Real-time monitoring of hydrodynamics and suspended sediment concentrations in a coastal reef

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INTRODUCTIONS AND FIELD EXPERIMENTS

The algal reef ecosystem in Taoyuan coast, Taiwan, is considered a unique endemic species population, but the coastal constructions might cause the sensitive ecological area problems (Kuo et al., 2020). Several studies have confirmed that suspended sediment concentration *(c)* is a major detrimental factor affecting reef health. In recent years, there has been a focus on long-term monitoring of the *c*, but without continuous data. Most of study used an optical backscatter sensor (OBS) for long-term monitoring of the *c* because of its small size, low power, highly linear response and insensitivity to bubbles or organic matter. By contrast, few studies focus on testing how frequency the OBS should be calibrated because of other factor such as sediment size also affect the sensor response. Furthermore, although the long-term monitoring was demonstrated over the years ago, little attention has been paid to the real-time monitoring of *c*, especially since this method is achieved in the sensitive algal reef. For this reason, the real-time and long-term monitoring of waves and *c* (started in 2019 and lasts for 7 years) are necessarily performed in this algal reef conservation (Figure 1).

This paper presents a one-year monitoring dataset from 19 July 2019 to 19 July 2020. c was inferred from four OBS sampling at 2 Hz and was compared with water sample analysis. While the wave condition was measured by two pressure sensors (4 Hz) at two sites G2-S and G2-L. Significant wave height, Hs, has traditionally been defined as the average height of the highest one third of waves during a sampling interval (Dean & Dalrymple, 1991). Assuming surface-wave heights generally follow a Rayleigh distribution as Longuet - Higgens (Longuet-Higgins, 1952) argued and others have verified as Young (Young, 1999), this definition of significant wave height is equivalent to

$$\mathrm{Hs} = 4\mathrm{m}_0 = 4\left[\int \mathrm{S}_\eta(\mathrm{f})\mathrm{df}\right]^{1/2} \qquad (1)$$

The bottom orbital velocity:

$$u_{b,n} = \frac{a_n \omega_n}{sinhk_n h}, \qquad (2)$$

The effect of wave motion-induced shear stress on c should be dominated in the shallow algal reef (Pomeroy et al., 2017; Wiberg & Sherwood, 2008). For this reason, the bed stress of current could be neglected. Then, the wave bed stress (τ_w) is computed by:

$$\tau_\mathrm{w} = \rho \mathrm{u}_{*\mathrm{w}}^2 = \frac{1}{2}\rho \mathrm{f}_{\mathrm{w,r}}\mathrm{u}_\mathrm{b}^2 \qquad (3)$$

Where ρ is the water density; wave friction factor, $f_{w,r}$; and the wave-induced u_{*w} (wave shear velocity).

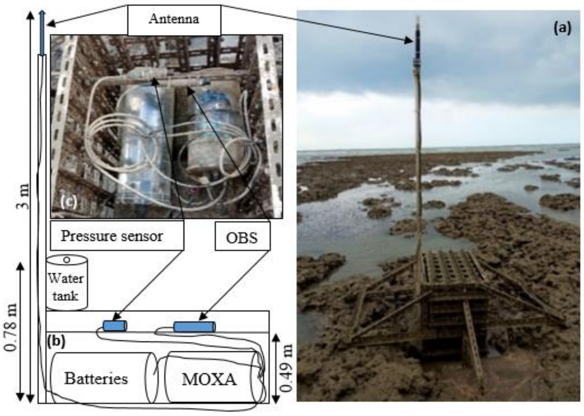

Figure 1 - (a) An image of the site with the deployed instrumentation. (b) Schematic illustration of the suit G2 seaward (G2 - S) deployed in the field experiment and (c) An down-looking image of the instrument at site G2 - S.

RESULTS

Overall the *c* inferred from the OBS was consistent with the *c* analyzed from water samples (Figure 2). However, the testing accuracy of this monitoring system over year-long timescales suggested that the OBS should be recalibrated. As a result, the *c* over the algal reef has a substantial seasonal variation; Specifically, the comparison of the seasonal averaged of *c* and the reef affected threshold showed the lower during summer and the higher in the winter.

Moreover, a good relationship of *c* to the significant wave height (Figure 3). On the algal reef flat, a simple estimation of the near-bottom orbital velocity vastly improves the predictive capability of established the regression for the *c*. The *c* was affected by the bottom orbital velocity, especially in the case of extreme conditions (typhoon).

This monitoring system has great advantages that it can be easily installed and operated at a very low cost, which is a priority for long-term monitoring. In short, this monitoring system is capable of continuously monitoring waves and *c* with high precision and flexibility. There are more results and discussions will be addressed in the full-text paper.

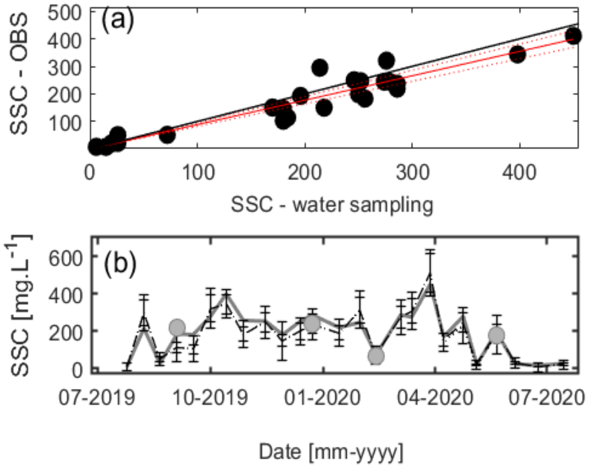

Figure 2 - The scatter plot of comparison among of SSC value were measured by OBS and water sample analyzed. The red line represented for the fit data and black line indicated for 1:1 line. The gray dots in (f) indicated for SSC value from water sample amazed by Intensive laboratory.

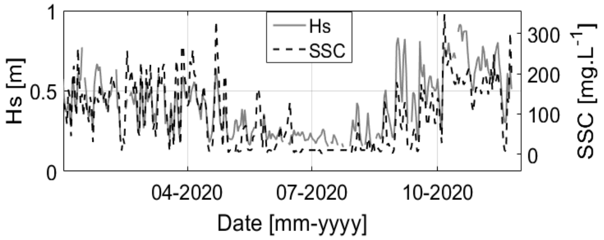

Figure 3 - Time series (daily) of the significant wave height (Hs: gray line) and suspended sediment concentration (SSC: dashed black line) at the G2 landward monitoring site.

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