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Comparative assessment of *Ulva* spp. in the port areas in Mabini, Batangas

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ABSTRACT

Port areas in Mabini, Batangas are vulnerable to anthropogenic influences from different sources such as sewage outflows, human and port-related activities. Monitoring *Ulva* spp. could provide information about the possible impacts of these anthropogenic factors, as these species were being utilized as bioindicators. The ports of Anilao and Talaga in Mabini, Batangas, were assessed for *Ulva* spp. composition, abundance, and dominance using the line transect-quadrat method. Physicochemical conditions of water, such as pH, salinity, dissolved oxygen, temperature, light intensity, phosphate, and nitrate of the sites, were assessed as well as to determine the possible influence on the composition, abundance, and dominance of *Ulva* spp. Three *Ulva* spp. were identified, namely *Ulva intestinalis, U. lactuca*, and *U. clathrata*. In Talaga port, *U. intestinalis* and *U. clathrata* were the dominant species, whereas the former was found to be the most abundant species, and *U. lactuca* was found to be the least abundant. In Anilao port, only *U. clathrata* was the only species present. Physicochemical conditions on both sites were relatively close in value except for salinity, dissolved oxygen, irradiance, and nitrate content. Nitrate content has a relatively huge difference between ports. However, Anilao port has a lower nitrate content of 1.9530 mg/L, while Talaga port has a higher value of 5.0843 mg/L, which might be caused by sewage outflows present in the latter. Overall, nitrate content had a possible effect on the composition, abundance, and dominance of *Ulva* spp. on each site.

Keywords: *Ulva* spp., anthropogenic influences, line transect-quadrat method, physicochemical parameters

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1. Introduction

Ulva is a marine and estuarine genus with a large number of species, and it is a chlorophyte, which is an informal grouping of three classical classifications (Ulvo-, Trebouxio-, and Chlorophyta) in the Neoproterozoic. Chlorophyceae developed from unicellular marine planktonic prasinophyte algae [1,2]. *Ulva* green tides have been described as a sign of eutrophication in several prior papers [3]. *Ulva* thallus development requires a constant supply of dissolved inorganic nitrogen (N) and phosphorus (P). Despite a large drop in N and P concentrations year after year, outbreaks of *Ulva* blooms have been reported in the shallow waters of Macajalar Bay in the City of El Salvador, ca. 18 km west of Cagayan de Oro City, and in Central Philippines [4-6].

Ulva grows in locations with high temperatures and irradiance, and abundant nutrients. Thus, sewage outfalls or runoff from surrounding agricultural regions might cause high nutrient levels and *Ulva* blooms. Most species will only grow if they are linked to a hard surface. In a free-floating condition, a select few can significantly increase their biomass, either by enlarging the thalli and their pieces or by reducing their size by constructing new floating thalli. As a result, unattached forms can accumulate vast biomasses, resulting in the formation of enormous tides of seaweed that can lead to green tide blooms [7].

Green tides are fast-growing macroalgal blooms that have been observed in many coastal waters in recent years. Green tides are usually large-scale transitory events on monospecific native species blooms that expand quickly [8]. It is often seasonal or episodic and consists of large biomasses of algae in a small area, which go through periods of rapid growth as they absorb large amounts of nutrients. The dissolved gases produce bioactive natural products that are stored in plants and are either released into the environment or decomposed. The green tides can cause ecological consequences through physical changes such as changing the flow of seawater and reducing the amount of light available to other algae and plants [9,10]. The utilization and creation of inorganic and organic substances by the algae in these have the potential to harm other organisms [10].

The Philippines is no stranger to green tide blooms, like the recent incidents in Boracay Island, Malay, Aklan. The growing concern for this outbreak has drawn attention to *Ulva* spp. The presence of *Ulva* spp. has also been detected in Mabini, Batangas. It is located within the Verde Island Passage Marine Corridor (VIPMC), which is known as the "Center of Marine Biodiversity."

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Mabini, a municipality in Batangas, is known as the home of Philippine scuba diving, making it a popular travel destination, particularly for divers. Beach resorts are also popular, specifically in Anilao, Mabini. Two ports located in Talaga and Anilao are present, which are capable of transporting passengers and goods to and from Mabini, Batangas. The seaports serve passengers traveling from Mabini, Batangas, to destinations like the town of Tingloy in the nearby Marikaban Island. With anthropogenic activities in the area and the presence of *Ulva* spp., Mabini might be at risk from a possible green tide bloom scenario in the future. Thus, an assessment of *Ulva* spp. in the area would provide baseline information about this. The objective of the study was to assess and compare the composition, abundance, and dominance of *Ulva* spp. in the port areas of Mabini, Batangas, including their physicochemical parameters.

