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Ulva species composition during northeast and southwest monsoons in Cuta West–Sta. Clara, Batangas City

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ABSTRACT

Batangas City is vulnerable to the anthropogenic inputs flowing from the Calumpang River to Batangas Bay and its industrialized area. Studying the composition of *Ulva* species is vital in monitoring and managing marine ecosystems as these species could be a bioindicator species. The composition of *Ulva* species in Cuta West–Sta. Clara, Batangas City was assessed during the southwest and northeast monsoons. *Ulva* species composition, abundance, dominance, and contribution were determined using the line transect-quadrat method. Physicochemical conditions of water, such as pH, salinity, dissolved oxygen, temperature, phosphate, and nitrate were also measured to determine any relationship with *Ulva* species composition during the two sampling periods. Three *Ulva* species were identified, namely, *Ulva intestinalis*, *U. lactuca*, and *U. reticulata*. During the southwest monsoon, *U. intestinalis* was the dominant species, which then shifted to *U. lactuca* during the northeast monsoon. Physicochemical conditions during the two sampling periods were closely similar and within the quality standard of the Department of Environment and Natural Resources (DENR), except for pH level, which ranged from 8.7-8.9. Dissolved oxygen showed an increasing trend from 6.13 mg/L to 9.19 mg/L. Nitrate content showed a decreasing trend from 2.18 mg/L to <0.075 mg/L. The declining trend of nitrate might indicate accumulation by *U. lactuca*, which may have contributed to its increased biomass during the northeast monsoon. The increase in biomass and wave action may explain the increase in dissolved oxygen during this period. Overall there is a possible relationship between the *Ulva* species composition and physicochemical conditions.

Keywords: *Ulva* species, pH, dissolved oxygen, nitrate, Cuta West–Sta. Clara, Batangas City

1. Introduction

Ulva species is a cosmopolitan green macroalgae that grows in rocky or sandy areas along the intertidal zone [1]. Species of this genus are observed to be the first species to inhabit disturbed environments because of their morpho-physiological features, allowing them to tolerate a wide range of environmental conditions and become common in anthropogenically disturbed areas [2]. These characteristics of *Ulva* species contribute to its ability to form green tide blooms in many areas of the world [3].

Green tide blooms are a widespread marine phenomenon and have been reported from the nutrient-enriched waters in temperate and tropical waters in the last century. The largest green tide bloom occurred in the Yellow Sea in China during summer of 2008 [4]. The bloom disrupted the yachting competition during the Summer Olympic Games. The over proliferation may be influenced by increased temperature, high light conditions, and increased nutrients [5].

In the Philippines, several green tide blooms have been reported, such as the green tide bloom in Boracay during the summer of 2017. Green tide blooms composed of *Cladophora vagabunda*, *U. clathrata*, *U. intestinalis*, and *U. reticulata* were also recorded in the coastal waters of Macajalar Bay at El Salvador, Misamis Oriental [6]. In Mactan Island in Cebu, free-living *U. lactuca* and *U. reticulata* were also reported to form blooms [7].

Studying the composition of *Ulva* species could be substantial in monitoring marine ecosystems. Previous studies have shown that *Ulva* species can be used as a bioindicator for water pollution because of its ability to survive in a wide range of physicochemical parameters. The present study identified the composition, abundance, and contribution of *Ulva* species in Cuta West–Sta. Clara, Batangas City during the southwest and northeast monsoons. The physicochemical conditions of the site were also assessed and monitored for possible relationship to *Ulva* species composition.

2. Materials and methods

2.1. Study sites

The study site is located in Cuta West–Sta. Clara, Batangas City (13.74913º N, 121.04522º S) as shown in Figure 1. The site is near the Batangas Port, Calumpang River, and a number of households. Surveys were conducted during the southwest monsoon (October 7-8, 2021) and the northeast monsoon (December 6-7, 2021).

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Figure 1. Map of study site located in Cuta West–Sta. Clara, Batangas City showing position of transect.

2.2. *Ulva* species assessment

The line transect-quadrat method [8] with modifications by [9] was used in the assessment of the *Ulva* species composition during two sampling periods.

Three 50-m transect lines were placed parallel to the shore with 30-m intervals at a distance of approximately 20 m to 40 m away from the shore. A 50 cm^2 quadrat subdivided into twenty-five 10 cm^2 grids was used and positioned at the right side of the transect every 5 m when scoring to avoid bias.

