Species composition, abundance and distribution of seagrasses along the coast of Tacloban, Philippines

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ABSTRACT

The seagrass ecosystems along the intertidal areas of Tacloban City, Philippines were rapidly assessed in October 7-29, 2017. This was specifically aimed to map the areas covered by seagrass beds, determine species composition, distribution, and abundance, and identify potential threats to these ecosystems. Seagrass beds observed in Cancabato Bay, Anibong Bay, Brgys. Tigbao-Diit, Brgy. Bagacay, Brgy, Cabalawan, Brgy. Suhi (San Isidro), Brgys. Sto. Niño-Kawayan and Tagpuro cover an area of at least 54,503 m^2 or 54.2 ha. Only 4 seagrass species were identified from all the sites, namely: *Enhalus acoroides* (Linnaeus f.) Royle, *Thalassia hemprichii* (Ehrenberg) Ascherson, *Cymodocea serrulata* (R. Brown) Ascherson & Magnus, and *Halodule uninervis* (Forsskål) Ascherson. *E. acoroides* was the most widely distributed of all the species. The average seagrass cover and biomass were 42.0 ± 9.5 %/m^2 and 53.8 ± 6.6 g dry weight/m^2, respectively. Some potential threats to adjacent seagrass beds such as, direct discharge of untreated wastewater, presence of fish pens, plastic pollution, human dwellings, docking areas for pumpboats, recreational areas, man-made intertidal structures, sedimentation, oil pollution and destructive shellfish gleaning were observed and subsequently, geotagged.

KEYWORDS

seagrass species composition, distribution, abundance, Tacloban

INTRODUCTION

Seagrasses are marine flowering plants (angiosperms) that thrive in the intertidal and subtidal areas of the ocean. About 12 to 18 species of seagrasses occur in the Philippines (Meñez et al. 1983, Calumpong and Meñez 1997, Fortes 2013). Seagrass beds provide a number of ecosystem services including, sediment stabilization, removal of nutrients in the water column and as food source and habitat for many marine organisms. They are also rich food sources for humans as multiple fish species and invertebrates (e.g. mollusks) can be harvested. Nordlund et al. (2017) recently demonstrated that these ecosystems support subsistence, commercial and recreational fisheries around the globe. The role of seagrass meadows in climate change mitigation and adaptation has also been pointed out by a number of authors (Duarte et al. 2005, McLeod et al. 2011, Duarte et al. 2013). These plants develop thick canopies and extensive rhizome-root systems making them efficient carbon sinks. Carbon burial in seagrass ecosystems are also exceptionally higher compared to those found in terrestrial ecosytems (Duarte et al. 2013). Apart from this, seagrasses are known to increase underwater sheer stress reducing the energy of waves and its impact on the coast (Duarte et al. 2013). Despite these services, seagrass ecosystems are often excluded from marine conservation efforts and coastal resource management planning. Seagrass habitats are being depleted in critical rates (McLeod et al. 2011) and are threatened by various factors, including eutrophication, land reclamation, and siltation (Duarte et al. 2005). Its current status in most areas in the Philippines is largely unknown, including the coast of Tacloban (Fortes 2013). Considering this gap, we provided information that will assist decision-makers in jumpstarting the proper management of this coastal resource. Future researchers can also design monitoring activities and seagrass studies aimed at more specific questions based on this preliminary information. We described in this report the current extent, species composition, abundance and the potential threats to the seagrass ecosystems in the intertidal area of Tacloban.

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METHODS

Site

The seagrass ecosystem assessment was conducted in October 7-29, 2017 in Cancabato Bay, Anibong Bay and the coastal areas of northern Tacloban (Brgys. 94 Tigbao; 99 Diit; 93 Bagacay; 97 Cabalawan; 105 Suhi/San Isidro; 106 Sto. Niño; 102 Old Kawayan; 108 Tagpuro). A reconnaissance survey was conducted to determine the actual extent of the study area.

