TRANSPLANTATION AND SURVIVAL RATE OF SEAGRASS *(Enhalus acoroides)* IN THE COASTAL AREAS OF TERNATE CAVITE

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Abstract

Based on the Coastal Conservation Management Unit-Provincial Environment and Natural Resource Office-Cavite, there is no current data about the existence of seagrass in the entire province, declaring "No Seagrass in Cavite." This study determined the physicochemical characteristics of the donor site and transplantation site for seagrass transplantation in terms of soil texture, pH, turbidity, temperature, and salinity; monitored the survival rate of transplanted seagrass; and formulated a strategic plan to be proposed for seagrass transplantation to the estuary in Ternate, Cavite. The physicochemical characteristics were analyzed using probes, wherein three trials were conducted during the assessment. The soil samples were obtained from three sampling points at the donor and transplantation site, and a soil texture analysis was conducted using the hydrometer method. Findings revealed that the donor and transplantation site have closer values in terms of the average pH, temperature, and soil texture; however, the transplantation site has a lower average value in terms of total dissolved solids. In the first trial of transplantation, no seagrass plants survived due to the extreme occurrence of low tide, and the site was dried since the water was not sufficient. In the second trial, 48% of the population survived at the newly selected site because the newly transplanted seagrass was still submerged in the water during the lowest tide. Matured Enhalus acoroides plants yielded an average survival rate and tolerance to desiccation. In the proposed strategic plan, it is crucial to assess the physicochemical characteristics of both transplantation site and donor site before the transplantation to determine their compatibility. Regular monitoring of the number of surviving seagrasses is highly recommended.

Keywords: marine conservation, restoration, rehabilitation, transplantation

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1.0 Introduction

Throughout the years, seagrass ecosystems have been relatively unknown and often underappreciated by the coastal communities, which significantly indicates that they are undervalued (Orth *et al.,* 2006). Seagrass ecosystem services are difficult to value and rank, and in many areas, the loss of seagrass would not directly affect the local communities (Nordlund *et al.,* 2013). The root causes of seagrass degradation in both tropical and temperate regions are biological, environmental, and climatological events (Orth *et al.,* 2016). The largest causes of seagrass degradation are primarily due to anthropogenic activities (McKenzie, 2003) such as coastal reclamation (Fortes, 2004), urban planning and coastal development (World Wide Fund, 2007), and the intensified degree of parameters such as sewage pollution, siltation and sedimentation, agricultural pollution and sea level rise that eventually lead to the destruction of mangrove forest and undervalues seagrass ecosystems (Fortes, 2012). Population pressure and economic necessities generate coastal development as well as destruction in areas occupied by seagrass, which is evident at present time (Paling *et al.,* 2001). It is most certain that the percentage of the population living adjacent to coastal waters, shores or estuaries will increase, indicating that the demand of marine products and other services associated with coastal resources will also increase, leading to the degradation and abuse of marine resources (Fortes, 1991).

Seagrass plays a vital role in a healthy marine ecosystem and forms a critical marine physicochemical system (Short *et al*., 2016). While seagrass provides a nursery for many commercial fish and other marine organisms and stabilizes the soil structure, it is also an important source of livelihood for fishermen and local communities living in coastal areas (Syukur *et al*., 2016). Seagrass ecosystems could store as much as 19.9 Pg (Petragrams) of organic carbon, and approximately the seagrass carbon pool slander between 4.2 and 8.4 Pg of carbon, suggesting the importance of the seagrass ecosystem to combat global warming (Fourqurean *et al*., 2012). The organic carbon in seagrass sediments is called blue carbon, which is accumulated from in-situ production from the water column (Greiner *et al.,* 2013).

The State of the Coasts of Cavite Province, the official online journal of the Coastal Conservation Management Unit of the Provincial Environment and Natural Resource Office of Cavite, stated that there were no current data and available information about the existence of seagrass in the entire province, declaring "No Seagrass in Cavite." On the other hand, the Provincial Environmental and Natural Resource Office, Cavite, introduced the GEF-Global Nutrient Cycle Project and explained that there are possible sites where seagrass ecosystem can be found based on the assessment conducted by National Mapping and Resource Information Authority (NAMRIA); hence, it is still subjected for validation and further tests.

