179	59.54	149	34.92	212	42.3
	Mean	41	41.0	116	57.85	161	53.54	154	38.93	194	38.7
Cabo negro	1	38	38.0	80	39.83	147	48.98	164	41.08	162	32.46
	3	49	49.0	114	57.0	144	48.1	172	43.08	90	42.66
	3	49	49.0	114	57.0	144	48.1	172	43.08	90	18.0
	Mean	51	51.0	156	176	44.22	51.86	176	44.22	156	31.04

NR -- *Number of mussels recovered.*
%R – *Percentage recovery.*

Overall average percentage recovery = 45.86%

Upon harvest, samples of 25 mussels were taken at random to determine the condition index of the bivalve. Each mussel was weighed, opened and the meat removed. Excess water was allowed to blot on tissue paper before weighing. The condition index was computed using the following formula:

$$\frac{\text{Meat Weight}}{\text{Whole Weight}} \times 100 = \text{Condition Index}$$

The different ropes were evaluated as to their condition at the end of experiment.

RESULTS AND DISCUSSIONS

Recovery of the Transplanted Mussels

The original plan was to evaluate the recovery rate and production of the transplanted mussels at the end of the study period which was scheduled on June 8, 1978. The unexpected occurrence of typhoon Atang on April 19 to 22, 1978 forced the termination of the study on April 23, 1978. During the typhoon, the raft broke loose from its mooring and was carried to the shallow portion of the study area. All the abaca and sasa ropes broke from the raft. Only the cabo negro and polypropylene blue ropes remained on the raft. Attempts to recover the lost ropes were futile. The recovery rate could, therefore, be evaluated only on the polypropylene blue and cabo negro ropes.

Actual count of the mussels from the different ropes is presented in Table 1. Using the initial stocking number of mussels per rope segment and the actual number recovered, the percentage recovery was computed using the formula:

$$\frac{\text{Number of Mussels Recovered}}{\text{Initial Stocking Density}} \times 100 = \text{Percentage Recovery}$$

Statistical analysis of the data obtained from the actual number recovered of the transplanted mussels showed that stocking density and water depth were the most important factors affecting recovery rate (Table 2).

To pinpoint which among the stocking densities used gave the highest recovery rate, a test of significance among the treatment means was made by Duncan's Multiple Range Test (DMRT). Result is shown in Table 3.

Table 2. Analysis of variance (Anova) table on the recovery rate of transplanted mussels: A-Rope type, B-Water depth and C-Stocking densities.

Source of Variance	Degree of Freedom	Sum of Squares	Mean Squares	F-Value
Treatments	29	9867.79	340.268	4.243*
A	1	22.50	22.0	.2805
B	2	1623.09	811.545	10.119*
C	4	4645.17	1161.292	14.4799*
AB	2	403.40	201.7	2.521
AC	4	745.23	186.307	2.523
BC	8	1203.36	150.42	1.87
ABC	8	6035.04	754.63	9.409*
Error	60	4812.00	80.20	
Total	89			

**Significant at 5% level (F = 2.13, F = 4.98, F = 3.65, F = 2.82)*

Table 3. Treatment means of percentage recovery of transplanted mussels in relation to stocking density arranged from highest to lowest.

Stocking Density (Mussels/m rope)	Treatment Means[1] (%)	Statistical Significance[2]
200	54.42	a
300	52.70	ab
100	45.80	c
400	41.57	cd
500	34.86	c

[1]Mean of three replicates

[2]Any two means having a common letter are not significantly different from each other at 5% level.

Stocking density of 200 mussels per meter rope gave the highest recovery rate of 54.42 per cent, but this value did not give any significant difference with the recovery rate using stocking density of 300 mussels which was 52.7 per cent. It was expected that percentage recovery will be inversely proportional to stocking density, so that, the low recovery rate from stocking density of 100 mussels which was only 45.8 per cent could not be explained. It almost gave the same recovery rate as the stocking density of 400 which was 41.5 per cent. Stocking density of 500 mussels per meter rope gave the lowest recovery rate of only 34.86 per cent. It was observed that despite the care employed when detaching the shackles coupling from one rope segment to another and weighing them segment by segment, many mussels were detached from the rope hangings at the densities of 400 and 500 per meter.

