SEEING THE LIGHT: A WATER CLARITY INDEX FOR INTEGRATED WATER QUALITY ASSESSMENTS

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National Coastal Condition

- Assessed condition including water quality
- Raised some issues (Water Clarity)

- 1997 – 2000 National Coastal Assessment survey data
- Evaluated changes over time
- Addressed some earlier criticisms
Why Make Water Clarity a Component of Water Quality?

• Clear waters have both social and economic value.

• Water clarity is often used as a “yard stick” for certain biological and physical processes.
Water Clarity – One Size Doesn’t Fit All

- A single reference value was used to assess all estuarine waters without considering regional difference.

- Evaluated Water Clarity as “Poor” or “Good”
Water Clarity – One Size Doesn’t Fit All

• Water clarity was evaluated using reference values reflecting “expected” clarity of specific coastal regions.
• Created a new category for waterbodies with “moderately” impacted clarity.
Regional Differences in Water Clarity

Florida Bay - Clear Water, Supports SAV

Pensacola Bay - Moderately Turbid, Partially Supports SAV

Mobile Bay - Naturally Turbid
A Water Quality Index

- Dissolved oxygen
- Chlorophyll a
- Dissolved Inorganic Nutrients (Nitrogen and Phosphorus)
- Water Clarity
Evaluating Water Quality for the Gulf of Mexico Region*

<table>
<thead>
<tr>
<th>REGION</th>
<th>N(mg/L)</th>
<th></th>
<th></th>
<th>P(mg/L)</th>
<th></th>
<th></th>
<th>Chl a(ug/L)</th>
<th></th>
<th></th>
<th>%Transmissivity@ 1m</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Majority of the Gulf</td>
<td>Good</td>
<td>Fair</td>
<td>Poor</td>
<td>Good</td>
<td>Fair</td>
<td>Poor</td>
<td>Good</td>
<td>Fair</td>
<td>Poor</td>
<td>Good</td>
<td>Fair</td>
<td>Poor</td>
<td>Good</td>
</tr>
<tr>
<td>Tampa south to Florida Bay and Laguna Madre</td>
<td>&lt;.10</td>
<td>.10-.50</td>
<td>&gt;.50</td>
<td>&lt;.01</td>
<td>.01-.05</td>
<td>&gt;.05</td>
<td>&lt;.05</td>
<td>.005-.01</td>
<td>&gt;.01</td>
<td>&lt;.05</td>
<td>0.5-1</td>
<td>&gt;1.0</td>
<td>&gt;20</td>
</tr>
<tr>
<td>Mobile Bay and Louisiana estuaries</td>
<td>&lt;.10</td>
<td>.10-.50</td>
<td>&gt;.50</td>
<td>&lt;.01</td>
<td>.01-.05</td>
<td>&gt;.05</td>
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<td>0.5-1</td>
<td>&gt;1.0</td>
<td>&gt;20</td>
</tr>
</tbody>
</table>

*Dissolved Oxygen Guidelines <2.0 mg/L= poor, 2.0-5.0 mg/L=fair, >5.0 mg/L=good
All Water Clarity Data Are Not Created Equal

<table>
<thead>
<tr>
<th>Water Body Name</th>
<th>Raw Water Clarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANNA MARIA SOUND</td>
<td>1.0</td>
</tr>
<tr>
<td>ARANSAS BAY</td>
<td>0.8</td>
</tr>
<tr>
<td>BACK BAY BILOXI/BERN</td>
<td>14.052</td>
</tr>
<tr>
<td>BAFFIN BAY</td>
<td>0.7</td>
</tr>
<tr>
<td>BANGS LAKE</td>
<td>12.881</td>
</tr>
<tr>
<td>BARATARIA BAY</td>
<td>29.732</td>
</tr>
<tr>
<td>BAY BATISTE</td>
<td>0.7</td>
</tr>
<tr>
<td>BAY BOUDREAUX</td>
<td>0.5</td>
</tr>
<tr>
<td>BAYOU CASOTTE</td>
<td>18.795</td>
</tr>
<tr>
<td>BILOXI BAY</td>
<td>2.875</td>
</tr>
<tr>
<td>BOCA CIEGA BAY</td>
<td>0.5</td>
</tr>
<tr>
<td>BON SECOUR RIVER</td>
<td>13.004</td>
</tr>
<tr>
<td>BRETON SOUND</td>
<td>0.5</td>
</tr>
</tbody>
</table>

41% of sampling sites did not have expected transmissivity data
Using Different Types of Data to Evaluate Water Clarity

When light meter data were available, the data were evaluated using the regional guidelines:

<table>
<thead>
<tr>
<th>REGION</th>
<th>%Transmissivity@ 1m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
</tr>
<tr>
<td>Majority of the Gulf</td>
<td>&gt;25</td>
</tr>
<tr>
<td>Tampa south to Florida Bay and Laguna Madre</td>
<td>&gt;40</td>
</tr>
<tr>
<td>Mobile Bay and Louisiana estuaries</td>
<td>&gt;20</td>
</tr>
<tr>
<td>Lake Pontchartrain, Breton Sound excluded</td>
<td></td>
</tr>
</tbody>
</table>
If Secchi was used as a substitute for light meter data ...

