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Improvement of a Low-Cost DIY Wave Gauge

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Abstract. The impacts of waves on shorelines and nearshore ecosystems has highlighted the need for extension and other environmental professionals to have access to accurate and affordable wave measurements. The development of a low-cost DIY wave gauge improved the accessibility of these measurements; however, the original design was limited in battery life. Here, an improved version of the low-cost DIY wave gauge, the DIY Feather Wave Gauge, is presented with the same performance, longer battery life, smaller design, and cheaper cost along with tutorials, parts lists, and other resources. This new gauge has been used to improve shoreline management recommendations.

INTRODUCTION

Waves are known to have a wide range of effects on shorelines and nearshore ecosystems (Feagin et al., 2011; Leonardi et al., 2016; Roland & Douglass, 2005). As development around waterbodies continues to increase (Seitz et al., 2018), Extension personnel and other environmental professionals are increasingly asked to answer questions, provide guidance, and make suggestions about shoreline management. Most of these requests are associated with reduction or prevention of shoreline erosion, which has led to the development of several Extension programs across the United States focused on shoreline issues (Mississippi-Alabama Sea Grant Consortium, 2018; Florida Sea Grant, 2020).

Waves, both manmade (through boat wakes) or natural (through wind-waves), are a major driver of shoreline erosion and, subsequently, shoreline management decision-making (Leonardi et al., 2016; McConchie & Toleman, 2003; SAGE, 2015). Wave climate—i.e., the magnitude and frequency of various wave events (Temple et al., 2021)—is often assessed using wind-wave models or wave gauges. Wave models utilize environmental measurements to estimate wave climates. However, these wind-wave models do not capture the contribution of boating activity to the wave climate (Temple et al., 2021). Wave gauges allow for field measurements that incorporate all contributing factors of wave activity. However, the cost of commercial wave gauges has largely inhibited the utilization of wave gauges by environmental professionals (Temple et al., 2020).

These constraints led researchers to develop a low-cost do-it-yourself (DIY) wave gauge (Temple et al., 2020). The subsequent DIY wave gauge utilized a combination of housing components found at home improvement stores and high-performance, yet affordable, electrical components. The DIY wave gauge returned results in acceptable to near-perfect agreement with those returned by a commercial wave gauge (Temple et al., 2020). This development allowed for access to premium wave climate estimations for a fraction of the cost of commercial counterparts. Additionally, these low-cost DIY wave gauges provided many opportunities for Extension and other STEM educators to incorporate low-cost teaching tools for product design, electrical engineering, data collection, coding, and processing into their curricula.

Presented here is an improved design of the wave gauge developed by Temple et al. (2020), featuring a reduced cost, smaller housing, and improved battery life. We also present a side-by-side comparison of functionality. The improved design expands the functionality and customization of the DIY wave gauge, thereby increasing ease of access and potential uses by Extension personnel and other environmental or STEM professionals.

IMPROVED DIY WAVE GAUGE DESIGN: DIY FEATHER WAVE GAUGE

Both the old (DIY Wave Gauge) and new (DIY Feather Wave Gauge) are fully described on the Mississippi State University Coastal Research and Extension Center Waves website (https://coastal.msstate.edu/waves). The website provides parts lists, build and deployment tutorials, and other materials for both gauges. Both gauges utilize a pressure sensor, microcontroller, battery, and waterproof housing. However, DIY Feather Wave Gauge substitutes some of these components to restructure the gauge. The pressure sensor remains the same, but the microcontroller and data logging shield from the previous version are replaced with the Adafruit Feather 32u4 Adalogger and DS3231 Precision RTC (Adafruit, New York City, New York, U.S.A.). This replacement allows for a more efficient datalogging process that consumes less power, which led to a reduction in battery size. Even with the decrease in battery size, the new gauge can measure continuously at 10 Hz (e.g., 10 times per second) for 15 days, while the previous gauge lasted only five. These changes allow the housing of the DIY Feather Wave Gauge to be smaller than the previous version (3.81 cm diameter vs. 7.62 cm diameter PVC pipe). Assuming you are equipped with the base tools (e.g., soldering iron and vices), the changes lead to about a $140 reduction in the cost of materials needed to construct each gauge, from roughly $300 to $160. However, these price estimates are subject to change based on current pricing of components.

