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Spatial and Seasonal Standing Crop of Seagrass Communities during Adverse Times in the North-Western Province of the Philippines

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ABSTRACT

Standing crop of seagrass beds and their associated species in Ilocos Sur were studied. It looked into the species classification as to their division, class, order, family, genus, species, and scientific names. Further, the seasonal and spatial standing crop of the species in terms of average number of individuals (N) in every square meter and environmental factors were determined. Differences in spatial and standing crop in the areas were computed, and the relationship of ecological factors was likewise determined. This study used descriptive- correlational research design. Surface water temperature, salinity, and pH were monitored every sampling period in each quadrat to determine their influence on the species' standing crop. Mean, analysis of variance, Scheffe Test and simple bivariate correlation were the statistical tools used. Results showed that ten seagrass species inhabit the four communities of the province. All belong to Division Angiospermae, Class Monocotyledonae, and Order Alismatale. Six (6) belong to Family Cymodoceaceae and four (4) belong to Hydrocharitaceae. These seagrass species belong to the genera Cymodocea, Enhalus, Halodule, Halophila, Thalassia, Thalassodendron and Syringodium. The biomass production of seagrasses in San Esteban, Santiago and San Juan was very high. In all the sites, salinity positively affected the standing crop; temperature had negative effect on it while pH had no effect. Thirty six (36) organisms were found out associated in the seagrass communities. Further monitoring is recommended to have a better assessment of the resource in order to identify factors causing disturbances to the seagrass habitats and to determine appropriate management efforts.

Keywords*: biomass production, Ilocos Sur, pH, associated species*

INTRODUCTION

Seagrasses are flowering plants that live in coastal under waters around the world. They are one of the three groups of angiosperms that colonise the ocean. Leaves of many species are long and narrow so that they are sometimes called eelgrasses. Frequently, they grow in beds looking like grasslands, and in sediment using their rhizomes to stabilize themselves on the sea floor. They have extensive root system which extends both horizontally and vertically, and stabilize the sea bottom in a manner similar to the way land plants prevent soil erosion. It has been reported in

Florida Fish and Wildlife Conservation Commission that seagrasses diminish the force of currents along the bottom which bring greater damage from storms to beaches, homes, and businesses. As submerged plants, they help clear the water by absorbing nutrients from coastal-run-offs. They slow down moving water, trap sediment, causing them to settle down. Such mechanism reduces sediment load in water which greatly benefits the corals. Aside from supporting life of other organisms, seagrasses help determine the overall health of coastal ecosystem. This is due to their inherent sensitivity to changes in water quality.

There are two seagrass meadows: one is monospecific if it is composed of one species and the other is polyspecific with more than one species coexisting together. In temperate areas, quite few species dominate the area while in tropical areas, like in the Philippines, more diverse with up to 13 species recorded. Seagrasses greatly upkeep the ecosystem. Aside from providing food and shelter, their meadows are the essential nursery to countless invertebrates, recreational and commercial fishes. Seahorses and lizardfish live in seagrass communities throughout the year while other fishes remain in them only at certain life stages.

The seagrass ecosystems are so diverse and productive harbouring lot of associated species from different phyla from epiphytic and free-living microalgae and macroalgae, juvenile as well as adult fishes, mollusks, arthropods, nematodes, to bristle worms. In the feeding relationships, few organisms feed directly on seagrasses but scientific literatures claimed that there are hundreds species of organisms like geese, swans, green turtles, dugongs, manatees, sea urchins, crabs and fishes that depend on seagrass. Some species of fish that grazed on seagrass usually raise their offspring in mangroves or coral reefs. These meadows provide habitats for commercially important smaller animals: arthropods like prawns, shrimps and crabs, smaller fishes, and mollusks like clams. As such, they support local economies. All species live entirely immersed in seawater except for one genus, the enhalus plants (E. acoroides). They must emerge to the surface to reproduce; all others flower and pollinate under water. Their nature of being under the seawater has obviously influenced their geographic distribution and speciation.