Seagrass mapping and sampling

Seagrass mapping and sampling methods suggested in Kirkman (2000), McKenzie et al. (2001), McKenzie (2003), Leliaert and Coppejans (2004) were adopted with some modifications. Snorkeling and bounce dives were conducted to confirm presence of seagrasses during reconnaissance survey. The landward and seaward boundaries of seagrass meadows were marked using Garmin GPS Map 64s. GPS points were recorded while walking, on board a paddleboat or on a pumpboat whichever was feasible at the existing site. Maps were generated using QGIS 2.18.13 (2017). Areas covered by seagrass beds were calculated using the reprojected GPS data (WGS 84 to PRS 92 Coordinate Reference System) and the $area function in QGIS. Considering the generally homogeneous nature of the seagrass beds and high water turbidity, eleven 50 m transects were laid parallel to the shore at a low tide depth ranging between 0.5 to 1.0 m. Four of these transects were laid in Cancabato Bay and 7 along the coasts of northern barangays. At each transect, 10 randomly placed 0.25 m^2 gridded quadrats were used to sample species composition and abundance.

Seagrass species composition and abundance

Seagrass species identification was verified using the following field guides and monographs: Seagrasses from the Philippines (Meñez et al. 1983), Field Guide to the Common Mangroves and Seagrasses and Algae of the Philippines (Calumpong and Meñez et al. 1997), Tropical Marine Plants of Palau (Ohba et al. 2007) and Field Guide to the Seagrassses of the Red Sea (El Shaffai 2011). Two parameters were used to describe abundance: (%) cover and biomass. Seagrass cover was determined by counting the number of subquadrats occupied by seagrasses, dividing it by the total number of subquadrats and expressing it in percentage for every m^2. To measure biomass, seagrasses found within the 3 quadrats were harvested using a shovel. Seagrass shoots and rhizomes were both collected and placed in zip-lock bags. The samples were washed with tapwater to remove debris and were dried to constant weight at 70ºC. Biomass was expressed in dry weight (g/m^2).

Identification and characterization of seagrass ecosystem threats

Surveyors identified and geotagged potential threats to seagrass beds during the reconnaissance and mapping surveys.

RESULTS

Seagrass Distribution

Seagrass meadows were observed in the bays of Cancabato (11.22967 N, 125.01269 E) and Anibong (11.26031 N, 124.97636 E), and along the coasts of the northern barangays of Tacloban [Brgys. 94 Tigbao (11.26453 N 124.97119 E); 99 Diit (11.26983 N, 124.96886 E); 93 Bagacay (11.27986 N, 124.96344 E); 97 Cabalawan (11.30422 N, 124.96539 E); 105 Suhi/San Isidro (11.30506 N, 124.96506 E); 106 Sto. Niño (11.32900 N, 124.96553 E); 102 Old Kawayan (11.33506 N 124.96875 E); 108 Tagpuro (11.34578 N, 124.96783 E)]. A total of 572 GPS coordinates were collected marking the landward and seaward boundaries of the meadows. These beds cover an area of at least 54,503 m^2 or 54.2 hectares (Table 1 and 2; Figure 1). Seagrasses covered the largest area (236,735.6 m^2 or 23.7 ha) in Cancabato Bay (Figure 2). This was followed by Anibong Bay at 104,869.6 m^2 or 10.5 ha. The smallest areas were recorded for Bagacay (5,318.1 m^2 or 0.5 ha) and Cabalawan (3,179.94 m^2 or 0.3 ha).

Characterization of seagrass ecosystems

Species composition. Four seagrass species belonging to two families (Hydrocharitaceae and Cymodoceaceae) were identified from all the sites

Table 1. Estimated area covered by seagrass beds in different sites in Tacloban City.

Site	Area (m^2)	Area (hectares)
Cancabato Bay	236,735.6	23.7
Anibong Bay	104,869.6	10.5
Tigbao-Diit	83,903.4	8.4
Bagacay	5,318.1	0.5
Cabalawan	3,179.94	0.3
Suhi-San Isidro	47,381.6	4.7
Sto. Niño-Kawayan	23,205.66	2.3
Tagpuro	36,909.5	3.7
TOTAL	**541,503.3**	**54.2**

Table 2. Total area covered by discrete seagrass polygons.

