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www.elsevier.com/locate/csr

PII: S0278-4343(16)30526-X
DOI: <http://dx.doi.org/10.1016/j.csr.2017.06.002>
Reference: CSR3606

To appear in: *Continental Shelf Research*

Received date: 5 October 2016
Revised date: 28 May 2017
Accepted date: 2 June 2017

Cite this article as: Benjamin K. Norris, Julia C. Mullarney, Karin R. Bryan and Stephen M. Henderson, The Effect of Pneumatophore Density on Turbulence: A Field Study in a *Sonneratia*-dominated Mangrove Forest, Vietnam, *Continental Shelf Research*, <http://dx.doi.org/10.1016/j.csr.2017.06.002>

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The Effect of Pneumatophore Density on Turbulence: A Field Study in a *Sonneratia*-dominated Mangrove Forest, Vietnam

Benjamin K. Norris^{a*}, Julia C. Mullarney^a, Karin R. Bryan^a, Stephen M. Henderson^b

^aCoastal Marine Group, Faculty of Science and Engineering, University of Waikato, Private Bag 3105, Hamilton, 3240, New Zealand

^bSchool of the Environment, Washington State University, Vancouver, 14202 Salmon Creek Ave, Vancouver, WA, 98686, United States

bkn5@students.waikato.ac.nz
julia.mullarney@waikato.ac.nz
kbryan@waikato.ac.nz
steve_henderson@wsu.edu

*Corresponding Author. Tel.: +64 7 838 4239.

Abstract

This paper examines the role of mangrove pneumatophore roots as a spatial control over the turbulent kinetic energy (TKE) dissipation rate within a natural mangrove forest. Measurements of turbulence at millimeter scales were compared with vegetation geometries reconstructed using a novel photogrammetric technique. These small-scale relationships were then averaged to show larger-scale patterns in turbulence across the mudflat and mangrove fringe-forest transition. Although turbulence estimates varied with across-shore position, TKE dissipation was always elevated in the fringe relative to mudflat and forest interior sample sites. The largest dissipation rates ($4.5 \times 10^{-3} \text{ W}\cdot\text{kg}^{-1}$) were measured as breaking waves propagated over canopies in very shallow water. Dissipation was reduced, but often remained intense ($10^{-5} - 10^{-4} \text{ W}\cdot\text{kg}^{-1}$) under non-breaking waves at the fringe, likely indicating turbulent generation in pneumatophore wakes. Pneumatophore density was positively correlated with the spatial distribution of TKE dissipation. Turbulence was also correlated positively with wave height and negatively with water depth. Fringe sediments were more sandy and less muddy than sediments onshore and offshore, suggesting that the intense turbulence may lead to winnowing of fine-grained sediments at the fringe.

Keywords:

Mangroves, Turbulence, Tidal Dynamics, Waves, Sediment Transport, Vietnam

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