All seagrasses belong to Division Angiospermae, in the Order Alismatales, and in the Class of monocotyledons are divided into five families: Cymodoceaceae, Hydrocharitaceae, Posidoniaceae, Ruppiaceae and Zosteraceae. Within these families, there are 12 genera with 60 species, half of these are tropical and the other half are temperate. Comparing their number with other plants and algae, only few genera and species occur in nearly all continent except Antartica. When present, they usually structure the basis of many ecologically significant habitats that support vast amount of benthic marine communities (Bjork, Short, McLeod, Beer, 2014). Forbes as reported in 2013, conducted a review on Philippine seagrass biodiversity, distribution, and conservation. From his investigation, there are eighteen seagrass species that thrive on 529 sites in the Philippine island.

Meñez (1983) stated that den Hartog (1970) reported 11 species of seagrasses are found in the Philippines. Thirty years after, there was an increase to 18 species as reported by Forbes (2013). Despite their widespread occurrence in the country, only few research information have been published. These include Blanco's (1837, 1845, 1879) accounts on Vallisneia sphaerocarpa found in Zambales and Merril (1918) on the same species in Palawan. Ostenfield (1909) recorded the presence of Halophila ovata in the Philippines that proves Loher's specimen from Luzon and Merrils from Manila Bay.

Decline of seagrasses has been reported globally due to human actions (Short and Wyllie-Echeverria 1996; Hemminga and Duarte, 2000; and Duarte, 2002). Among these human activity-stressors are landfilling, boating, dredging, destructive fishing, aquaculture fishing, and various ways and types of activities polluting the natural water. In like manner, natural disasters like storms and floods also cause negative effects. At the onset of rainy days, influx of nutrients and sediments' runoff greatly affects the water quality of the marine ecosystem. But with the presence of seagrasses, they trap suspended fine sediments and particles in the water column thus clarifying the water. Reduced lucidity or turbid water affects the behaviour of marine animals and the quality of recreational coastal water.

Climate change phenomenon causes rise in sea temperature and levels, deviates tidal regimes, sediment anoxia and hypoxia. It also causes UV radiation damage, intensifies storm and flooding events which adversely affect the seagrass ecosystem (Bjork, Short, McLeod and Beer 2014). As reported by Lotze et al. (2006) there was an approximate loss of 65 percent of seagrass on areas where they inhabit. Short and Wyllie-Echeverria (1996) reported that natural disturbances have crushed seagrass ecosystems which supported the report of Short and Neckles (1999) on an almost disappearance of the eelgrass Zostera marina during those times in the middle of the 1980s.

Seagrasses have thermal tolerance and consequently their productivity are affected by increases in water temperature. In a chain of event, increased water temperatures combined with nutrient pollution further enhance growth of competitive algae like, phytoplankton and seaweeds, and their population increase can lead to reductions in sunlight and carbon that seagrasses need for survival.

Increased water depth restricts also the amount of light reaching seagrasses thereby reducing their photosynthetic process, productivity, and geographic distribution. Changes in tidal dynamics, like tidal range, circulation flow patterns, and water current speed bring about impacts such increased exposure of the communities at low tide, increased water column turbidity which in turn reduce light penetration. However, increased atmospheric CO2 causes an increase in the dissolved CO2 concentration in seawater. This somehow boosts photosynthesis in many types of seagrasses but at the expense of those species with a reduced carbon-extraction capacity. This is expected to lead to shifts in species distributions. Increased CO2 levels may also benefit the algae attached to seagrasses; increased algal growth would restrict light levels by shading plant leaves leading to seagrass decline. Seagrasses require specific salinities for reproduction and propagation; shifting salinity regimes limit their reproduction and distribution of some seagrass species (Lotze et al., 2006). Increased salinities are associated as well with an increase in prevalence of 'wasting disease', a highly destructive disease currently impacting eelgrass meadows in some U.S. coastal areas.

Determination of the status of the resource which is not yet established has been going on for the last 30 years, and its conservation program is the emphasis of scientific investigation for the last fifteen years. There are many factors affecting the resource in the Philippines. Among these is eutrophication which constitutes major threat of the habitats plus the development of numerous facilities along the coastline of the country. Numerous researches were conducted to save the habitats and prevent further loss of the species. Some of these are studies on management concerns, development of a unified framework for action, species economic valuation, forging public-private partnerships for responsive and efficient collaborative effort, and public information thru publications and circulation of high quality scientific researches. Since these seagrass communities are being lost at alarming rate, research, therefore, is very important to help direct future conservation of these productive and biodiverse ecosystems.