2. Materials and methods

2.1. Study sites

The ports of Anilao and Talaga in Mabini, Batangas, were the study sites (Figure 1). Because it is located in an industrialized region, the location is close to many ports, which might have anthropogenic influences that cause green tide blooms and impact the composition of *Ulva* spp .

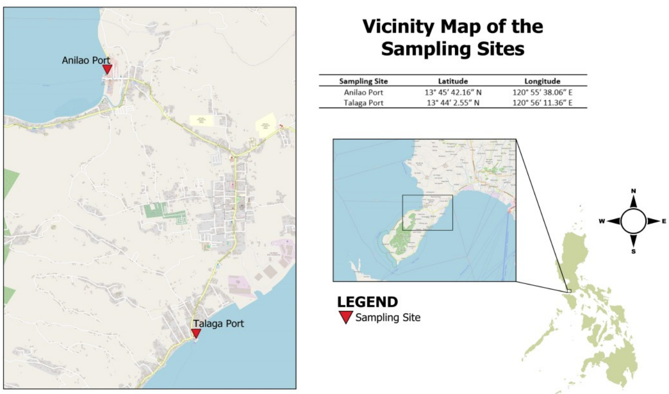

Figure 1. Anilao Port and Talaga Port vicinity map showing the sampling site.

2.2. Line transect-quadrat method

The composition, contribution, and abundance of *Ulva* spp. were determined using the line transect-quadrat method [11] in each sampling site in Mabini, Batangas. In both ports, three (3) 50-m transect lines were laid parallel to the shore. To eliminate bias during scoring, a 0.25 m^2 quadrat partitioned into twenty-five (25) 10 cm^2 grids is used and placed every 5 m on the right side of the transect.

The species composition was assessed by identifying all of the *Ulva* species found inside each quadrat (Table 1). The total surface area covered by each species inside the quadrat was estimated using the line transect-quadrat method [12] with modifications by [11] index matrix to compute the percent cover (C, %). The formula shown in Equation (1) was used to calculate the percent cover (C, %) of each species:

$$C\ (\%) = (qn_6 \times 4) + (qn_5 \times 3) + (qn_4 \times 1.5) + (qn_3 \times 0.375) + (qn_1 \times 0.1875) \quad (1)$$

where qn is the total number of little squares with a cover that corresponds to the index n in the matrix. Cover was calculated for each species in each location and may thus exceed 100% .

Table 1. Degree index of seaweed or seagrass cover in a quadrat with its corresponding multiplier

Index	Degree of seaweed or seagrass cover	Multiplier
6	Covering 98%–100%	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%	0.1875

There could be one or more dominant species in the area, which was determined by identifying species with cover values equal to or more than 50% of the total *Ulva* spp. cover. The proportion of the contribution of each species to the overall *Ulva* spp. cover in the site is referred to as species contribution (percent). The formula for calculating the dominance was shown in Equation (2):

$$\%\ contribution\ of\ a\ species = \frac{total\ C\ of\ a\ species}{grand\ total\ C\ of\ all\ species} \times 100\% \quad (2)$$

Thus, if the percent contribution of a species is greater than 50%, it is considered to be dominant.

2.3. Physicochemical characterization

The temperature (°C), salinity (PSU), pH, and dissolved oxygen (mg/L) in each site are measured once for 10 min using a portable multiparameter probe meter (YSI, Yellow Springs, Ohio, USA).

2.4. Statistical analysis

One-way Analysis of Variance (ANOVA) was used to determine the significant difference between the diversity of *Ulva* spp. (computed using Shannon-Wiener Diversity Index) in the port areas of Mabini, Batangas. All statistical tests were conducted using R Software (version 4.2.2).

3. Results and discussion

3.1. The composition of *Ulva* spp. in the port areas of Mabini, Batangas

A total of three species are identified in the port areas: *Ulva lactuca, Ulva intestinalis,* and *Ulva clatharata.* Firstly, *Ulva lactuca* has a discoid holdfast with a flat green blade. Next, *Ulva intestinalis* possesses inflated tubular fronds with uneven constriction that develop from a tiny discoid base. Lastly, *Ulva clatharata* is a light green *Ulva* spp. with a thin, cylindrical, thread-like blade.

In Anilao Port, only one *Ulva* sp. was present, which is *Ulva clathrata* (Figure 2), and was observed attached to rocks and coral rubble. While in Talaga Port, three *Ulva* spp. were present, which are *Ulva clathrata, Ulva intestinalis,* and *Ulva lactuca* (Figure 3). These species were observed to be attached to the concrete sea walls, moistened with or submerged in water. This is in line with the study on Verde Island, Batangas City, as the same types of macroalgae are also present [13], and from the study on Cuta West–Sta. Clara, Batangas City, with the same species present, such as *Ulva intestinalis* and *Ulva lactuca* [14] .