Hence, this research aims to determine the factors that affect the donor and transplantation site, which in turn, determines the survival rate of the seagrass. The findings of this investigation will be used as the basis for the formulation of a strategic plan that can be proposed for seagrass transplantation in the coastal communities of Ternate Cavite. Specifically, the study aimed to: (1) determine the physicochemical characteristics of donor site and transplantation site in terms of soil texture, pH, turbidity, temperature and salinity; (2) determine the survival rate of transplanted seagrass; and (3) create a strategic plan that can be proposed for seagrass transplantation in the coastal communities in Ternate, Cavite.

2.0 Methodology

There were two (2) study sites for the study: (1) the estuary located at Barangay Quilitisan, Calatagan, Batangas 13.8845, 120.6266 (13° 53' North, 120° 38' East) (Figure 1), where *E. acoroides* matured plants were obtained, and (2) the estuary of Barangay Poblacion III, Ternate, Cavite (14.2890, 120), where seagrass was transplanted. A letter of request for the conduct of the study in the Ternate, Cavite was approved by the Municipal

Figure 1. Satellite Image of the donor and transplantation sites: A.) Quilitisan, Calatagan, Batangas, B.) Poblacion III, Ternate, Cavite (Google Earth Pro)

Mayor.

The donor site located at Barangay Quilitisan, Calatagan, Batangas (13.885657°, 120.616897°) was selected because of the observed abundance of seagrass (*E. acoroides*) and the proximity of the area to the transplantation site.

The researchers conducted a site visit to the coastal barangays of the municipality of Ternate to determine the possible sites for seagrass transplantation. The donor site was situated in the estuary, which is why the transplantation site was also situated in the estuary. Suitable sites for seagrass transplantation in the area were then selected. The selected site is the estuary of Barangay Poblacion III, Ternate, Cavite (14.287549°, 120.712466°), with a depth range of approximately 1 to 3 meters. Then, the researchers prepared a 2m x 2m square plot where thirteen (13) individual seagrass plants were planted on each side of the plot.

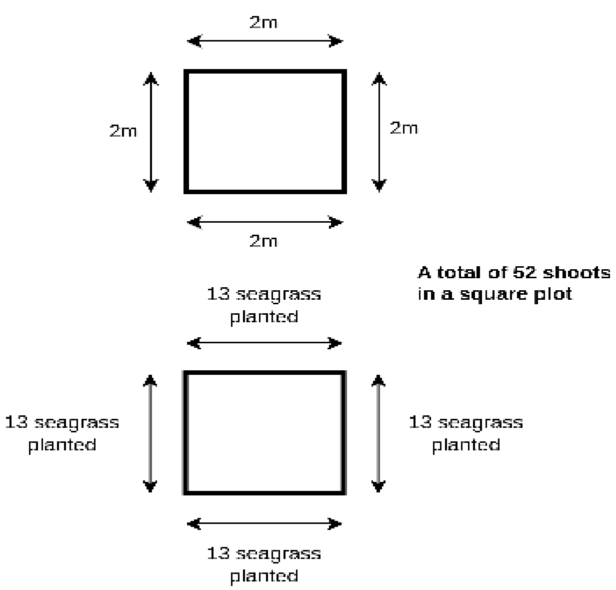

Figure 2. Plot for seagrass transplantation

The physicochemical characteristics of the selected sites were assessed to determine the differences and similarities between the systems from the donor and transplantation sites. Three sampling points were established from each sampling site in Barangay Quilitisan, Calatagan, Batangas and Barangay Poblacion III, Ternate, Cavite. Three trials from each sampling point were conducted to test the pH, total dissolved solids, temperature, salinity, and obtained soil samples. The results were then computed to get the average value for each parameter.