Another reason for low recovery was due to migration of the mussels as shown by the presence of mussels on the underside of the raft and on nearby fish corrals. This phenomenon is a natural behavior of mussels. Maclean (1972), Bayne (1964) and Tortell (1978) reported that mussel spats tend to wander from one place to another before re-attaching permanently when they are transferred from their natural grounds to another area. This activity always results in the loss of stock from the culture ropes.

Table 4. Treatment means on percentage recovery of transplanted mussels in relation to water depth.

Water Depth	Treatment Means (%)	Statistical Significance*
2	52.04	a
3	45.92	b
1	40.78	c

** Each mean is statistically significant from one another at 5% level.* evel.

The type of rope does not appear to have any effect on the recovery rate. This observation, however, is based only on the two, polypropylene blue and cabo negro which lasted till the end of the study.

Water depth showed a moderate effect on recovery rate (Table 4). Recovery rate was highest at two meters depth with 52.04% followed by three meters depth with 45.92% and one meter depth with only 40.79%. The differences between means show statistical significance.

Recovery from the first meter depth was quite low. This might be due to the downward migration of mussels as a negative reaction to light (Maclean, 1977; Tortell, 1978; and Bayne, 1964).

Growth of the Transplanted Mussels

A bi-weekly sampling of 25 mussel samples taken at random from the different sampling ropes showed that from an initial average shell length of 1.9 cm and initial weight of 1.46 grams, the mussels attained a mean length of 5.43 cm and 8.9 grams in weight in 100 days culture period (Figure 4). This was equivalent to a shell length increase of 9.8 mm per month which compares favorably with the shell growth of 10 mm per month in Sapian Bay, Capiz and Himamaylan River, Negros Occidental (unpublished data). Increase in shell length of the transplanted mussel is shown in Plate IV.

The mussels showed signs of stress during transplantation from the source to the laboratory and then later to the study area through the presence of shell contortion or disturbance rings which clearly marked the size at transplantation, Plate V. Formation of disturbance rings is a common characteristic in all bivalve molluscs which have been subjected to stress such as when taken out of the water for a certain period of time. New shell growth appeared green compared with the original brownish color of the spats.

One desirable feature of suspended mussel culture is its amenability to a continuous monitoring of the total weight of the entire stock at any time which in effect gives the growth rate in biomass of each culture rope unit. The increase in biomass at each rope unit was linear with time (Figure 5). From an average initial weight of 0.11 kg. to 0.69 kg. at various stocking densities tested, the mussel attained an average weight of from 1.03 kg. to 2.31 kg. representing an average percentage weight gain of from 795% down to 234.8% (Table 5).

Statistical analysis of the data on the biomass shows that weight increment was mainly affected by stocking density, Table 6. Water depth did not show any effect, except in the analysis of the percentage weight gain, Table 7.

A comparison of treatment means on percentage weight gain at different water depths showed that the two meters depth of water gave the highest percentage weight gain of 567.66% compared to 513.12% for [illegible] Each mean is statistically different