Polygon	Site Name	Station Name	Area (m^2)	Area (hectares)
1	Anibong Bay	Anibong Bay	104,869.64	10.5
2	Bagacay	Bagacay	5,138.67	0.5
3	Bagacay	Bagacay	179.41	0.0
4	Cabalawan	Cabalawan	3,179.94	0.3
5	Cancabato Bay	Brgy. Kataisan (1)	23,364.68	2.3
6	Cancabato Bay	Brgy. Kataisan (2)	23,987.95	2.4
7	Cancabato Bay	PNP Firing Range	1,680.08	0.2
8	Cancabato Bay	Fisherman's Village	45,253.81	4.5
9	Cancabato Bay	Fisherman's Village	5,535.74	0.6
10	Cancabato Bay	Fisherman's Village	1,373.51	0.1
11	Cancabato Bay	Fatima Village	4,700.77	0.5
12	Cancabato Bay	Cafe Lucia	33,650.7	3.4
13	Cancabato Bay	Magallanes (San Fernando)	14,899.6	1.5
14	Cancabato Bay	Magallanes (Near Mcdonald's)	6,883.78	0.7
15	Cancabato Bay	Family Park	2,972.8	0.3
16	Cancabato Bay	UP Botanical Garden	434.26	0.0
17	Cancabato Bay	Middle Cancabato Bay (Shallow area)	71,997.91	7.2
18	San Isidro	San Isidro	1,675.1	0.2
19	San Isidro	San Isidro	23.57	0.0
20	San Isidro	San Isidro	39,105.92	3.9
21	Sto. Niño-Kawayan	Kawayan	23,205.66	2.3
22	Suhi/San Isidro	Suhi/San Isidro	6,576.96	0.7
23	Tagpuro	Tagpuro	26,456.07	2.6
24	Tagpuro	Tagpuro	802.00	0.1
25	Tagpuro	Tagpuro	7,363.42	0.7
26	Tagpuro	Tagpuro	2,287.97	0.2
27	Tigbao	Tigbao (before river)	24,542.47	2.5
28	Tigbao-Diit	Tigbao (docking area)	59,360.88	5.9
		TOTAL	**541,503.27**	**54.2**

surveyed, namely: *Enhalus acoroides* (Linnaeus f.) Royle, *Thalassia hemprichii* (Ehrenberg) Ascherson, *Cymodocea serrulata* (R.Brown) Ascherson & Magnus, and *Halodule uninervis* (Forsskål) Ascherson. Kataisan (2) in Cancabato Bay harboured all the 4 species and was the most species rich of all the stations sampled. *E. acoroides* was the most widely distributed (Figure 3). This species was found in all of the sites surveyed. However, *E. acoroides* was not observed within the quadrats in Kataisan (site 1) (Table 3). *T. hemprichii* was found to co-occur with *E. acoroides* but not in all sites (Figure 3). It co-occurred with *E. acoroides*, *C. serrulata* and *H. uninervis* at Kataisan (2) (Table 4). The last two species were both limited to the sites in Kataisan Point (Figure 3).

Seagrass abundance. The average seagrass cover of the surveyed sites is at 42.0 ± 9.5 %/m^2. The largest cover ranging from 54.8 ± 3.1 %/m^2 to 89.6 % cover/m^2 was observed in the Cancabato stations (Table 4). Kawayan (11.6 ± 2.4 % /m^2) and Anibong Bay (3.6 ± 0.9 %/m^2) stations obtained the smallest seagrass cover. It is notable that plants grow sparsely in the latter site but at the same time covers the second largest area (Table 1).

The average seagrass biomass of the surveyed sites is at 53.8 ± 6.6 g dry weight/ m^2 (Table 4). Cabalawan and Fatima Village (Cancabato) stations obtained the highest seagrass biomasses at 94.3 ± 6.6 g dry weight/m^2 and 86.0 ± 1.4 g dry weight/ m^2, respectively. Anibong Bay recorded the lowest biomass of all stations at 19.2 ± 3.5 g dry weight/m^2.

Associated Flora (seaweeds/macroalgae). No macroalgae fell within the randomly-thrown quadrats in all of the sampling stations. Seaweeds were generally observed occurring at the fringes of seagrass beds in Bagacay, Cabalawan, San Isidro and Kawayan. The good diversity observed in these areas warrants a separate floristic study. We have collected and identified few seaweed species that were ubiquitous in the study sites. A noteworthy observation was the presence of a long and thick bed of *Caulerpa serrulata* growing at the landward edge of seagrass beds in San Isidro

Seagrass Ecosystem Threats

Potential threats to adjacent seagrass ecosystems noted during the mapping include discharge of untreated wastewater, fish pens, plastic pollution, human dwellings, recreational areas, docking areas for pumpboats, man-made intertidal structures, sedimentation, oil pollution, and destructive shellfish gleaning (Figure 4). These threats were observable along the entire coast. Managing of fish pens was common to both northern Tacloban and Cancabato Bay barangays (Figure 4). Sedimentation was observed between Cabalawan and Suhi. Destructive gleaning of bivalves (locally known as "punaw") was reported in Cancabato Bay (pers. comm. with Mr. Jess Gariando, a long-time resident of San Jose, Tacloban City).

