Calculated and Mapped Depths of Closure Along the U.S. Coastlines Using WIS Hindcast Data

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Introduction

- A tool is being developed to allow user to view mapped Depths of Closure across the U.S. coastlines
- Illustrates the seaward extent of sediment transport
- Tool will aid coastal planners and engineers in designing coastal projects
Depth of Closure

- Depth of Closure (DOC) is an important concept used in coastal engineering.
- Kraus et al. (1998) defined the Depth of Closure (DOC) as the most landward depth seaward of which there is no significant change in bottom elevation and no significant net sediment transport between the nearshore and the offshore.
- Location where beach profiles converge through time.
Depth of Closure

  - First theoretical definition of DOC using wave tank and field data
  - Inner DOC
    • Marks seaward extent of the littoral zone, which is characterized by increased bed stresses and sediment transport due to waves near breaking and fluid circulation
  - Outer DOC
    • The seaward limit of the shoal zone, where wave shoaling is the dominant process and bed agitation remains relatively moderate

- Birkemeier (1985) later revised
Depth of Closure

- Applied often in coastal sciences
- Web Application was initially intended for use in nearshore placement projects
Existing Methods

**Hallermeier (1978, 1981)**

**Inner limit**

\[ d_l = 2.28H_e - 68.5\left(\frac{H_e^2}{gT_e^2}\right) \]

\[ H_e = \bar{H}_s + 5.6\sigma_s \]

\[ d_l = 2\bar{H}_s + 11\sigma_s \]

**Outer Limit**

\[ d_i = (\bar{H}_s - 0.3\sigma_s) \bar{T}_s \left(\frac{g}{5000D}\right)^{0.5} \]

**Birkemeier (1985)**

\[ d_l = 1.75H_e - 57.9\left(\frac{H_e^2}{gT_e^2}\right) \]

\[ d_l = 1.57H_e \]
Methods

- WIS hindcast wave data were downloaded to calculate DOC
- Snell’s Law was used to shoal waves into certain depth based on historical placements for each coast line
- Calculated wave statistics:
  - $H_e$, $H_s$, $H_{mean}$
- Calculated Hallermeier (1978, 1981) Inner, Outer (using 0.15 mm, 0.2 mm, 0.3 mm)
- Calculated Birkemeier (1985), simplified

<table>
<thead>
<tr>
<th>Coastline</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pacific</td>
<td>15.2 m [50 ft]</td>
</tr>
<tr>
<td>Atlantic</td>
<td>12.2 m [40 ft]</td>
</tr>
<tr>
<td>Gulf</td>
<td>9.1 m [30 ft]</td>
</tr>
<tr>
<td>Great Lakes</td>
<td>9.1 m [30 ft]</td>
</tr>
</tbody>
</table>
Methods

- DOCs calculated for each year on record as well as entire record
- Created profiles extending from WIS station to shoreline and found intersections with contours
- Placed DOCs along the profiles
Overall Trends

- Regional trends based on 20 year dataset
Calculated Zones

- Yearly calculated DOCs
- Project specific zones of depth of closure
- Allows the user to view minimum, maximum, and mode of DOCs
- Determine yearly trends
Wave Statistics

33 Years of $H_e$ Data for WIS Station 73002

- Entire data set for WIS Station 73002
- Most frequent waves are in the 4 m range
Wave Statistics

33 Years of $H_e$ Data in the Gulf of Mexico

- Entire data set for all stations in the Gulf of Mexico
- Most frequent waves are in 2-4 m range
Wave Statistics

- Determine trends using total $H_e$ data across entire Gulf of Mexico
- Most frequent waves are in 2-4.5 m range
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Static Database

Depth of closure (DOC) is an important concept used in coastal engineering. The DOC is a theoretical depth along a beach profile where sediment transport is very small or non-existent, dependent on wave height and period, and occasionally, sediment grain size. More specifically, Kraus et al. (1998) state that the “depth of closure for a given characteristic time interval is the most landward depth seaward of which there is no significant change in bottom elevation and no significant net sediment transport between the nearshore and the offshore.” Often the DOC is used in coastal engineering design for projects such as beach and nearshore area nourishment, and jetty and navigation channel designs. The database provided here estimates DOC’s for all of the coastlines of the United States, including the Great Lakes, using the USACE Wave Information Study (WIS) wave hindcast data. A draft CHRTN detailing methods used to produce the dataset is provided as well.

Future Phases

- Interactive map
  - User will choose grain size, more specific location
- DOC contouring
- Wave statistics histograms
- Add Sediment Mobility Tool for nearshore berm sitting (McFall)
  - Scoping level tool that describes frequency of sediment mobility and general transport direction based on waves, grain size, and depth of placement
Summary


https://geoplatform.usace.army.mil/home/webmap/viewer.html