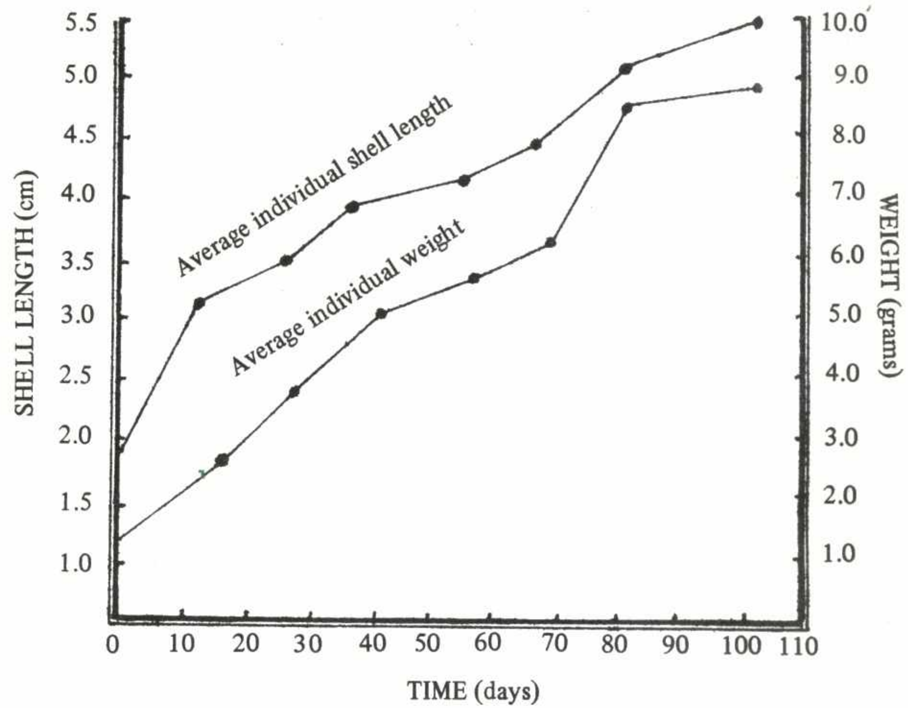
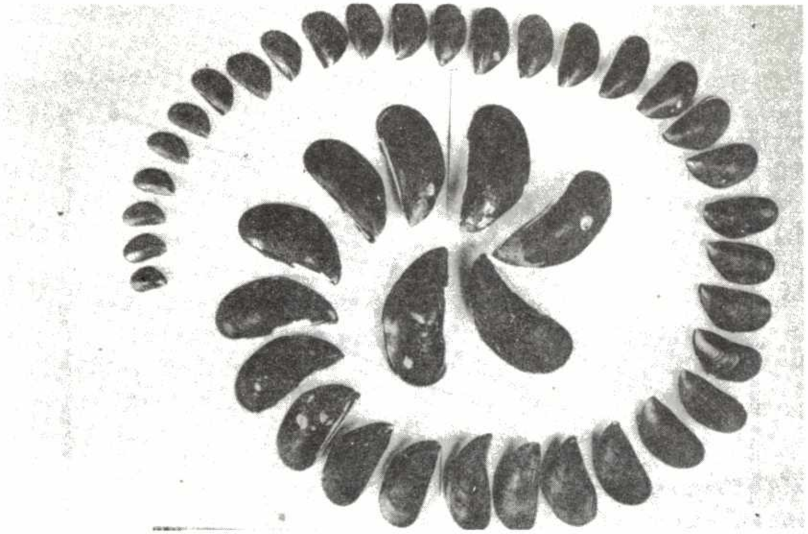


Figure 4. Growth, length and weight of transplanted mussels based on fornightly samples of 25 mussels, January 8 to April 19, 1978, Cañas Bay, Ajuy, Iloilo.

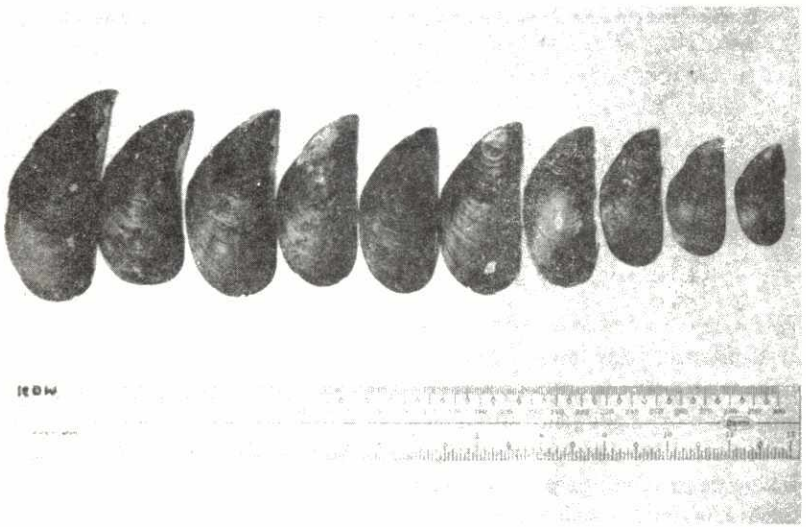
and significant from each other, although the difference is much more pronounced between the two meter and one meter water depths. But, again, the most significant differences on percentage weight gain appeared between stocking density. There is clearly an inverse relationship between stocking density and percentage weight gain. Individual mussel growth rate is higher in less crowded conditions. This confirms the findings of Dare and Davies (1975). It is for this reason that regular thinning is practised in mussel farming countries such as Spain (Bardach *et. al.* 1972).

PLATE IV



Growth rate of transplanted mussels in terms of shell length from January 8 to April 23, 1978.