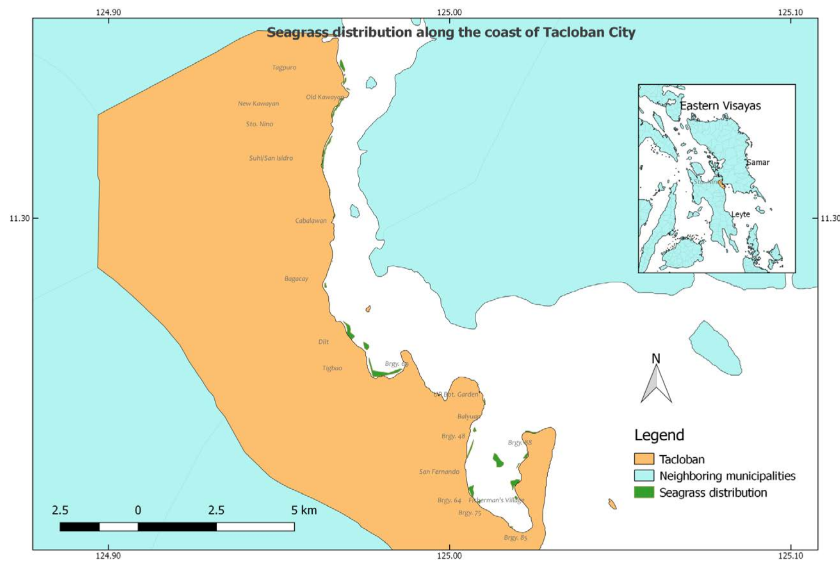

Figure 1. Location of seagrass meadows along the coast of Tacloban City.

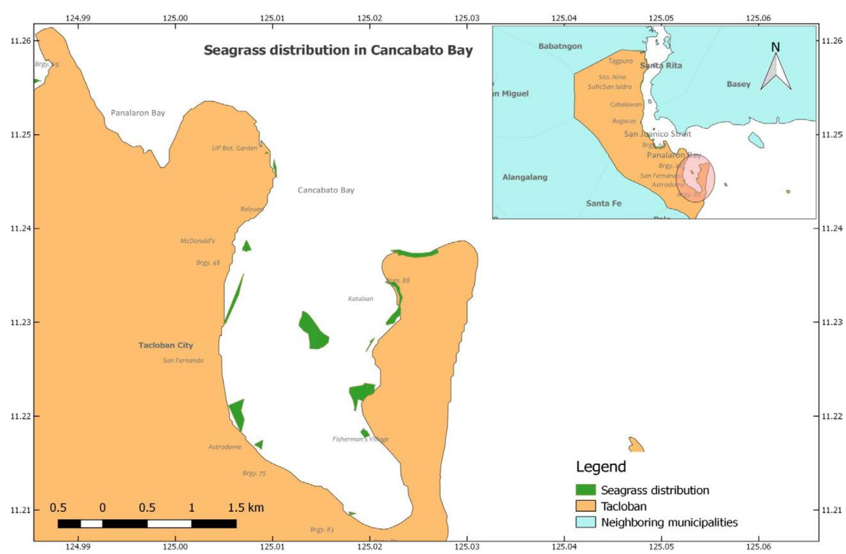

Figure 2. Location of seagrass meadows in Cancabato Bay.

