# Optical side-scattering by particulate matter in the Hahei Marine Reserve

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## INTRODUCTION

The suspended sediment concentration, SSC, is an important parameter in coastal monitoring. For example, SSC is used to determine when tidal currents transport sediments and associated contaminants. Because it is often impractical to measure SSC at high temporal and spatial resolution with laboratory techniques, surrogates and approaches have been developed to provide such resolution.

In one approach, a defined volume of water is illuminated in situ with near-infrared (NIR) light to measure how much of this light is scattered by suspended particles at 90° relative to its path (**Figure 1A, B**). The conversion between this side-scattering and SSC is constrained, however, because light scattering is affected by particle properties (Boss et al. 2009). If properties of particles in coastal regions differ then establishing region-specific conversion factors becomes imperative.

## PROBLEM

We ask to what degree the relationship between SSC and NIR side-scattering (turbidity) varies in New Zealand's coastal waters. To begin to answer this question, we studied this relationship in the Hahei Marine Reserve, Coromandel (**Figure 2**).

## EXPERIMENTAL

- Seawater–sediment suspensions were either collected along a turbidity gradient between Whitianga Harbour and the nearby Hahei Marine Reserve or made in the laboratory by suspending sediment from a landslide in the eastern region of the reserve in seawater (**Figure 2**).
- Optical side-scattering was measured with a YSI 6136 turbidity sensor (Nephlometric Turbidity Units, NTU) mounted to a YSI 6600 V2 sonde (**Figure 1C**).
- SSC (g $L^{-1}$) was obtained by filtering 1 L samples of the seawater–sediment suspensions.

## DISCUSSION

We established linear correlations between SSC and NTU for two potential sources of turbidity in the Hahei Marine Reserve. The slopes of the regressions in **Figure 3** do not differ significantly suggesting that either the properties of the suspended particles did not differ or that differences in properties did not affect optical side-scattering. We conclude that the measurement of optical side-scattering is a suitable means of monitoring variations of in situ suspended sediment concentrations at high spatial and temporal resolution (see **Figure 4**). In our future research we will determine if this correlation holds for other New Zealand coastal regions.

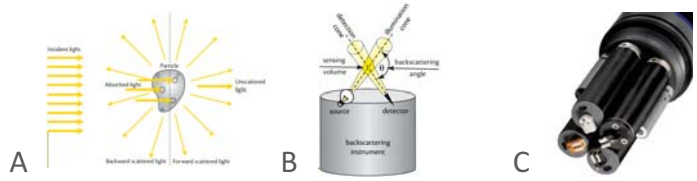


**Figure 1.** (**A**) Diagram showing how attenuation of light occurs through absorption and scattering. Scattered light is divided into the light scattered in the backward and forward directions relative to the direction of the un-attenuated beam. The measurement of backscattering provides information on the abundance and distribution of suspended particles. (**B**) Schematic of a single-angle backscattering sensor showing a light detector and a light source. The light backscattered near the angle, θ, emanates from the volume created by the intersection of the illumination and detection cones. Adopted from Boss et al. (2004). (**C**) Photograph showing the sensor head of a YSI 6600 V2 multi-parameter sonde with four self-cleaning optical sensors.

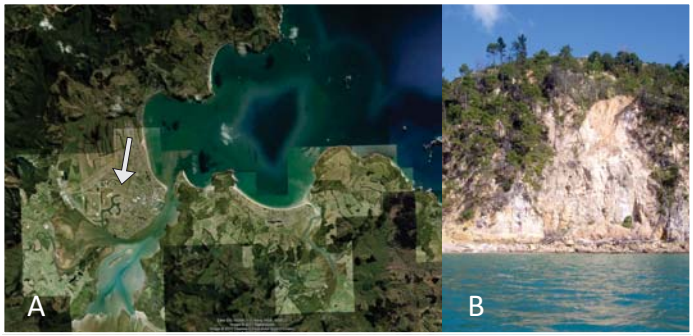


**Figure 2.** Te-Whanganui-A-Hei Marine Reserve receives suspended sediment from two sources: (**A**) Google™ Earth view of Whitianga Harbour showing a large plume of suspended sediment originating from recently developed water ways (arrow). (**B**) Photograph showing a landslide in the Hahei Marine Reserve in April 2011.

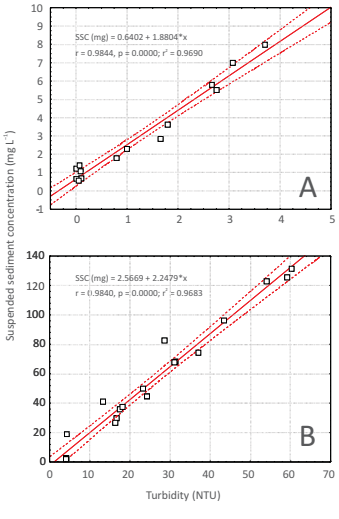


**Figure 3.** Scatter plot showing the correlation between seawater turbidity (NTU) and suspended sediment concentration (SSC, g $L^{-1}$) for (**A**) seawater collected in Whitianga Harbour / Hahei Marine Reserve and (**B**) seawater in which sediment from a landslide in the eastern region of the reserve had been suspended. Linear regression and 95% confidence intervals are depicted by the solid and dashed lines.

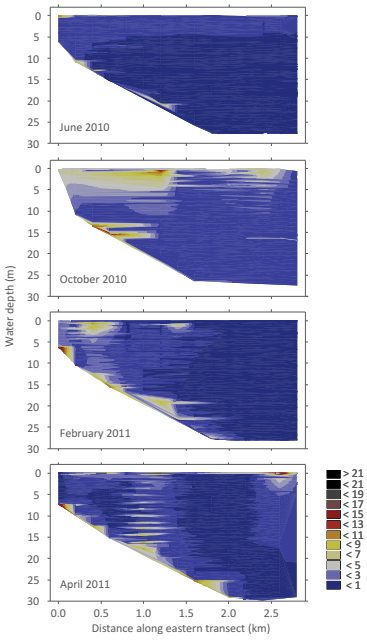


**Figure 4.** Waver plots showing temporal variability in seawater turbidity (NTU) along a 3-km long transect across the eastern Hahei Marine Reserve. The large surface plume of turbid seawater observed in October 2010 was caused by a landslide near Hahei Beach (see **Figure 2B**).

Boss E, Stramski D, Bergman T, Pegau WS, Lewis L (2004) Why should we measure optical backscattering? *Oceanography* 17(2):44–49

Boss E, Taylor L, Gilbert S, Gundersen K, Hawley N, Janzen C, Johengen T, Purcell H, Robertson C, Schar DWH, Smith GJ, Tamburri MN (2009) Comparison of inherent optical properties as a surrogate for particulate matter concentration in coastal waters. *Limnology and Oceanography: Methods* 7:803–810

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