PLATE V



Transplanted mussels exibiting disturbance rings on the outer shell as a result of stress during transplantion.

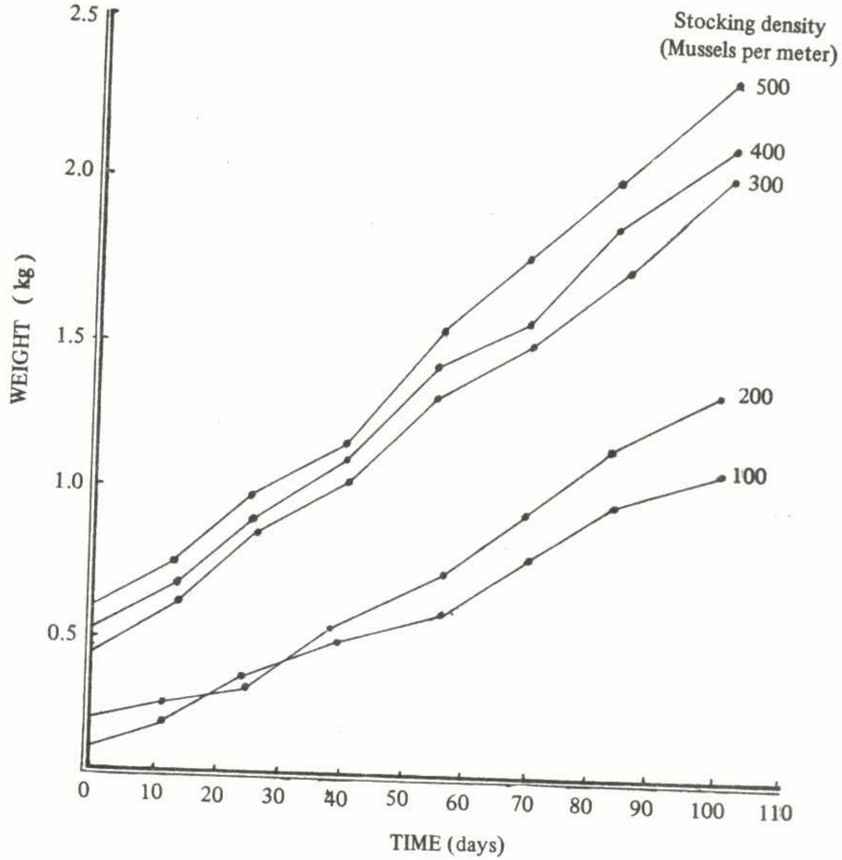


Figure 5. Increase in biomass per rope unit at different stocking densities of transplanted mussels, January 8 to April 19, 1978, Cañas Bay, Ajuy, Iloilo.

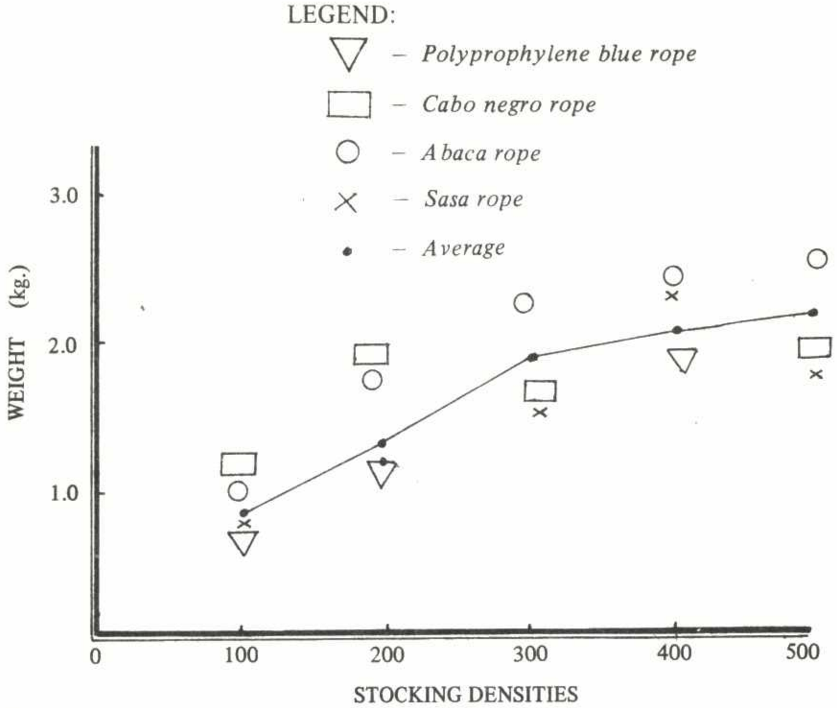


Figure 6. Relationship between stocking density and production per one rope unit of transplanted mussels after 100 days of culture, Cañas Bay, Ajuy, Iloilo.