DISCUSSION

Although seagrass research in the Philippines has progressed from basic taxonomic investigations to ecological observations and more recently, to climate change response studies (Fortes 2011, Fortes 2012), such efforts have been limited to few localities. The few studies that exist are mainly dedicated to floristic investigations, for example, in Hundred Islands (Domantay 1962), Luzon (Cordero 1981), Davao Gulf (Calumpong et al. 1985), in western Palawan (Meñez and Calumpong 1982) and in Negros Oriental (Meñez and Calumpong 1985). Meñez et al. (1983) released a monograph on the seagrasses of the Philippines but the materials examined were restricted to sites in the Visayas, Palawan, La Union, and Ilocos Norte. The seagrass meadows in Bolinao, Pangasinan are probably the most studied in the country. A handful of investigators studied the area's seagrass growth rates (Vermaat et al. 1995), species composition and response to siltation (Bach et al. 1998; Terrados et al. 1998), the influence of environmental factors on spatial and temporal variation of *Enhalus* reproduction (Rollon et a. 2003), and the effects of excessive siltation and fish culture nutrient loading (Fortes et al. 2012, Tanaka et al. 2014). On the contrary, simple baseline surveys of marine resources in many localities are still wanting as in the case of the Tacloban coastline. Consequently it is difficult to know how these local resources respond to increasing anthropogenic stresses (e.g. milkfish aquaculture), changing bathymetry, strong impacts due to typhoons (e.g. Typhoon Haiyan in 2013) and eventually, sea level changes. Researchers were able to measure the impact of the Indian Ocean tsunami in 2004 on seagrass beds in the coast of Thailand along the Andaman Sea because species diversity, coverage and biomass data were collected before and after the disturbance (Nakaoka et al. 2006). In contrast, the impact of Typhoon Haiyan in 2013 on seagrass meadows could not be measured due to absence of before and after impact data. The current study provides the first account of the extent, species diversity, distribution, and abundance of the seagrass

Table 3. Seagrass species cover (%/m²) and biomass (g/m²) in different sites in Tacloban City.

Site	Station Name	Cover (%/m² ± SE)	Dry Weight (g/m²)	Species Observed
Cancabato Bay	Kataisan (1)	89.6 ± 3.6	48.9 ± 3.7	*Cymodocea serrulata*
				Halodule uninervis
Cancabato Bay	Kataisan (2)	74.4 ± 8.4	37.6 ± 4.4	*Cymodocea serrulata*
				Enhalus acoroides
				Halodule uninervis
				Thalassia hemprichii
Cancabato Bay	Fatima Village	82.4 ± 5.8	86.0 ± 1.4	*Enhalus acoroides*
Cancabato Bay	Magallanes (McDonald's)	54.8 ± 3.1	55.7 ± 15.6	*Enhalus acoroides*
Cancabato Average		***75.3 ± 7.5***	***57.1 ± 10.3***	
Anibong Bay	Anibong	3.6 ± 0.9	19.2 ± 3.5	*Enhalus acoroides*
Tigbao	Tigbao (before river)	16.4 ± 1.6	54.0 ± 16.8	*Enhalus acoroides*
Tigbao-Diit	Tigbao (docking area)	39.6 ± 8.1	39.8 ± 30.3	*Thalassia hemprichii*
				Enhalus acoroides
Cabalawan	Cabalawan	20.0 ± 5.4	94.3 ± 13.0	*Enhalus acoroides*
				Thalassia hemprichii
Suhi-San Isidro	San Isidro	12.0 ± 4.3	58.2 ± 14.1	*Enhalus acoroides*
Sto. Niño-Kawayan	Kawayan	11.6 ± 2.4	36.0 ± 7.9	*Enhalus acoroides*
Tagpuro	Tagpuro	24.8 ± 2.1	61.8 ± 11.8	*Enhalus acoroides*
				Thalassia hemprichii
Tacloban Average		**42.0 ± 9.5**	**53.8 ± 6.6**	

resource in Tacloban City.

There are no recent estimates of the total area covered by seagrass meadows in the country. Fortes et al. (2018) presented an estimate of 27,262.2 km² based from a World Bank report thirteen years ago (2005). Fortes (2004) also provided estimates of those from 96 sites in the country. The seagrass areas from these sites totalled to 978 km² (97800 ha). The current study provided the first estimate (54.2 ha or 0.542 km²) of the total seagrass area in Tacloban. This value may be slightly larger as shallow edges of some intertidal areas (in particular, Anibong Bay) could not be explored, and eventually, mapped in greater detail due to extremely muddy substrate. However, ground survey of seagrass contours is useful in turbid waters and if intending to include sparsely vegetated areas which could be disregarded in remote sensing methods.