a. Soil texture analysis. Soil samples were obtained from the three sampling points established at the donor and transplantation sites. Soil texture was identified using the hydrometer method. A soil sample (50g) from the sites was placed inside the beaker, and about half of the beaker was filled with distilled water and 10mL of sodium hexametaphosphate. The mixture was stirred for three to four minutes, and then the solutions were transferred to a 1000mL graduated cylinder. A washed bottle was used to remove the remaining soil in the beaker, then the 1000mL graduated cylinder was filled with tap water. Using a plunger, the contents were mixed vigorously for 40 seconds to become \homogeneous. Following the procedures of Jasrotia (2007), the mixture was left to settle down the cylinder for 2 hours, after which the temperature and the hydrometer reading were obtained. The textural class of soil was determined using a soil triangle. Percent sand, silt, and clay were calculated using the formula:

$$\%\ Sand = \frac{corrected\ 40\ seconds\ reading}{soil\ weight}\ x\ 100$$

$$\%\ Clay = \frac{corrected\ 2\ hours\ reading}{soil\ weight}\ x\ 100$$

$$\%\ Silt = 100 - (sand + clay)$$

b. Turbidity. Turbidity measurement was done using the meter and probes. The probes were put in the water and waited for the reading to stabilize, then the results were recorded. The procedure was repeated then the average of the three readings was computed (Environmental Management Bureau-Ambient Water Quality Monitoring, 2008).

c. Temperature. Direct reading of the water temperature was done by simply dipping the probe into the water, at least 4 inches below the surface or halfway to the bottom of shallow waters. The temperature was recorded quickly as the reading stabilized, and the average temperature from both sampling points was computed (Environmental Management Bureau-Ambient Water Quality Monitoring, 2008).

d. Salinity. Using the calibrated meter/probe, the salinity was obtained by simply dipping the instrument 4 inches below the water surface. Reading for salinity was quickly recorded as the reading stabilized, and the average reading for salinity was computed (Water Quality Monitoring Manual-Manual on Ambient Water Quality Monitoring).

e. pH. The calibrated meter/probe was used to obtain the average *pH* value of water (Water Quality Monitoring Manual on Ambient Water Quality Monitoring). The calibrated meter/probes were submerged 4 inches on the water surface, the reading was recorded as it stabilized, and the average pH was computed.

The bare-root transplantation was used as a transplantation method. The obtained seagrass plants were placed inside the container with sufficient water from the donor site to avoid desiccation during the transport going to the transplantation site in Barangay Poblacion III, Ternate, Cavite. Seagrass was then immediately transplanted to the sediment by hand after the transport. The collected seagrass includes all the necessary parts for transplantation, especially the rhizome and leaves. The entire transplantation, including the transport of seagrass was done on the same day.

Monitoring of transplanted seagrass was done through regular on-site-visit once a week after the transplantation. The number of actual surviving transplanted seagrass was counted every week of the monitoring. Monitoring of the seagrass during the first transplantation trial lasted for two weeks. In the second trial of seagrass transplantation, the researchers were not able to conduct monitoring due to the COVID-19 pandemic; rather, a key person from the area of transplantation was contacted and asked for weekly counting and photo documentation of the surviving seagrass.

A strategic plan for seagrass transplantation in the area was proposed. The basis for creating the strategic plan are the results of the first and second trials and the data gathered from the monitoring phase of the study.

3.0 Results and Discussion

Compatibility of the transplantation sites to the donor sites is crucial for the success of seagrass transplantation (Marine Pollution Bulletin, 2009). Based on the results of the analysis for physicochemical characteristics (table 1), the donor site (Barangay Quilitisan, Calatagan, Batangas) has compatible results in terms of the average pH value, temperature, and soil texture. Salinity bracket of brackish water ranges from 0.5 to 25 ppt (Globe, 2014). The donor site has an average salinity of 22.80 ppt, while the transplantation site has an average salinity of 26.71 ppt, which is 1.71% higher than normal salinity range of the brackish water. Salinity should be monitored since the photosynthetic rate and other metabolic processes of seagrass can be altered when salinity fluctuates. Salinity fluctuations happen because the stored energy that should be used to metabolic processes are spent by the seagrass to cope with the changing salinity levels.

On the other hand, in terms of total dissoved solids (TDS),

Table 1. Physicochemical characteristics of donor and transplantation site

Physicochemical Parameters	Donor Site (Ave from 3 Trials)	Transplantation (Ave from 3 Trials)
pH	8.33	8.06
TDS (g/L)	27.02	20.95
Temperature (°C)	26.27	27.06
Salinity (ppt)	22.80	26.71
Soil texture	Silt loam	Silt loam

transpantation site was lower, which implies less turbid than the donor site, and this has a positive impact on the transplanted seagrass, since elevated turbidity affect the seabeds' light levels, which, in turn, hinder the photosynthetic rate of seagrass species ausing the plants diminished growth (Bulmer *et al.*, 2018).