Thinning as a process is laborious. Through appropriate stocking densities at transplantation, it is possible to aim for an optimum size without further thinning during the culture period. While larger mussels might be produced at lower stocking density, the overall production is still higher with increasing density. The increase in production, however, starts to decline beyond 300 mussels per meter rope (Figure 6).

The effect of stocking density on yield could be better evaluated by standardizing the production figure with weight per 100 mussels stocked. The highest figure is obtained at the 200 and 300 mussels per meter rope stocking density with 0.66 kg. per 100 mussels, dropping off to .52 kg. and .46 kg. respectively for 400 and 500 stocking densities. Since there is no significant difference in the production of mussels using stocking densities of 200 and 300 mussels per meter rope, it is concluded that a stocking density within the range of 200 to 300 mussels per meter rope is the best.

Condition Index or Quality of Mussels

Condition index is the percentage of flesh weight to total weight and is an indication of maturity of the mussels as affected by its stage of maturity (Yap *et. al,* 1976; Baird, 1977). Table 8 shows the condition index

Table 8. Condition index of twenty five transplanted mussels at the termination of the study on April 23, 1978.

Sample No.	WT. of Mussel (g)	Weight of Meat (g)	Sex	Condition Index (%)
1	26.0	15.1	female	58.0
2	32.5	18.1	–do–	55.6
3	19.4	9.0	–do–	46.4
4	22.4	11.4	–do–	50.8
5	16.3	8.0	–do–	49.0
6	13.6	6.6	male	48.5
7	20.0	10.0	–do–	50.0
8	15.0	6.8	–do–	45.3
9	20.0	9.0	–do–	45.0
10	18.5	8.3	–do–	44.8
11	17.5	8.0	–do–	45.7
12	25.1	12.6	–do–	50.1
13	17.5	7.7	–do–	44.0
14	13.4	6.3	male	47.0
15	20.9	11.0	female	52.6
16	21.1	10.9	–do–	51.6
17	19.6	8.2	–do–	41.8
18	14.3	6.3	–do–	44.0
19	12.1	5.2	–do–	42.9
20	19.1	8.1	–do–	42.4
21	21.3	11.3	–do–	53.0
22	13.4	6.0	–do–	44.7
23	13.6	5.6	male	41.1
24	13.9	5.3	female	38.1
25	11.3	4.9	–do–	43.3
Mean condition index				47.0

of 25 pieces of transplanted mussels on April 23, 1978. Most mussels by the time were above 50 mm, a size at which condition index reaches its maximum (Baird, 1977). The percentage weight of meat in relation to the whole live weight of the bivalve average 47% which is comparable to those gathered from the natural environment. Maclean (1975) stated that mussels with condition index above 40% are fat and ready for marketing, although, in the Philippines, mussels are marketed at any time of the year and at any size. A condition index below 40% indicates that the mussels are lean caused either by its reproductive stage (spent) or lack of food in the environment.

Among samples opened, females were dominant. The mesosoma were mostly small and were in the developing stage (Plate VI). It was possible that the bivalves had already spawned during the month of March. Yap et. al. (1979) reported that the peak of spawning of mussels in Sapian Bay, Capiz is February to March and September to October of each year, although spawning can take place all year round. No histological studies on the gonadal development was conducted on the mussels, but it is worthwhile mentioning here that spats measuring 2 to 4 mm (Plate VII) were found attached on the test raft and nearby fish corrals on November 1977 indicating that spawning must have taken place among the test animals used during the preliminary experiment.