Low seagrass diversity was also observed along the intertidal area of the coast of Tacloban. Only 4 seagrass species, namely, *Enhalus acoroides*, *Cymodocea serrulata*, *Halodule uninervis and Thalassia hemprichii* were observed during the survey period in October 2017 as opposed to the 12 to 18 species (Meñez et al. 1983, Calumpong and Meñez 1997, Fortes 2013) reported for the Philippines. The low diversity may be attributed to the generally turbid seawater condition. Seagrasses primarily grew in sandy-silty to muddy substrates with the exception of those growing in sandy to sandy-rocky substrates found in some sites in Bagacay, San Isidro and Tagpuro. The presence of silt and other suspended materials in the water column reduces the amount of light available for plants, and can therefore influence the growth of some species (Meñez et al. 1983, Vermaat et al. 1995, Bach et al. 1998). In Cape Bolinao (Philippines), Bach et al. (1998) observed declining seagrass species diversity with increasing amounts of suspended material and increasing light attenuation. *E. acoroides*, *C. serrulata*, *H. uninervis and T. hemprichii* were the most siltation-tolerant of the 8 species found in the area. The current report does not exclude the possibility of the occurrence of other species, for example, *Halophila* in periods of favourable growth. A whole suite of environmental factors (e.g. temperature, irradiance, rainfall, etc.) have been identified to influence the temporal dynamics of seagrasses including that of *Halophila* (Qiu et al. 2017). Seagrass seed germination also appears dependent on certain environmental cues (e.g. temperature and sediment oxygen levels) (Orth et al. 2000). Thus, long-term monitoring is necessary to understand the temporal dynamics and to fully capture the diversity of seagrasses in the area.

Of all the 4 species encountered in Tacloban coast, *E. acoroides* was the most widely distributed species. Most sites were monospecific *E. acoroides* meadows. The *Enhalus*-*Thalassia* association found in muddy substrates as described in Calumpong and Meñez (1997) were observed in Tigbao, Cabalawan and Tagpuro. This was present in sandy-silty and silty-muddy substrates. *Thalassia* was more limited in the shallows at 30-40 cm deep. *C. serrulata* and *H. uninervis* were found only in Kataisan where the water was less turbid compared to other sites in Cancabato Bay and the northern coast.

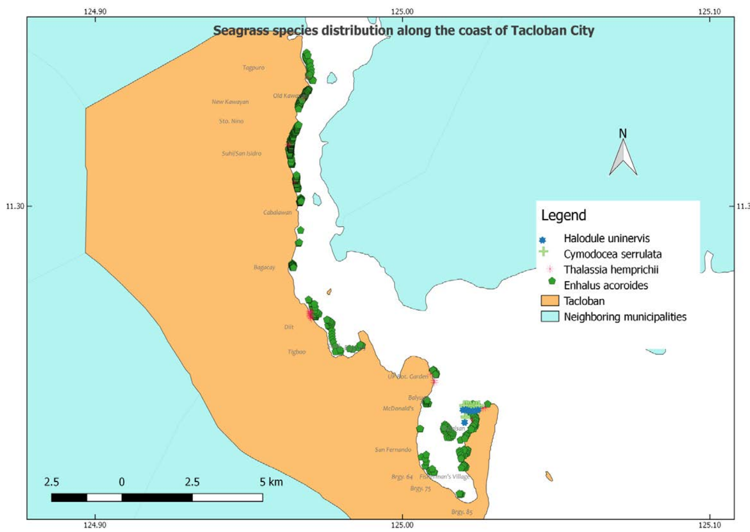

Figure 3. Distribution of various seagrass species along the coast of Tacloban.

There are many ways to quantify seagrass abundance and that includes leaf cover, biomass, shoot density and canopy height (Duarte and Kirkman 2001). We estimated the seagrass abundance using leaf cover and biomass. These two parameters were more practicable in turbid water than counting the shoots of shorter species. The average seagrass cover in the intertidal area of Tacloban is lower (42.0 ± 9.5 %/m^2) compared to other reported seagrass cover values in other parts of the Philippines, for example, Cape Bolinao (75%), Puerto Galera (95%), Ulugan Bay (90%), and Honda Bay (90%) (UNEP 2004). However, the largest cover (89.6 %/m^2) observed in a Cancabato Bay station is comparable to the latter values. Future investigations can include canopy height measurements especially for monospecific *E. acoroides* beds. The average biomass (i.e., shoot and rhizome dry weight) is smaller (53.8 ± 6.6 g dry weight/m^2) compared to the reported leaf-only biomasses from other sites, for example, Bolinao (282.2 g dry weight/m^2), Puerto Galera (81.6 g dry weight/m^2), and Bacuit Bay (El Nido) (87.9 g dry weight/m^2) (Terradoes et al. 1998).