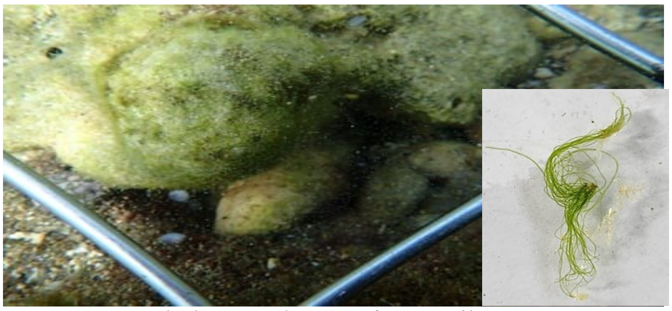

Figure 2. *U. clathrata, Ulva* spp. from Anilao Port.

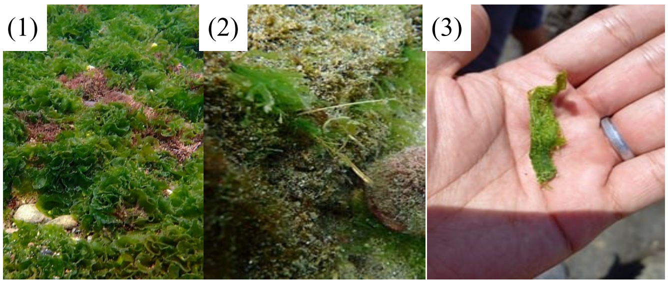

Figure 3. *Ulva* spp., *(1) U. lactuca, (2) U. intestinalis, and (3) U. clathrata* from Talaga Port.

3.2. Community structure of *Ulva* spp. in the port areas in Mabini, Batangas

The community structure of *Ulva* spp. in the port areas of Mabini, Batangas, was determined in terms of abundance and contribution of the species (Table 2). *Ulva clathrata* has a 51.04% abundance from the Anilao Port and a 100% percent contribution. *Ulva intestinalis*, *Ulva clathrata*, and *Ulva lactuca* are abundant in Talaga Port, with abundances of 40.06%, 41.48%, and 4.14%, respectively. *Ulva intestinalis* and *Ulva clathrata* together make up the species with the largest percentage contribution (95.19%), making them the most dominant species from both port areas compared to Cuta West, Sta. Clara, Batangas City, the most abundant species are *Ulva lactuca* and *Ulva intestinalis* [14].

Table 2. Abundance and percent contribution of *Ulva* spp. in the port areas in Mabini, Batangas

Ulva spp.	Anilao Port		Talaga Port	
	Abundance, % cover	% contribution of each species	Abundance, % cover	% contribution of each species
Ulva clathrata	51.04%	100%	40.06%	46.56%
Ulva intestinalis	-	-	41.48%	48.63%
Ulva lactuca	-	-	4.14%	4.81%

The presence of more *Ulva* spp. in Talaga Port might be due to significantly higher nitrate levels in the area, as *Ulva* thrives in locations with abundant nutrients. Talaga Port has 72% higher nitrate than Anilao Port. The nitrate levels might be high because the Talaga Port has a more industrialized port area and has sewer outfalls directed into the seawater.

Talaga Port scored higher on the diversity index in all replicates. Reason being that only *U. clathrata* is present in Anilao Port, thus having a score of 0 in all replicates (Table 3).

Table 3. Shannon-Wiener Diversity Index per transect of *Ulva* spp. in the port areas in Mabini, Batangas

	Transect	Anilao Port	Talaga Port
Diversity	T1	0	0.91
	T2	0	0.72
	T3	0	0.67
		N = 3	N = 3

3.3. Physicochemical conditions of the water in the port areas in Mabini, Batangas

The temperature between the two ports was relatively close to one another (Table 4) and in comparison with the study on marine macrophyte composition at Verde Island, Batangas City, with temperatures ranging from 28 to 32 °C [13]. The salinity was lower in Talaga Port than in Anilao Port, which might be due to the freshwater inputs from the number of sewage outfalls. The measured salinity in both ports was lower than the values measured in Verde Island, Batangas City, ranging from 32 to 33 ppt [13].