According to the National Oceanic Atmospheric Administration (NOAA), an online American journal, the pH scale runs from 0 to 14, with 7 being neutral. Thus, anything higher than 7 is basic (or alkaline) and anything lower than 7 is acidic. There is a higher rate of photosynthesis on seagrass when the pH is lower than the normal pH of seawater which is 8.2 (Invers *et al.,* 2001).

Table 2 below shows the survival rate of the seagrass in the two trials of transplantation.

Table 2. Survival rate of seagrass during the first and second trial of transplantation

Trial	Transplanted Seagrass	Survived Seagrass	Survival rate
1	40	0	0
2	52	25	48

During the first trial of seagrass transplantation, forty (40) young seagrass shoots were transplanted but failed to survive after two weeks of monitoring from March 03 to March 10, 2020, due to desiccation. The seagrass leaves were bleached due to the temperature rise and the occurrence of low tide. The average temperature during the second week of monitoring rose to 3.71°C compared to the initial average temperature of the transplantation site, and the occurrence of the extreme low-tide exposed the transplanted seagrass to direct sunlight without water for a long period, which eventually desiccated the seagrass leaves. The first trial resulted in zero (0) surviving seagrass.

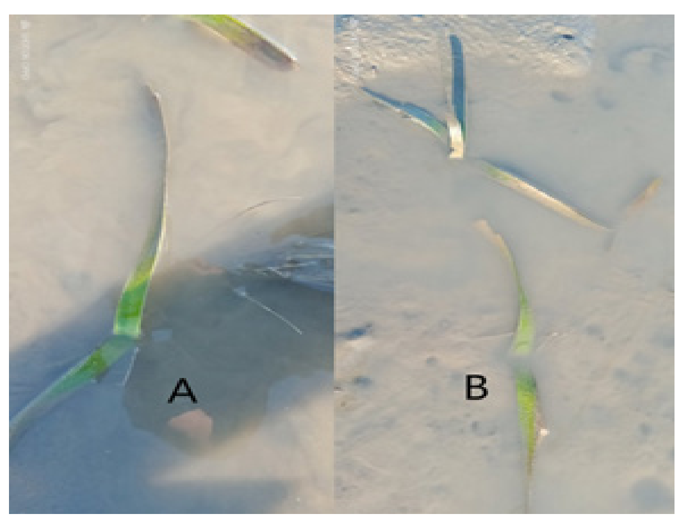

Figure 3. Photo of (A) seagrass with long green leaves and (B) seagrass with mixed brown and green leaves

A total of fifty-two (52) matured seagrass plants were transplanted on the newly selected site in the same transplantation area, where water is available and sufficient even during low tides. The physicochemical parameter was not assessed due to the COVID-19 pandemic; instead, the researchers contacted a focal person who was with them during the transplantation and was asked to monitor the surviving seagrass once a week for the whole two months. There were a total number of twenty-five (25) surviving seagrass, which consisted of twelve (12) matured seagrass with long green leaves and thirteen (13) matured seagrass with mixed brown and green leaves (Figure 3). The survival rate of the transplanted seagrass is 48% after two months. Matured seagrass plants were used instead of the young shoots. It has matured rhizomes that hold the seagrass on the substrate (Marbia & Duarte, 1988) and long leaves that withstand desiccation better compared to young seagrass shoots (Suykerbuyk et al., 2018).

Figure 4 exhibits the photo of a young seagrass shoot used during the first trial of transplantation and the matured seagrass plants used in the second trial of transplantation. The photo also shows the difference between the size of the rhizome and leaves of the young and the matured seagrass plant. After the transplantation, it was observed that matured seagrass plant used during the second trial of transplantation is better than a young seagrass shoots, since developed rhizomes keep the hold of seagrass in the soil, and long leaves of matured seagrass withstand desiccation better. Delving on these results, table 3 exhibits the proposed strategic plan to provide guidelines and different options on how to improve the local coastal ecosystem in Ternate, Cavite, through the transplantation of seagrass.