PERFORMANCE COMPARISON BETWEEN BOTH GAUGES

We performed a field test to determine agreement between the two wave gauge versions. Two wave gauges, one of each version, were deployed in Back Bay of Biloxi (Biloxi, MS) for a three-day period. Both gauges were deployed at a depth of one meter in relation to Mean Lower Low Water (MLLW) and sampled continuously at 10 Hz. We processed the raw wave gauge data in MATLAB® (2021) using routines utilized by Temple et al. (2021) and found at the Waves website referenced in the previous section. These routines aided researchers in determining overall wave climate statistics (e.g., average wave height) and constructing power spectral density (PSD) curves. We then assessed the total energy in the wave field (i.e., area under the PSD curve; m_0) contained in the DIY Feather Wave Gauge signal as a percentage of energy contained in the old DIY signal to determine agreement (Equation 1).

$$\text{Percentage agreement} = [m_0(\text{new})/m_0(\text{old})] \times 100 \qquad (1)$$

The two wave gauges showed similar wave energy density distributions (Figure 1) and displayed high total wave field energy agreement (99%). The overall wave climate statistics also displayed high overall agreement between the two versions (Table 1). The only differences seen were in average wave period (0.05 s) and significant wave period (0.07 s).

CONCLUSIONS

The need for site-specific and cost-effective wave estimations by Extension personnel and other environmental managers has become increasingly important. The introduction of low-cost DIY tools has expanded the accessibility of these site-specific estimations. Here we expanded on previous work performed by Temple et al. (2020) to develop an improved version of the DIY wave gauge. This development resulted in a smaller and cheaper wave gauge with increased battery life while still maintaining the accuracy and functionality of the previous version.

Table 1. Comparison of Calculated Wave Parameters Derived from the Three-Day Deployment of Two Different Wave Gauge Types

Wave Parameter	DIY Wave Gauge (old)	DIY Feather Wave Gauge (new)
Average Wave Height (m)	0.05	0.05
Significant Wave Height (m)	0.06	0.06
Average Wave Period (s)	1.49	1.54
Significant Wave Period (s)	1.78	1.85

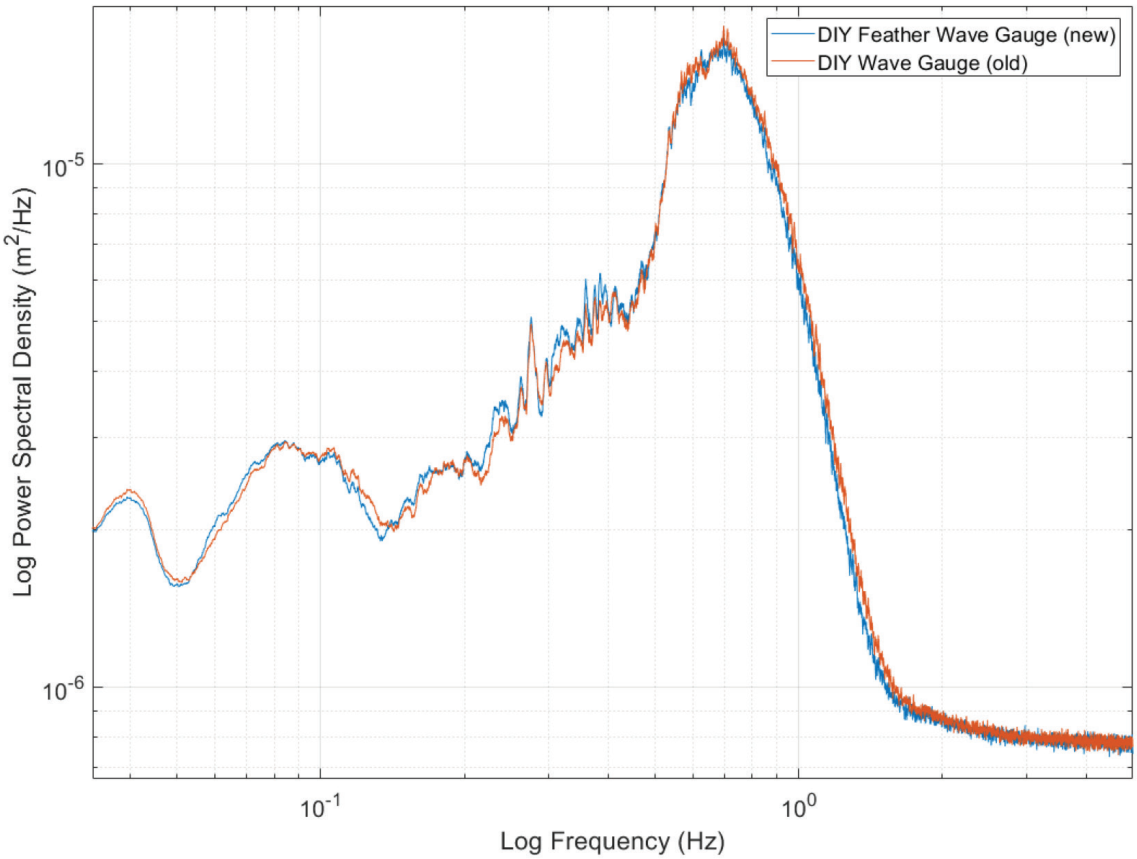

Figure 1. Wave power spectral density comparison over a three-day deployment period: DIY wave gauge and DIY feather gauge.

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