Hazard Mapping for Coastal Resilience
Ventura

David Revell, PhD
drevell@esassoc.com

ESA PWA Team
Bob Battalio, Elena Vandebroek, To Dang, Louis White
Outline

• Coastal Resilience Ventura
• Coastal erosion hazard zones
• Flood hazard zones:
  – Coastal flood hazards (extreme tides and wave impact areas)
  – Fluvial flood hazard zones (Santa Clara River and Ventura River)
• Uncertainty - Spatial Aggregation of Hazards
• Others – Cliffs, Fluvial, Habitat modeling (SLAMM)
Sea Level Rise:
- Low: 0.44 meters by 2100
- Medium: 0.93 meters by 2100
- High: 1.47 meters by 2100

Wave Climate:
- Existing conditions
- A doubling of El Nino frequencies
- A 500-year or an Arkstorm event at 2060 with a doubling of El Nino frequencies

Flooding:
- Historic coastal storms
- 100 year river events from climate models
Model Inputs

- **Physical Forcings**
  - Offshore wave/climate “scenarios”
  - Transformed nearshore waves
  - Tides
  - Total Water Levels

- **Backshore Characterization**
  - Geology
  - Geomorphology (slopes, heights)
  - Backshore type (cliff, dune, inlet, armored)
  - Historic erosion rates (short term, long term)
  - Coastal Armoring
  - Topography

**Scale of Analysis ≤500m**
Coastal Erosion Hazards Concepts

**Total Water Levels**
- Sea Level Rise
- Tides
- Wave Run-up
- Storm Surge
- El Niños

**Climate Change**
- Sea Level Rise
- Wave Climate

**Elevation of the dune or cliff toe**

**Erosion Response based on:**
- Backshore Type
- Geology
- Shoreline Change
- Geomorphology

**Results**
- Accelerated Erosion
- Inland Migration of Shore
- Loss of Upland

*Photo by D. Revell*
Wave Transformation Model (SWAN)

Initial SWAN grid courtesy USGS
• Combined SLR and Wave Run-up
• Generate exceedance curves for each block using individual slopes and toe elevations (75 for Ventura)
Dune Erosion Model

• 3 components –
  1. Changes in TWL from SLR combined with shoreface slope
  3. Impact of a “100 year storm event” (Komar et al 1999)
Predict future toe locations using TWL exceedance curves for each site.

Calculate the retreat distance using a shoreface profile slope from the 10 m contour to the back beach elevation.
Model Outputs

1. Erosion hazard zones (integrated with coastal flooding)
   
   *Future erosion increases hydraulic connection and risk of flooding*

2. Coastal wave run-up hazard zone - *momentum impact*

3. Coastal Flooding – *inundation during extreme coastal events*

4. Coastal Inundation - *inundation during monthly extremes*

5. River Flooding
   
   *Ventura and Santa Clara Rivers only*

Data Mining:

- Projected future erosion rates
- Updated historic erosion rates
- 100 year TWL elevations
- Geomorphic variability
- Dynamic water level elevations
- Wave overtopping elevations
- Depth of flooding
- Duration of exceedance levels

... for 9 future scenarios:

<table>
<thead>
<tr>
<th>Year</th>
<th>Low SLR + Existing Fluvial Flood</th>
<th>Medium SLR + B1 Climate Fluvial Flood</th>
<th>High SLR + A2 Climate Fluvial Flood</th>
</tr>
</thead>
<tbody>
<tr>
<td>2030</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2060</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>2100</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Model Assumptions

- Equilibrium shoreline profile response
- TWL exceedance of toe relates to shoreline position
- Relationship between toe elevation and TWL will remain constant in the future
- Historic erosion rates indirectly accounts for sediment budget
- Coastal erosion driven by marine processes
- Cliff Armoring will eventually be abandoned
Model Applications

• Model analysis scale designed to support local decision making
• Pacific Institute 2009 (Revell et al 2011)
  – General Plan - City of Santa Barbara
  – City of Capitola General Plan
• Coastal Resilience Ventura (TNC)
  – LCPs – City of Oxnard, Ventura County
  – General Plan – Ventura County
• Monterey Bay (Coastal Conservancy, Natural Capital)

• Model results included in publications
  – Economics of Sea Level Rise Impacts (King and MacGregor)
  – USFWS/UCSB – SLR Impacts on Endangered Plants
Model Uncertainties

Input data sets:
- Topographic
- Scenarios

Address uncertainty:
- Sensitivity analysis of inputs
- Spatial aggregation

Spatial Aggregation Schematic

Coastal hazard zones for various future scenarios

Result of spatial aggregation analysis

Spatial Aggregation = Adding together overlapping hazard zones, pixel by pixel, to show relative probability.
Model Constraints
(e.g. advantages/disadvantages)

**Advantages**
- Planning Scale
- Includes geology, backshore type
- Scenario Approach (waves, SLR)
- Integrate erosion and flooding
- Modular
- Not dependant on time series
- Consistent with FEMA guidance
- Can address wave overtopping of structures
- Can include land motion

**Disadvantages**
- Potential erosion NOT actual erosion (project vs. predict)
- No direct sediment budget element (in dev)
- No beach width (in dev)
- No statistical analysis of uncertainties
Acknowledgements

• Funding
  – Ocean Protection Council / Pacific Institute
  – The Nature Conservancy
  – Coastal Conservancy (Monterey and Ventura)
  – County of Ventura
  – City of Capitola
  – Natural Capital Project / Stanford/ Packard
  – ESA PWA (internal R&D)

• Technical inputs
  – Peter Ruggiero, Cheryl Hapke, Adam Young, Gary Griggs, Patrick Barnard, Lesley Ewing, Bill O’Reilly, Matt Heberger