Table 4. Shows the comparison of the physicochemical parameters between the Anilao Port and the Talaga Port

Physicochemical parameters	Anilao Port	Talaga Port
Temperature (°C)	30.02	29.62
Salinity (PSU)	29.404	26.846
pH	8.528	8.49
Dissolved Oxygen (mg/L)	9.508	6.206
Irradiance (μmol photon m^{-2} s^{-1})	781.762	654.314
Phosphate (mg/L)	0.0350	0.0187
Nitrate (mg/L)	1.9530	5.0843

The pH level from both ports seems to be relatively the same, and in comparison with the values measured in Verde Island, and Cuta West–Sta. Clara, Batangas City [13,14]. The dissolved oxygen was relatively higher in Anilao Port than in Talaga Port, which might be due to other metabolic processes in the latter area. The irradiance levels at the Anilao Port were relatively higher than those of the Talaga Port. The latter has turbid waters due to strong wave action. Thus, materials suspended in the water make it turbid, blocking the sunlight.

Nitrate seems to be relatively higher in Talaga Port. From field observation, Talaga Port has direct sewage outflow from nearby households. On the other hand, Phosphate seems to be almost similar between the two ports. Thus, nutrients were also considered one of the principal factors restricting algal development, and to acquire optimal development of the algal species, the proper concentration of nutrients, particularly nitrate and phosphate, is required. It is also mentioned that the growth of *Ulva* spp. generally increased when cultured at doses of nitrate and phosphate [15] .

Strong wave movements were observed in Talaga Port, while Anilao Port exhibited only minor wave movements. This phenomenon makes the water turbid due to suspended sediments. Due to turbidity, the availability of light was reduced, and it may be a disadvantage for the photoautotroph species [16]. Also, strong wave movements may rip apart species with thin foliose thalli, such as *Ulva lactuca,* that may limit their ability to absorb sunlight for photosynthesis.

3.4. The difference in the diversity of *Ulva* spp. in the port areas of Mabini, Batangas

Talaga Port has a higher diversity than Anilao Port (Figure 4; ANOVA, $F(1,4) = 110.6$, $p < 0.001$). With Talaga Port having a diversity index of 0.6-0.9, while Anilao Port has 0. This is due to Anilao Port having only one present *Ulva* species, namely *U. clathrata*, throughout all the replicates. On the other hand, Talaga Port, with higher nitrate content, has a total of three species present, *U. clathrata*, *U. intestinalis*, and *U. lactuca,* confirming that nutrients, especially nitrate and phosphate, are the main limiting factors of algal growth in aquatic ecosystems [15] .

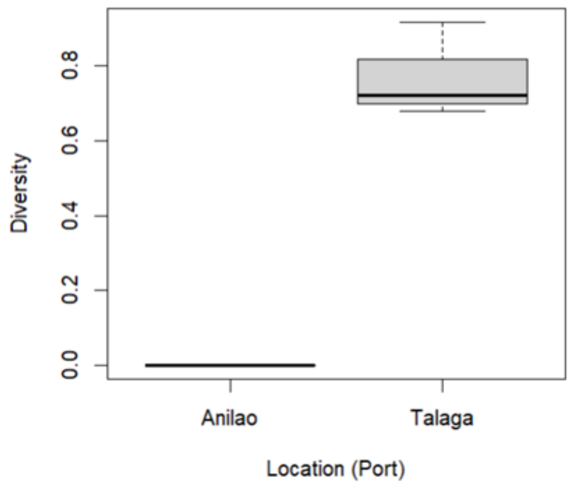

Figure 4. Box plot showing the difference in diversity of *Ulva* spp. between the Anilao Port and the Talaga Port.

4. Conclusions

There were more *Ulva* spp. found in Talaga Port than in Anilao Port. *Ulva intestinalis* and *Ulva clathrata* were the most dominant species in the Talaga Port, while in Anilao Port was *Ulva clathrata*. A low abundance of *Ulva lactuca* was observed in Talaga Port, possibly because of the habitat characteristic in which strong waves were unsuitable for their wide, thin thallus. The nitrate content had a greater value in Talaga Port, which might be due to direct sewage outfalls. Physicochemical parameters in Anilao Port were generally higher than those of Talaga Port. Thus, *Ulva* spp. thrives in nutrient-rich areas, such as in Talaga Port, whereas sewage outfalls are flowing directly to the seawater, resulting in the difference in abundance of *Ulva* spp. in the two ports. Overall, nitrate has a possible effect on the abundance, composition, and dominance of *Ulva* spp. in the two ports.

Year-round assessment of *Ulva* spp., their nutrient update, and physicochemical monitoring to provide robust information on the possible vulnerability of the ports to green -tide bloom. Further assessment of the relationship between the species composition and physicochemical factors in the ports of Mabini, Batangas, is recommended .

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