Fouling Organisms

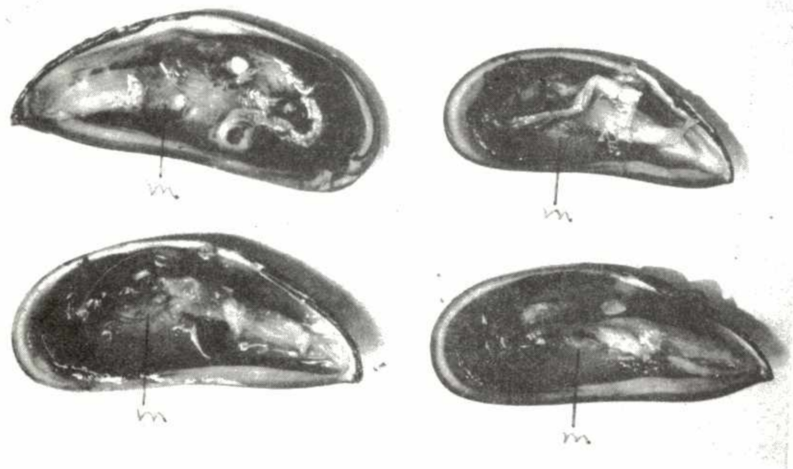
The most common fouling organisms encountered were: barnacles, tunicates, sponges, algae and coelenterates. Barnacles attached themselves abundantly on ropes and on mussels, particularly at the upper 30 cm depth of the water. The submerged portion of the raft was almost completely covered with barnacles and mussels.

A colonial tunicate, a whitish-gelatin-like organisms was found attached on ropes and on the mussel shells. While it did not appear to have an effect on the growth of affected mussels, it did make the mussels look unattractive for the market, however, they could be easily removed.

Some amount of algal growth and sponges gave the mussels a dirty yellow appearance, but again, they could easily be washed. A red alga, *Galaxaura sp.* appeared to be luxuriant during March, 1978. It was found on all ropes at different water depths. They were removed manually during every sampling and its proliferation was checked by Arpil, 1978.

An unidentified hydrozoan coelenterate which could be considered

PLATE VI



Transplanted mussels with small mesosoma at termination of the study on April 23, 1978.

PLATE VII

Spats measuring 2 to 4 mm in shell length collected from the test raft in November, 1977.

the most troublesome among the fouling organisms encountered was found attached to rope hangings and the raft. The nematocysts of the animal could cause painful blisters on any part of the human body upon contact. This made handling of the mussels difficult. This was removed carefully by hands with gloves whenever it was encountered.

SUMMARY

Increasing urbanization around traditionally rich mussel areas, notably the Manila Bay-Bacoor Bay, Cavite is causing a rapid degradation of the environment. There is, therefore, a need to find alternative locations which although presently devoid of mussels could be developed into mussel growing areas through spat transplantation.

This study conducted in Cañas Bay, Ajuy, Iloilo, an area not known to have green mussels shows the possibility of farming mussels using transplanted spats.

Four different types of rope were tested: (1) abaca or Manila rope *(Musa textilis)*, (2) *cabo negro (Arenga saccharifera)*, (3) *sasa* or nipa rope *(Nipa fruticans)*, and (4) polypropylene blue rope. There was no difference in the growth and recovery rate of mussels among rope types. As to durability, polypropylene blue rope proved to be the best, although cabo negro had shown certain strength also to withstand the inclement weather.

Sinamay strips can be used to bind the spats to ropes during the reattachment process.

Stocking densities ranging from 100 to 500 mussels per meter rope with increment of 100 mussels were tested. While larger mussels were produced at lower stocking density, the total yield per rope was considered rather low. Yield increased with increasing stocking density but showed declining yield increments over 300 mussels per meter rope.

The overall biomass production was highest at two meters depth. The lower yield at one meter can be attributed to downward migration of spats away from light. No biological importance can be given to the slightly higher yield at two meters depth compared with the three meter level.

The damage of the raft by a severe typhoon indicates that there is a need to study the engineering aspect of floating mussel farm structure. It is believed that damage can be minimized if not avoided all together

by using a design and installation techniques appropriate to the area. The buoy and long line system being employed in New Zealand for instance could be tried as an alternative to raft culture since one of its advantage is the ability to play with the waves in contrast to the raft which is rigid.

Likewise, a study on the effect of the rapid siltation on the present mussel farms, notably Sapian Bay, Capiz, should be made to preserve the area as seeding ground for mussel transplantation. The effect of the stake method of mussel culture on the environment needs a serious consideration

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