Introduction

- Redwood Creek is a third order coastal stream flowing through Muir Woods National Monument and Golden Gate National Recreation Area in Marin County, California.
- Redwood Creek was once a spawning site to a relatively large and southernmost population of Coho Salmon (Oncorhynchus kisutch). This population is listed federally as endangered, with less than 1% of historic populations returning to spawn (O’Herron, 2009).
- The original stream path has been significantly altered in the past to make way for development and agriculture (O’Herron, 2009).
- The National Park Service has been working to restore much of the stream’s natural functionality, in order to improve habitat for anadromous fish.

Background

- Turbidity is a measure of light scattering in the water and is highly influenced by the presence of suspended sediments (Janstram et al., 2010).
- Sampling for suspended sediments has proven to be challenging for water resource managers, and semi-automated turbidity sampling provides means of obtaining a more complete representation of SSC levels in watersheds.
- Janstram et al., (2010) demonstrated that incorporating hydrologic variables that affect particle size and DOC provides and even more accurate representations for turbidity-based estimations.
- Measurements of turbidity taken in the infrared wavelength range reduces variation in the relationship between turbidity and SSC. Instruments that measure in the visible range are most likely to be affected by DOC (Gippel, 1995).
- Turbidity based SSC estimations can be affected by several variables including particle size, particle composition and dissolved organic carbon (DOC) that influences the water’s color and consequently its clarity (Janstram et al., 2010).

Methods

- Semi-regular field sampling occurred in which water samples were collected and analyzed for TSS and SSC using standard methods, Standard Method 2540 D (Rice et al., 2012) and ASTM Method D3977-97 Test Method B: Filtration (ASTM International, 2007), respectively, and turbidity measurements were taken.
- Turbidity was measured using a Hach 2100Q portable turbidimeter (Loveland, CO) in accordance with Standard Method 2130 B: Nephelometric Method (Rice et al., 2012).
- Turbidity measurements were also taken automatically on a semi-continuous schedule using Hach Hydrolab DSSX datasondes with self-cleaning turbidity sensor (Loveland, CO) in accordance with the same standard method as the portable turbidimeter.
- The Hach Hydrolab DSSX datasondes were calibrated for turbidity at a near zero value, ≤ 0.1 NTU, and a calibration standard at a known concentration of 200 NTU, with a linearity check at 40 NTU. Upon retrieval from data collection in the field, a calibration check at 20 NTU was performed prior to instrument cleaning and/or maintenance.
- SSC, TSS, and turbidity samples were collected from the middle of the water column at each site, adjacent to the deployed Hydrolab sondes.
- Prepared glass fiber filters were used to analyze water samples through the methods mentioned prior. Filters were dried in a drying oven for at least one hour before weighing both before and after the sample was run. The mass difference was normalized with the volume of sample filtered to obtain a concentration in mg/L for both TSS and SSC.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sample Size</th>
<th>Collection Method</th>
<th>Analytical Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS (mg/L)</td>
<td>1000 mL aliquot</td>
<td>Grab Sample</td>
<td>Standard Method 2540 D</td>
</tr>
<tr>
<td>SSC (mg/L)</td>
<td>Entire sample of approximately 1000 mL</td>
<td>Grab Sample</td>
<td>ASTM Method D3977-97 B</td>
</tr>
<tr>
<td>Turbidity (NTU) with Hydrolab DSSX</td>
<td>N/A</td>
<td>In Situ</td>
<td>Standard Method 2130 B</td>
</tr>
<tr>
<td>Turbidity (NTU) with portable turbidimeter</td>
<td>10 mL</td>
<td>Grab Sample</td>
<td>Standard Method 2130 B</td>
</tr>
</tbody>
</table>
From figures A and B, it is clear that there is a relationship between TSS and turbidity (R² values of 0.97 and 0.99, respectively), and SSC and turbidity (R² values of 0.97 and 0.97, respectively).

Confirmation sampling with the Hach 2100Q portable turbidimeter corroborated the validity of the data provided by in situ monitoring for turbidity using the Hach Hydrolab DSSX datasonde. R² = 0.99 at Muir Beach, R² = 0.99 at Highway 1 Bridge and R² = 0.99 for data consolidated from both sites, figure C.

There was a strong correlation between TSS & SSC with R² = 0.99 at Muir Beach, R² = 0.99 at Highway 1 Bridge and R² = 0.99 for all data consolidated from both sites, figure D.

The current data is preliminary due to a limited number of large precipitation events and high flows during the study period. However, a preliminary relationship can be seen between suspended solids and turbidity.

**Discussion & Conclusions**

- More data from high-flow events is needed to develop a statistically significant model sufficient to predict concentrations of suspended solids from turbidity.
- Williamson & Crawford (2011) determined that turbidity values < 6 NTU are not sufficient for developing a strong correlation with suspended solids. Our results concur with this research showing a correlation between turbidity and TSS and turbidity and SSC is likely at higher sediment concentrations. However, the data scatter at low concentrations and turbidity values.
- Particle size was not analyzed at these sites because of their consistently low concentrations of suspended sediments, making characterization of sediment size distribution unfeasible.
- As observed by Janstram (2010), additional analysis of dissolved organic carbon (DOC) may elucidate differences in turbidity and sediment between the two sample sites.

**References**


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