This study provides a broad survey of seagrass communities in Ilocos Sur, a North-Western province of the Philippines and the effects of climate change on them. This study focused on the seagrass species in these coastal northern municipalities of Sinait, San Juan, and southern towns of San Esteban and Santiago. Specifically, the research focused on the species classification as to their division, class, order, family, genus, species, and scientific names. Further, the seasonal and spatial standing crop of the species in terms of average number of individuals (N) in every square meter and environmental factors were determined. Differences in spatial and standing crop in the areas were computed, and the relationship of ecological factors like surface water temperature, pH, and salinity was likewise looked into. Determination of the associated species in the seagrass communities completed this particular study.

METHODOLOGY

This study used the descriptive -correlational type of research. First it listed down and identified the seagrass species found in the four municipalities of Ilocos Sur, a coastal province of the Philippines located in its North Western part, namely, Sinait, San Juan, San Esteban, and Santiago. Standing crop of the species was also determined. Data gathering was conducted for six months from December to May. A representative of the seagrasses species and the associated species present in the sampling stations were collected and identified. Verification of the scientific names and classification of the collected species classification was done by experts of the Botanical Division of the National Museum of the Philippines. Data gatherers visited the identified areas every two weeks during the duration of the study and did the necessary data to be collected. The standing crop of the seagrasses in terms of average numbers of individuals was determined through random sampling method using a quadrat (0.5m X 0.5m). Three throws of the quadrat at the seagrass beds at appropriate 30 meters apart were done. Seagrass individuals covered by the inside area of the quadrat were counted and recorded. The number of individuals counted was multiplied by four so that the values are converted equivalent to that of a square meter. The values of the three throws were added and divided by three to get the average number of individuals (N) in a particular sub-area. Variations of the three ecological factors namely, surface water temperature, pH, and salinity were monitored for every sampling period.

The statistical tools used were mean, analysis of variance (ANOVA), Scheffe Test, simple bivariate correlations and multiple regressions.

RESULTS AND DISCUSSION

The seagrass species found in the four areas of Ilocos Sur and their classification as to class, order, family, genus, species and scientific names is presented in Table 1. There are ten (10) seagrass species present in the four areas of Ilocos Sur.

All belong to Division Angiospermae, Class Monocotyledonae, and Order Alismatales. Six (6) belong to Family Cymodoceaceae and four (4) belong to Hydrocharitaceae. These seagrass species belong to the genera Cymodocea, Enhalus, Halodule, Halophila, Thalassia, Thalassodendron and Syringodium.

Table 1
Seagrass Species Found in Ilocos Sur and their Classification

									Santiago			San Esteban			San Juan			Sinait		
Species	Characteristics	Division	Class	Order	Family	Genus	Species	Scientific Name	Ambucao	Gabao	Sabang	Apatot	Batteria	San Pablo	Solot-solot	Saoang	Dardarat	Pug-os	Cabangtalan	Dadalaquiten
1	leaf tip obtuse	*Angiospermae*	*Monocotyledonae*	*Alismatales*	*Cymodooceaceae*	*Cymodocea*	*Rotundata*	*Cymodocea rotundata*	+	+	+	+		+	+				+	+
2	serrulate leaf tip	*Angiospermae*	*Monocotyledonae*	*Alismatales*	*Cymodooceaceae*	*Cymodocea*	*Serrulata*	*Cymodocea serrulata*	+	+	+	+		+			+	+		
3	Leaves distichous, rhizome covered with black fibrous strands	*Angiospermae*	*Monocotyledonae*	*Alismatales*	*Hydrocharitaceae*	*Enhalus*	*Acoroides*	*Enhalus acoroides*	+	+		+	+				+			
4	leaf tip rounded more or less serrulate	*Angiospermae*	*Monocotyledonae*	*Alismatales*	*Cymodooceaceae*	*Halodule*	*Pinifolia*	*Halodule pinifolia*	+		+	+		+		+	+			+
5	leaf tip tridentate	*Angiospermae*	*Monocotyledonae*	*Alismatales*	*Cymodooceaceae*	*Halodule*	*Univervis*	*Halodule univervis*	+					+	+		+			+
6	Leaves ovate, dioecious with 7-12 cross-veins	*Angiospermae*	*Monocotyledonae*	*Alismatales*	*Hydrocharitaceae*	*Halophila*	*Minor*	*Halophila minor*	+											
7	Leaves ovate with 11-12 pairs of cross-veins	Angiospermae	Monocotyledonae	Alismatales	Hydrocharitaceae	Halophila	Ovalis	*Halophila ovalis*						+						
8	Leaves distichous, rhizome without the strands	Angiospermae	Monocotyledonae	Alismatales	Hydrocharitaceae	Thalassia	Hemprichii	*Thalassia hemprichii*										+		