Species composition was determined by identifying all the *Ulva* species found in each quadrat. The abundance or total cover of each species was calculated using the formula below, which is based on the total surface area covered inside the quadrat. The formula below was used to calculate the cover (C, %) of each species:

$$C\ (\%) = (qn_6\ x\ 4) + (qn_5\ x\ 3) + (qn_4\ x\ 1.5) + (qn_3\ x\ 0.75) + (qn_2\ x\ 0.375) + (qn_1\ x\ 0.1875)$$

where *qn* represents the total number of small squares with cover corresponding to index n defined in the matrix in Table 1. The total cover may exceed 100% because of overlapping thalli.

Table 1. Index matrix showing index and multiplier for each degree of seaweed cover.

Index, *n*	Degree of seaweed cover on a small square, q_n of the quadrat	Contribution (%)
6	Covering 98% - 100% of the substratum surface	4.0
5	Covering 50%-100% of the substratum surface	3.0
4	Covering 25% - 50% of the substratum surface	1.5
3	Covering 12.5% - 25% of the substratum surface	0.75
2	Covering 6.25% - 12.5% of the substratum surface	0.375
1	Covering <6.25% of the substratum surface	0.1875

The contribution (%) or proportion of each *Ulva* species in relation to the overall cover of *Ulva* species within the site were computed as well.

2.3. Measurement of physicochemical parameters

The pH, salinity, dissolved oxygen, and temperature of the seawater were measured by submerging a multiparameter probe meter (YSI, Yellow spring, Ohio, USA) at 1 m depth for 10 minutes. Water samples (1.5 L) were collected and sent to Batangas Provincial Government – Environment and Natural Resources Office for analysis of phosphate and nitrate content through stannous chloride and brucine sulphanilic respectively.

2.4. Statistical analysis

Principal component analysis was conducted to determine the possible relationship between the composition of *Ulva* species and the physicochemical conditions in Cuta West–Sta. Clara, Batangas City during the two sampling periods. Statistical test was conducted using R software (version 4.1.2, 2021-11-01).

3. Results and discussion

3.1. Composition, abundance, and contribution of *Ulva* species in Cuta West–Sta. Clara, Batangas City during southwest and northeast monsoons

Three *Ulva* species were identified in the area during the two sampling periods (Figure 2). *U. lactuca* has a foliose form, with ruffled edge and lobed blade. *U. intestinalis* has a tubular form that grows from a small holdfast. *U. reticulata* is reticulate and has an irregular shape, forming a tangled mass.

U. lactuca *U. intestinalis* *U. reticulata*

Figure 2. *Ulva* species collected in Cuta West - Sta. Clara, Batangas City during southwest and northeast monsoons.

The composition of *Ulva* species was similar between the two sampling periods (southwest and northeast monsoons). The species of *Ulva* identified include *U. lactuca*, *U. intestinalis* and *U. reticulata.*

However, during the southwest monsoon, *U. reticulata* was observed free-floating within site but was outside the quadrat during the assessment, unlike those observed in the northeast monsoon. This resulted in the absence of data for abundance and contribution as shown in Figure 3. The tendency of *U. reticulata* to float freely around the site can be attributed to the matured thalli being easily detached from the substratum by the water movement.

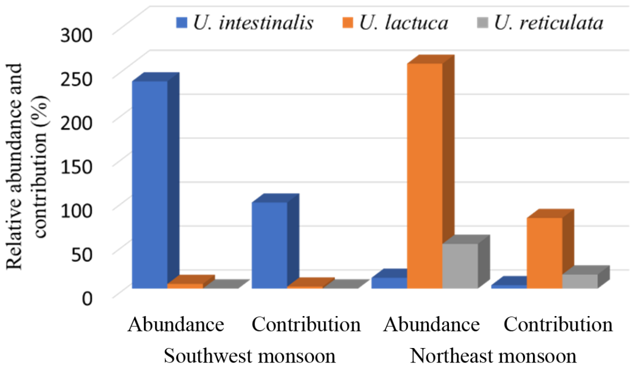

Figure 3. Abundance and contribution of *Ulva* species in Cuta West–Sta. Clara, Batangas City during two sampling periods.