Figure 4. Photo of the young (A) and matured seagrass (B) plants used during the transplantation

Table 3 Proposed strategic plan of seagrass transplantation

Project/Activity	Objectives	Suggested Method	Implementing Agency & Stakeholders	Expected Output
Identification for possible transplantation site in Ternate Cavite, and selection for donor site where *E. acoiroides* will be obtained	To determine the possible site for *E. acoroides* transplantation To determine accessibility of the donor site to the transplantation site	In selecting the site, it is important to consider the similarities and the difference in terms of the physicochemical characteristics of both the donor site where *E. acoroides* will be obtained and the transplantation site where *E. acoroides* will be planted It is also important to consider the depth of water to prevent the absence of water during the occurrence of extreme low tide Site must be on a location where less disturbance in terms of grazing fisher-folks, passage of boats and less human activities were observed.	LGUs in partnership with MENRO	Establishment of sites for *E. acoroides* transplantation
Assessment for the physicochemical characteristics of the donor and transplantation site	To assess the physicochemical characteristics of the donor site and transplantation site To compare the results of the parameters from both donor and transplantation site	pH, temperature, salinity, turbidity and soil texture are the primary parameters to be assessed as such has a significant role in the survival of *E. acoroides*	LGUs in partnership with MENRO	Averaged results from both sites Determined the compatibility of both sites in terms of physicochemical characteristics
Transplantation of *E. acoroides* to the selected transplantation sites in Ternate, Cavite	Transplant *E. acoroides* to complete the primary coastal ecosystem in the area improved the local livelihood in the area Create a resilient coastal ecosystem and community in Ternate, Cavite	It is advised to adopt the bare root method of transplantation using an matured seagrass plant, where a complete rhizome and leaves was obtained from the donor site and transplanted either by anchoring or securing the sample into the sediments. It is the most easy and cost effective method of transplantation	LGUs in partnership with MENRO	Reintroduction of *E. acoroides* to the coastal areas in TernateCavite A well developed and organized transplantation activity A varied ecosystem services
Regular monitoring of the transplanted *E. acoroides*	To monitor the progress of the transplanted *E. acoroides* To assure that the transplanted *E. acoroides* is surviving in the site	Monitoring for the surviving *E. acoroides* and physicochemical analysis of the site must be done at least once a week after the transplantation, and must last until the transplanted *E. acoroides* reproduce	LGUs in partnership with MENRO	Data for survival rate and average value of each assessed parameters

4.0 Conclusion

The donor and transplantation sites have closer values in terms of the average pH, temperature, and soil texture. Moreover, the donor and transplantation sites have the same soil texture which is silt loam. The transplantation site has a lower average value compared to the donor site in terms of total dissolved solids (TDS), which means that the water is less turbid and acceptable for supporting the metabolic and chemical processes of the newly transplanted seagrass.

The seagrass survival rate is related to the environmental features in its surroundings. In the first trial of seagrass transplantation, no seagrass plant survived due to extreme occurrence of low tide, and the site was dried due to insufficient water, leaving all the transplanted seagrass directly exposed to sunlight and desiccated. In the second trial for seagrass transplantation, almost half (48%) of the population survived at the newly selected site.

The proposed strategic plan recommends the assessment of the physiochemical characteristics of both the transplantation site and donor site before transplantation procedures to determine their compatibility. Matured *Enhalus acoroides* plants yielded an average survival rate and tolerance of desiccation. Lastly, regular monitoring for the number of surviving seagrass and assessment for the physicochemical parameters is highly recommended to determine if the transplantation is successful.

It is recommended to the local government and community to transplant *Enhalus acoroides* to the coastal areas in Ternate, Cavite. Fencing is also recommended for marking the site to lessen the disturbance and to locate the transplantation site easily. For future studies, monoculture or mixed culture for other species of seagrass can be used in transplantation. In-vitro culture of seagrass can also be done aside from the in-situ transplantation. It is also suggested that the local government create a project for seagrass rehabilitation to the local coastal areas. Local government can partner with the experts from the academe and the local community to start transplanting seagrass and protect the local coastal areas in the municipality.

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