									Santiago			San Esteban			San Juan			Sinait		
Species	Characteristics	Division	Class	Order	Family	Genus	Species	Scientific Name	Ambucao	Gabao	Sabang	Apatot	Batteria	San Pablo	Solot-solot	Saoang	Dardarat	Pug-os	Cabangtalan	Dadalaquiten
9	Leaves flat, rhizome ligneous	Angiospermae	Monocotyledonae	Alismatales	Cymodooceaceae	Thalassodendron	Ciliatum	*Thalassodendron ciliatum*	+	+			+					+		
10	leaves subulate or terete	Angiospermae	Monocotyledonae	Alismatales	Cymodooceaceae	Syringodium	Isoetifolium	*Syringodium isoetifolium*	+	+	+	+		+						

Legend: + = presence

Findings of this study wherein only 10 species were found indicate that there is a decline in the number of species in the province. In 1970, there were 11 species found in the Philippines by Hartog as mentioned by Meñez, Phillips, and Calumpong (1983) and then there was an increase to 18 species as reported by Forbes in 2013. All these numbers fall far behind the reported sixty (60) species of the seagrass.

The seagrass spatial and seasonal standing crop in terms of average number of individuals (N) per square meter found in the four municipalities of Ilocos Sur are reflected in Table 2.

Table 2
Seasonal and Spatial Crop of Seagrass in Ilocos Sur

Sampling Station	STANDING CROP (Average Number of Individuals (N) per square meter)						
	Dec.	Jan.	Feb.	March	April	May	MEAN
Sinait							
Cabangtalan	630	657	692	732	601	496	**635**
Dadalaquiten	774	842	978	1037	917	832	**897**
Pug-os	558	592	637	678	514	400	**563**
MEAN	**644**	**697**	**769**	**816**	**677**	**576**	**698**
San Juan							
Dardarat	759	812	839	893	858	800	**827**
Saoang	809	948	1157	1478	1350	1264	**1168**
Solot-solot	976	1457	1871	2003	1987	1952	**1708**
MEAN	**848**	**1072**	**1289**	**1458**	**1398**	**1339**	**1234**
San Esteban							
Apatot	1232	1287	1315	1407	1257	1120	**1270**

Sampling Station	STANDING CROP (Average Number of Individuals (N) per square meter)						
	Dec.	Jan.	Feb.	March	April	May	MEAN
Sinait							
Batteria	1013	1092	1182	1217	1073	978	**1092**
San Pablo	1657	1692	1745	1892	1616	1432	**1672**
MEAN	**1301**	**1357**	**1414**	**1505**	**1315**	**1177**	**1345**
Santiago							
Ambucao	1542	1660	1792	1912	1602	1290	**1633**
Gabao	1004	1122	1216	1464	1192	874	**1145**
Sabang	1278	1484	1688	1756	1504	1214	**1487**
MEAN	**1275**	**1422**	**1565**	**1711**	**1433**	**1126**	**1422**

The highest standing crop in terms of the seagrass seasonal standing crop was noted in the month of March in all sampling stations and the least is on May except in San Juan which is on the month of December.

In terms of seagrass spatial standing crop distribution I Ilocos Sur, Santiago has the highest standing crop with 1422 N/m2, followed by San Esteban with 1345 N/m2, San Juan with 1234 N/m2, and Sinait with only 698 N/m2 .

Data gathered indicate that the seasonal and spatial standing crop of seagrass differs from one month to another and from one station to another.