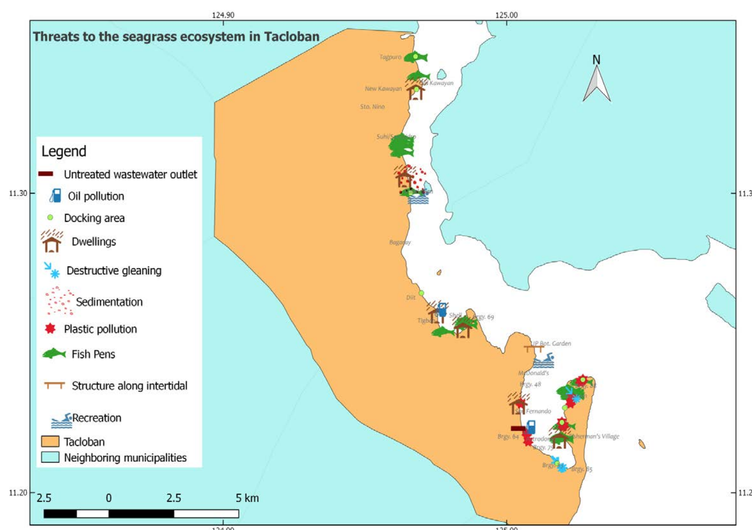

Figure 4. Potential threats to seagrass ecosystems in Tacloban City.

The current study identified and geotagged potential threats to adjacent seagrass beds. There are no seagrass meadows that can be considered pristine (sensu Fortes 1991) as the entire coast is either inhabited or disturbed by human activities. Most of the threats observed can cause the deterioration of water quality. The current proliferation of fish pens for bangus (*Chanos chanos*) culture in Tacloban, if unregulated, can lead to further decline of surrounding coastal waters due to excess fish feed particles. The nutrient-loaded feeds encourage the growth of microalgae and epiphytes (Vermaat 1997, Fortes 2000). Consequently, light availability for seagrass growth becomes limited. Siltation (possibly due to nearby land development) observed between Cabalawan and Suhi may also bring a similar outcome. Silt limits light availability for benthic organisms including seagrasses (Fortes 2000). In Bolinao, Pangasinan some species disappeared and species composition changed due to mariculture-induced nutrient loading and siltation (Fortes et al. 2012, Tanaka et al. 2014). Some human activities can also cause direct physical harm or scars on seagrass beds. For example, destructive gleaning of bivalves (locally known as "punaw") by shovelling has already caused the thinning of seagrass beds in Cancabato Bay (Mr. Jess Gariando pers. comm.).

Considering these threats, we propose a few actions to ensure conservation of these seagrass ecosystems in the coast of Tacloban: First, conduct regular monitoring. Future monitorings should be designed to capture natural variations (e.g. seasonal variation in biomasses) and detect changes brought by anthropogenic disturbances. It takes 5-10 years to detect anthropogenically-induced changes on seagrass ecosystems (Duarte and Kirkman 2001). Less destructive sampling for biomass estimations should be considered. Second, explore the creation of several seagrass protected areas in areas with relatively higher diversity and density (e.g. Kataisan sites 1 & 2, Fatima Village, Magallanes, Tigbao and Tagpuro. Finally, explore the possibility of seagrass transplantation or revegetation, particularly with *Enhalus acoroides*, in areas with low densities (e.g. coastal areas along UPV Tacloban Botanical Garden and Brgy. Bagacay). Seagrass transplantation is not new to the Philippines. Earlier efforts have been conducted in Bolinao Bay (Pangasinan), Calancan Bay (Marinduque) (Fortes 1991) and in Negros Oriental Calumpong and Fonseca (2001). The latter authors also described seagrass transplantation and restoration methods.

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