• The regional reference values for the three types of expected water clarity were used to calculate reference light attenuation coefficients (k).

• Secchi depth was used to calculate k values for evaluating water clarity.
Beer-Lambert’s Law

\[ k = \ln \left( \frac{L_z}{L_0} \right) / -z \]

where,
- \( k \) = light attenuation coefficient
- \( L_z \) = light at depth
- \( L_0 \) = light at surface
- \( z \) = depth
Beer-Lambert’s Law continued

• Since $L_z/L_0 = \text{transmissivity}$, and $z = 1 \text{ meter}$, the reference $k$ values were calculated from the regional guidelines for transmissivity at 1 meter.

• The $k$ reference values were calculated using:
  
  $\text{ref } k = -\ln(\text{ref transmissivity})$
Resulting in ...

<table>
<thead>
<tr>
<th>Lower reference value (lo ref)</th>
<th>Light attenuation coefficient for lo ref (klo)</th>
<th>Upper reference value (hi ref)</th>
<th>Light attenuation coefficient for hi ref (khi)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>2.99</td>
<td>20%</td>
<td>1.61</td>
</tr>
<tr>
<td>10%</td>
<td>2.30</td>
<td>25%</td>
<td>1.39</td>
</tr>
<tr>
<td>20%</td>
<td>1.61</td>
<td>40%</td>
<td>0.916</td>
</tr>
</tbody>
</table>
Using Secchi Depth to calculate $k$

$$k = \frac{\text{constant}}{z_{\text{secchi}}}$$

Constants for estuarine types

- 1.7 for clear water estuaries
- 1.4 for moderately turbid estuaries
- 1.0 for highly turbid estuaries
# Guidelines for Evaluating Light Attenuation Coefficients ($k$)

<table>
<thead>
<tr>
<th>Estuarine Type</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>&lt;0.916</td>
<td>0.916-1.61</td>
<td>&gt;1.61</td>
</tr>
<tr>
<td>Moderately Turbid</td>
<td>&lt;1.39</td>
<td>1.39-2.30</td>
<td>&gt;2.30</td>
</tr>
<tr>
<td>Highly Turbid</td>
<td>&lt;1.61</td>
<td>1.61-2.99</td>
<td>&gt;2.99</td>
</tr>
</tbody>
</table>
**Water Clarity**

*Transmissivity and Secchi Depth*

- **Secchi Depth**
  - Good: 28±12%
  - Fair: 47±15%
  - Poor: 25±15%

- **Transmissivity**
  - Good: 51±8%
  - Fair: 20±12%
  - Poor: 29±12%

n=106
Gulf of Mexico Water Clarity: All Data

- Good: 52±9%
- Fair: 23±4%
- Poor: 22±8%
- Missing: 3%

n=191
The Local Scale-Pensacola Bay

Secchi Depth

- Good: 71±15%
- Fair: 26±5%
- Poor: 3±5%

Transmissivity

- Good: 66±15%
- Fair: 26±9%
- Poor: 8±9%

n=38
Concluding Remarks

• No statistical differences were observed in the ‘poor’ water clarity category when the two types of data were evaluated for the Gulf Region subset.

• This is an important issue since ‘poor’ is the only condition contributing to ‘poor’ overall water quality in the Eutrophication Index.
Concluding Remarks (continued)

- The use of combined data resulted in a gulf-wide assessment similar to the transmissivity data subset.
- This similarity may imply that the combined water clarity index can successfully be used to estimate water clarity when light meter data sets are incomplete.
Concluding Remarks (continued)

• The overlapping conditions observed in the water clarity assessment for Pensacola Bay, using transmissivity and secchi depth, are evidence that the secchi depth can be used to estimate water clarity with confidence.

• The water clarity index can be adapted for natural turbidity differences and successfully applied at regional and local scales.
Gulf of Mexico Water Clarity… Then and Now

First National Coastal Condition Report
- Good: 78%
- Poor: 22%

Second National Coastal Condition Report
- Good: 52%
- Poor: 22%
- Fair: 23%
- Missing: 3%
Special Acknowledgments

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