The Analysis of Variance (ANOVA) for the significant difference in the spatial and seasonal standing crop of seagrass between and among the areas and months is on Table 3a. The standing crop of the species in all 12 stations was considered in this analysis.

Table 3a
Summary ANOVA for the Significant Difference in the Spatial and Seasonal Standing Crop of the Seagrass

Source	Sum of Squares	df	Mean Square	F	Sig
Town	5771786.264	3	1923928.756	18.498	.000
Month	1047253.236	5	209450.647	2.014	.093
Town*month	685339.819	15	4568.321	.439	.958

From Table 3 the computed probability level came to be lower than the set probability level at .05 significance. This indicates that the numbers of standing crop in at least one pair of town are significantly different from one another ($p<0.05$).

For the significant difference between seasonal standing crop and between town and month, the computed probability is greater than the probability level at .05

significance (p>0.05). These results indicate that the number of standing crop is not significantly different between and among the sampling months and there is no significant interaction effect between months and towns.

Inasmuch as the spatial standing crop of the seagrasses in Ilocos Sur significantly differs, Scheffe test was used to find out which towns significantly differ in the standing crop. Table 3b presents the Scheffe test for multiple comparison in the significant difference in the spatial standing crop of seagrass in Ilocos Sur.

Table 3b
Scheffe Test for Multiple Comparison in the Significant Difference in the Spatial Standing Crop in Ilocos Sur

Sampling Period	Temperature				pH				Salinity			
	Sinait	San Juan	San Esteban	Santiago	Sinait	San Juan	San Esteban	Santiago	Sinait	San Juan	San Esteban	Santiago
December	29.30	28.22	27.30	27.83	8.39	8.37	8.30	6.48	26.67	27.33	26.00	26.33
January	30.83	29.25	28.38	28.08	8.47	8.36	8.36	8.41	28.33	27.33	27.33	26.67
February	32.32	29.58	31.77	28.50	8.64	8.38	8.52	8.46	29	27.33	29.67	27.00
March	33.56	31.89	33.07	31.77	8.65	8.39	8.57	8.29	31	28.33	31.33	29.33
April	33.68	31.97	33.38	32.73	8.65	8.41	8.65	8.61	31.33	29	30.67	30.00
May	33.39	31.80	32.33	32.08	8.67	8.27	8.63	8.57	26.67	27.33	30.00	29.33

*The mean difference is significant (p<0.05)

Table 3b shows that there is a significant difference in the standing crop between San Esteban and Sinait, Santiago and Sinait, and Sinait and San Juan. For these particular findings, they indicate that the seagrass communities in San Esteban, Santiago, and San Juan have higher standing crop than Sinait.

This study also monitored variation of three ecological factors, namely, surface water temperature, pH and salinity in all stations in the four municipalities of Ilocos Sur. Data is presented in the following.

Table 4a
Mean Variations of the Ecological Factors in the Seagrass Communities of Ilocos Sur

(I) Town	(J) Town	Mean Difference (I-J)	Sig.
San Esteban	Santiago	-77.06	.890
	Sinait	646.67*	.000
	San Juan	110.78	.733
Santiago	Sinait	723.72*	.000
	San Juan	187.83	.311
Sinait	San Juan	-535.89*	.000

A. Surface Water Temperature

Seagrasses thrive best at the shallower part of the coastal areas of the sea. Hence, it is best to note at which temperature of the water in the specific sites that the seagrasses thrive best.

Variations in surface temperature reading where the seagrasses thrive can be noted in the table but coldest month can be noted from the month of December with 27.3®C and the hottest in the month of April with 33.38®C.

B. pH

The pH of the water in all sampling stations varied. Lowest was noted during the month of May in San Juan with 8.27 and highest also in the month of May but in Sinait with 8.67. Based on the neutral pH 7.0, data on the pH of the seawater in all sampling stations implies basic characteristics as evidenced by the slightly higher pH values.

C. Salinity

As revealed in the table, fluctuations in salinity levels of the seawater ranged from 26-31.330/00 wherein, lowest was noted in the month of December and highest in the month of March and April. Data gathered implies that salinity of the seawater fluctuates from one month to another and from one station to another. The lower readings of salinity during the month of December could be attributed to precipitation influx of freshwater from run-offs and rivers since this month is preceded with rainy months while higher salinity readings during dry months (March to May) could be due to higher evaporation rates.

