OPEN PACIFIC COAST STUDY REVIEW AND CLIMATE CHANGE IMPLICATIONS

By

Weixia Jin, PhD, PE

Co-Authors

Rob Duboux Esq, PE, Qing Wang PE, and Aaron Holloway PE
Outline

• OPC Study Overview
• 1-D Transect Based Analyses
• Wave Runup Methods
• Key Review Findings of OPC Study
• Climate Change Implications to BFE
• Conclusions
California Open Pacific Coast (OPC) Study

- Part of nationwide Risk Mapping, Assessment and Planning (Risk MAP) program
- Last study was completed in 1983
- Took advantage of advances in science, technology and new large data collected since 1983
- Used the response-base approach: BFEs are calculated statistically from the annual maxima (or peaks-over-threshold) of calculated Total Water Levels over a 50-year period from 1960 through 2009
- Based on *FEMA’s Guidelines for the Pacific Coast of the United States, 2005*
Coastal BFE (1% Total Water Levels, TWL)

\[ TWL = SWL + \text{Wave} \]

- SWL = Tide + surge (no wave effects)
  - Tide: 5-7 ft
  - Surge components: atmospheric pressure, wind setup, El Niño effects: 1-3 ft
- Wave = Wave setup + runup:
  - 10-20 ft
What are not Included in the OPC Study

• Tsunami hazards,
• Sea level rise, and
• Combined probability of coastal and riverine flood events
Open Pacific Coast Study Approach

- Offshore Water Levels
- Offshore Waves
  - Deepwater wave hindcast
- Shoaling Zone
  - Nearshore wave transformation
- Surf Zone and Backshore
  - Transect based analysis
Offshore Water Levels

Based on hourly still water level (SWL) time series recorded at the nearest NOAA tide station over the 50-year study period (1960-2009). For example,

- The Santa Barbara station (NOAA station ID 9411340) was used on mapping northern Ventura County from Rincon Point to Port Hueneme.

- The Santa Monica station (NOAA station ID 9410840) was used for mapping southern Ventura County and northern LA County from Port Hueneme to Ranch Palos Verdes.
Offshore Deepwater Wave Hindcast

- Performed by Oceanweather Inc.
- Hindcasted 50-year hourly waves (1960-2009)
- Hindcast results rigorously validated by comparison with NOAA and Coastal Data Information Program (CDIP) buoy data
- Accounted for offshore swell propagation around islands and local wind waves
- Provided boundary input for nearshore wave model
Nearshore Wave Transformation

- Performed by Scripps Institution of Oceanography (SIO)
- Validated with nearshore buoy data
- Modeled both swell and wind seas
- Transformed waves from offshore to points outside of the surf zone up to 5 m depth to drive the 1-D transect based analysis. However, the 1-D analysis started at 40-m depth.
1-D Transect-Based Wave Analyses

- Wave Runup Method Selection
- Wave Setup
- Wave Runup (beaches, bluffs, structures)
- Overtopping
- Overland Wave Propagation
Wave Runup

- Wave runup is the maximum vertical uprush of water on the beach/shore due to wave action.
- Wave runup is sensitive to the beach slope.
Critical Parameters in BFE Determination

- SWL
- Wave parameters (height and period)
- Shore types (roughness)
  - Structures (seawall, revetment)
  - Sandy (bluff)
  - Cobble/reef
- Slope (nearshore, foreshore and structure)
- Toe/Crest elevations
- Wave approach angle
Wave Runup Analysis Methods

1. Stockdon Method:
   Natural beaches \((m_f < 0.11, \text{ or } m_f > 0.11 \text{ and } 0.3 < \xi < 3.5)\)

2. DIM Method:
   Natural beaches \((m_f > 0.11)\) or Armored beaches with DWL2% below structure toe

3. TAW Method:
   Armored beaches and bluff backed beaches
Malibu Coastline
Comparison Between Effective & Preliminary BFES

- IMPACTS TO COMMUNITIES
- Flood Insurance Rate
- Communities are required to amend their floodplain ordinances
## Comparison of Stockdon and DIM Average TWLs

<table>
<thead>
<tr>
<th>PFIRM Transect # (Study #)</th>
<th>Average TWLs (ft, NAVD88)</th>
<th>Difference (ft) (Stockdon - DIM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stockdon</td>
<td>DIM</td>
</tr>
<tr>
<td>Transect 8 (1116)</td>
<td>13.6</td>
<td>10.8</td>
</tr>
<tr>
<td>Transect 9 (1109)</td>
<td>15.6</td>
<td>11.1</td>
</tr>
<tr>
<td>Transect 23 (987)</td>
<td>13.6</td>
<td>10.7</td>
</tr>
<tr>
<td>Transect 24 (981)</td>
<td>14.7</td>
<td>10.4</td>
</tr>
<tr>
<td>Transect 25 (976)</td>
<td>12.7</td>
<td>9.3</td>
</tr>
<tr>
<td>Transect 27 (956)</td>
<td>14.9</td>
<td>10.5</td>
</tr>
<tr>
<td>Transect 28 (946)</td>
<td>13.0</td>
<td>10.9</td>
</tr>
<tr>
<td>Transect 34 (885)</td>
<td>14.4</td>
<td>11.2</td>
</tr>
<tr>
<td>Transect 36 (870)</td>
<td>14.2</td>
<td>10.5</td>
</tr>
<tr>
<td>Transect 40 (846)</td>
<td>14.8</td>
<td>10.9</td>
</tr>
<tr>
<td>Transect 42 (824)</td>
<td>13.7</td>
<td>10.2</td>
</tr>
<tr>
<td>Transect 43 (817)</td>
<td>13.6</td>
<td>10.4</td>
</tr>
</tbody>
</table>
### Impacts of Roughness Factor and Oblique Wave to TWL (ft, NAVD88)