During the southwest monsoon, *U. intestinalis* had the highest abundance and contribution in contrast with *U. lactuca*. Most of the *U. intestinalis* remained inside the quadrat, while *U. lactuca* were free-floating. The result was similar to the study conducted in Verde Island, Batangas City, wherein *U. lactuca* had the highest cover among *Ulva* species during the northeast monsoon than in southwest monsoon.

On the other hand, there was a shift in *Ulva* species abundance and contribution during the northeast monsoon. *U. lactuca* had the highest abundance followed *by* *U. reticulata*, and *U. intestinalis*. Having a broad lobed morphological structure enables *U. lactuca* to accumulate limiting resources. This competitive advantage of *U. lactuca* over the other two *Ulva* species allowed it to grow more abundantly as observed. Its morphology also maximized the quadrat resulting in covering up mostly to 100% throughout the assessment. The monsoonal change does not affect the composition of *Ulva* species.

3.2. Physicochemical conditions of the study site in Cuta West–Sta. Clara, Batangas City during the southwest and northeast monsoons

The physicochemical conditions during the two-sampling periods are shown in Table 2. All physicochemical conditions passed the standard value of DENR during the two sampling periods except for pH. The pH value for both monsoons were both high ranging from pH 8.70 to pH 8.90 and exceeding the standard range of pH values of the DENR (pH 6.5 to pH 8.5). This indicates the possible accumulation of carbon dioxide, which may be due to the increase in temperature and the anthropogenic inputs flowing to Batangas Bay.

The dissolved oxygen levels increased from 6.13 mg/L during the southwest monsoon to 9.19 mg/L during the northeast monsoon. Contributing factors of the increase trend were the increase in abundance of *Ulva* species and the monsoonal changes. The temperature during both monsoons was within the DENR limits of 25 °C to 31 °C. Moreover, during both monsoons, the phosphate and nitrate concentration were also within the DENR standard of 0.5 mg/L and 10 mg/L, respectively.

Table 2. Physicochemical analysis of Cuta West–Sta. Clara, Batangas City during southwest and northeast monsoon.

Physicochemical parameters	Southwest monsoon	Northeast monsoon
pH	8.70	8.90
Salinity (ppt)	31.02	32.08
Dissolved oxygen (mg/L)	6.13	9.19
Temperature (°C)	30.90	28.60
Phosphate (mg/L)	0.04	<0.021
Nitrate (mg/L)	2.18	<0.078

The decreased nitrate concentrations during the northeast monsoon may indicate accumulation mostly by *U. lactuca*, resulting in its increased growth and higher dissolved oxygen levels. Another contributing factor to the increased dissolved oxygen is the typhoon occurrences affecting wind direction and wave action during the northeast monsoon. Since the site is near to the mouth of the river flowing to the sea, nitrate was washed out flowing to the coastal area resulting in the decrease of nitrate concentration.

3.3. Relationship between the composition of *Ulva* species and the physicochemical conditions in Cuta West–Sta. Clara, Batangas City during the two sampling periods

The abundance of *U. reticulata* is also possibly correlated with other physicochemical parameters such as pH, salinity, dissolved oxygen, and temperature. Meanwhile the abundance of *U. intestinalis* is not correlated with nutrient content. Since, *Ulva* species can still thrive with a limiting source of nutrient content. No parameters were found to be correlated with the abundance of *U. lactuca.*

High nutrient levels, which are associated with low salinity concentrations and influenced by outflows from nearby rivers, could supply enough nutrients for the growth and production of macroalgae [10]. Previous studies have noted increased growth of *Ulva* species at 20 and 35 ppt and its high sensitivity to variations in external nutrient concentrations [11]. These studies further support the possible relationship between *Ulva* species composition and the physicochemical conditions (i.e., dissolved oxygen and nutrients) in the present study.

4. Conclusions

Three *Ulva* species were identified at Cuta West- Sta. Clara, Batangas City - *U. lactuca*, *U. intestinalis* and *U. reticulata* during southwest monsoon and northeast monsoon. *U. intestinalis* as the dominant species in southwest monsoon shifted to *U. lactuca* during northeast monsoon. The shifting of abundant species is due to the occurrence of interspecific competition since these species thrive on nutrient rich areas and within range of sunlight. Unlike *U. intestinalis, U. lactuca* possesses a foliose form with lobed blades allowing it to maximize limiting resources like nutrients and sunlight.

Although the study warrants further investigations, the results can provide baseline information for future research about the composition of *Ulva* species and their implications to possible occurrences of green tide bloom.

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