Table 4b presents the correlation coefficient of the three ecological factors between and among the seagrass spatial and seasonal standing crop. This is to find whether the ecological factors have any influence/effect on the standing crop of the species.

Table 4b

Relationship of the Three Ecological Factors between and Among the Seagrass Spatial and Seasonal Standing Crop

Variable	Descriptives		Regression Coefficients			Model Summary		
	Mean	SID	b	beta	Sig	R^2	ANOVA	
Standing crop	1174.74	419.536					F	Sig
pH Level	8.4789	.16558	-691.27	-.273	.064	0.176	48.49	0.004
Salinity	28.4722	1.80744	124.80*	.538	.002			
Temperature	30.9468	2.18984	-79.08*	-.413	.023			
Constant			5930.036		.026			

*Significant correlation/coefficient

Simple bivariate correlations were first conducted to examine the relationship between the number of standing crops and various physical parameters as possible predictors. The table above shows the descriptive statistics for each of the variable. Correlation shows that pH level is inversely related to the number of standing crop (r=0.223, p=0.030). Salinity and temperature do not result to significant relationships in the preliminary tests.

Multiple regression with three predictors present shows R2 value of 0.176, meaning the model accounts only for 17 percent of the variations in the number of standing crop, although the model is statistically significant (p=0.004).

Salinity has a positive and significant regression weight of 124.80, meaning the higher the salinity, the higher the number of standing crop present. On the other hand, temperature has a negative and significant regression weight of 79.08, meaning the higher the temperature, the lower the standing crop present in the area (suppressor effect). The pH level does not contribute to the multiple regression model.

Data gathered support previous studies that increase in temperature affects standing crops of seagrasses (Bjork, Short, McLeod, and Beer ,2014) and salinity has positive effect on the species productivity (Lotze et al., 2006).

Table 5 shows that there are 36 associated species found in all seagrass communities in Ilocos Sur. Fourteen (14) marine plants and twenty two (22) marine animals were found thriving in the seagrass meadows.

Table 5
Associated Species of the Seagrass Communities in Ilocos Sur

Marine Plants		Marine Animals	
1	*Avrainvillea canariensis*	1	*Anadara maculosa*
2	*Caulerpa serrulata*	2	*Anthopleura xanthogrammica*
3	*Caulerpa sertularioides*	3	*Archaster typicus*
4	*Galaxaura oblongata*	4	*Atrina pectinata*
5	*Gracilaria coronopifoli*	5	*Barbatia bicolorata*
6	*Halimeda macroloba*	6	*Calappa hepatica*
7	*Halimeda opuntia*	7	*Cymatium musicinum*
8	*Hypnea pannosa*	8	*Cymatium pileare*
9	*Mastophora rosea*	9	*Dolabrifera dolabrifera*
10	*Padina minor*	10	*Holothuria habilis*
11	*Rosenvingea orientalis*	11	*Istiblennius enosimae*
12	*Sargassum sp.*	12	*Nassarius albescens*
13	*Turbinaria ornata*	13	*Nerita chamaeleon*
14	*Udotea sp.*	14	*Nerita undata*
		15	*Polineces mammilla*
		16	*Polineces melanostonous*
		17	*Siganus canaliculatus*
		18	*Sipunculus nudus*
		19	*Strombus gibberulus*
		20	*Trachycardium flavum*
		21	*Tripneustus gratilla*
		22	*Varuna litterata*

CONCLUSIONS

There are ten seagrass species found in the four communities of Ilocos Sur belonging to Division *Angiospermae*, Class *Monocotyledonae*, and Order *Alismatales*. The biomass production of seagrass in San Esteban, Santiago and San Juan is very high. Salinity positively affect the standing crop while, temperature has a negative effect. There are 26 associated species found in the seagrass communities.

RECOMMENDATIONS

A more extensive monitoring is recommended to have a better assessment of the resource and to identify disturbances to the seagrass communities. Enhanced data to be gathered may serve as a baseline in formulating management efforts and program in the preservation and conservation of these economically important and likewise environmentally vulnerable species.

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