<table>
<thead>
<tr>
<th>Transect _Study #</th>
<th>PFIRM</th>
<th>Roughness Factor of 0.8</th>
<th>45 Degree Wave Approach</th>
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<tbody>
<tr>
<td></td>
<td>BFE</td>
<td>BFE</td>
<td>Change (ft)</td>
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<tr>
<td>Tr23_987</td>
<td>21.8</td>
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<tr>
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<td>21.8</td>
<td>19.6</td>
<td>2.2</td>
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<tr>
<td>Tr25_976</td>
<td>20.1</td>
<td>17.8</td>
<td>2.3</td>
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<td>Tr28_946</td>
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<td>Tr36_870</td>
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<td>17.9</td>
<td>2</td>
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<tr>
<td>Tr40_846</td>
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<td>2</td>
</tr>
<tr>
<td>Tr41_831</td>
<td>24.1</td>
<td>21</td>
<td>3.1</td>
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</table>
Climate Change Implications

• Higher Still Water Level due to Sea Level Rise
• Extreme Coastal Storms - Larger and More Frequent Wave Events
  ▪ Three Transects using the three different wave runup methods were selected for detailed SLR analyses
Transect #9 (1109)

Site Description (Stockdon)
Sandy beach backed by bluffs. Transect intersects residential parcels on low bluff.
Effective BFE: 13 ft, PFIRM BFE: 20 ft
Transect #9 with SLR

<table>
<thead>
<tr>
<th>SLR (ft)</th>
<th>Forshore slope</th>
<th>DWL2% &gt; Toe Elev.</th>
<th>Method</th>
<th>TWL (ft NAVD)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>0.1093</td>
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<td>1</td>
<td>0.123</td>
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<td>2</td>
<td>0.132</td>
<td>Yes</td>
<td>DIM</td>
<td>15.2</td>
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<td>3</td>
<td>0.141</td>
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<td>19.1</td>
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<td>4</td>
<td>0.157</td>
<td>Yes</td>
<td>TAW</td>
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<td>5</td>
<td>0.187</td>
<td>Yes</td>
<td>TAW</td>
<td>25.1</td>
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</tbody>
</table>
Site Description (TAW)
The transect intersects a parcel fronted by riprap and characterizes a wet sandy beach backed by a bluff, and most appear to be pile-supported.

Effective BFE: 14 ft, PFIRM BFE: 31 ft
Transect #28 with SLR

<table>
<thead>
<tr>
<th>SLR (ft)</th>
<th>Forshore slope</th>
<th>DWL2% &gt; Toe Elev.</th>
<th>Method</th>
<th>TWL (ft NAVD)</th>
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</thead>
<tbody>
<tr>
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<td>18</td>
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<tr>
<td>4</td>
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<td>DIM</td>
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<tr>
<td>5</td>
<td>0.387</td>
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<td>DIM</td>
<td>20.3</td>
</tr>
</tbody>
</table>

![Graph showing TWL (ft NAVD) vs SLR (ft)](image)

![Graph showing Profile 28 (946)](image)
Transect #39 (854)

Site Description (DIM)
Wet sandy beach backed by residential parcels with seawalls and pile-supported structures. Transect intersects a parcel with a seawall.
Effective BFE: 15 ft, PFIRM BFE: 13 ft
Transect #39 with SLR

<table>
<thead>
<tr>
<th>SLR (ft)</th>
<th>Forshore slope</th>
<th>DWL2% &gt; Toe Elev.</th>
<th>Method</th>
<th>TWL (ft NAVD)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>0.160</td>
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<td>1</td>
<td>0.242</td>
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<td>0.829</td>
<td>No</td>
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<td>17.6</td>
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</tbody>
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Profile 39 (854)
Conclusions

• OPC study is a well done large effort, used the latest and best technology and data

• For 1-D transect based analyses:
  ▪ PFIRM BFEs are conservative as oblique wave and roughness impacts are ignored
  ▪ Wave runup on steep beaches should be higher than that on mild beaches. However, the current wave runup methods and selection guidelines would result in opposite results, and cause unrealistic alongshore BFE variation. Additional research is necessary.
  ▪ 1-D analysis should start at 10 or 15 m water depth instead of 40 m such that wave refraction and oblique wave approach impacts captured in the 2-D nearshore model can be considered.

• SLR would increase the BFE and flood risk. The BFE will increase linearly with SLR on natural beach with a constant slope. But beaches in Southern California are often backed by bluff or structures, and the foreshore slope is steeper than the nearshore slope, which amplifies the wave runup and flood risk due to SLR.
THANK YOU!
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