What Will Adaptation Cost?
An Economic Framework for Coastal Community Infrastructure

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Eastern Research Group, Inc.

Written under contract for the
National Oceanic and Atmospheric Administration (NOAA)
Coastal Services Center

NOAA Coastal Services Center
(843) 740-1200
www.nos.noaa.gov
The Approach: A Comparative Study

1. Understand Your Baseline Risk
   - Task 1: Select Appropriate Local Sea Level Rise Scenarios
   - Task 2: Develop High Water-Level Event Scenarios
   - Task 3: Assess Exposed Infrastructure for Your No-Action Scenario

2. Assess What You Can Do Differently
   - Task 1: Select Adaptation Strategies to Form Action Scenarios
   - Task 2: Re-Assess Exposed Infrastructure for Each Action Scenario

3. Calculate Costs and Benefits
   - Task 1: Identify Impacts
   - Task 2: Monetize Impacts
   - Task 3: Estimate Costs of Implementing Adaptation Strategies

4. Make a Decision
   - Task 1: Calculate Total Benefits of Each Action Scenario
   - Task 2: Compile Capital and Maintenance Costs
   - Task 3: Assess Each Action Scenario

The Approach:

1. Understand Your Baseline Risk
2. Assess What You Can Do Differently
3. Calculate Costs and Benefits
4. Make a Decision

Tasks:
- Task 1: Select Appropriate Local Sea Level Rise Scenarios
- Task 2: Develop High Water-Level Event Scenarios
- Task 3: Assess Exposed Infrastructure for Your No-Action Scenario
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- Task 1: Calculate Total Benefits of Each Action Scenario
- Task 2: Compile Capital and Maintenance Costs
- Task 3: Assess Each Action Scenario
Adaptation Strategies

- Beach Sand Nourishment
- Seawalls & Revetments
- Groins
- Elevate Structure
- Remove Structure

Action Scenarios
# Del Mar Action Scenarios

## Del Mar Action Scenario 1a
Beach Nourishment, Groins, Raise Structures, Remove Structures

<table>
<thead>
<tr>
<th>TRIGGERS</th>
<th>0’</th>
<th>1’</th>
<th>2’</th>
<th>3’</th>
<th>5.5’</th>
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</thead>
<tbody>
<tr>
<td>SLR (ft):</td>
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<td></td>
<td></td>
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<tr>
<td>Summer</td>
<td>120’</td>
<td>80’</td>
<td>35’</td>
<td>0’</td>
<td>0’</td>
</tr>
<tr>
<td>Winter</td>
<td>65’</td>
<td>25’</td>
<td>0’</td>
<td>0’</td>
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<tr>
<td>*Risk:</td>
<td>1%</td>
<td>5%</td>
<td>15%</td>
<td>50%</td>
<td>100%</td>
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</table>

<table>
<thead>
<tr>
<th>Lead times:</th>
<th>5-10 years</th>
<th>15-20 years</th>
<th>5-10 years</th>
<th>15-20 years</th>
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</thead>
<tbody>
<tr>
<td>Protect - Natural</td>
<td>Beach Nourishment</td>
<td>Groins</td>
<td>Raise Structures</td>
<td>Remove Structures</td>
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### Del Mar Action Scenario 1b
Beach Nourishment, Seawalls/Revetments, Raise Structures, Remove Structures

<table>
<thead>
<tr>
<th>TRIGGERS</th>
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<th>2’</th>
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<td>5%</td>
<td>15%</td>
<td>50%</td>
<td>100%</td>
</tr>
</tbody>
</table>

#### Lead times:

- **Protect - Natural**
  - 5-10 years
  - Beach Nourishment

- **Project - Engineered**
  - 15-20 years
  - Raise/Improve Seawalls and Revetments

- **Accommodate**
  - 5-10 years
  - Raise Structures

- **Retreat**
  - 15-20 years
  - Remove Structures
## Del Mar Action Scenarios

### Del Mar Action Scenario 2
Beach Nourishment, Remove Structures

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<th>TRIGGERS</th>
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<td>Winter</td>
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<tr>
<td>*Risk:</td>
<td>1%</td>
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<table>
<thead>
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<th>Beach Width</th>
<th>SLR (ft):</th>
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<th>2’</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
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<tr>
<td>*Risk:</td>
<td>5%</td>
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### Lead times:

- **Protect - Natural**: 5-10 years, Beach Nourishment
- **Project - Engineered**: 
- **Accommodate**: 
- **Retreat**: 15-20 years, Remove Structures
Carlsbad Action Scenarios

Carlsbad Action Scenario 1
Beach Nourishment, Groins

Protect - Natural

Project - Engineered

Groins

Accommodate

Retreat

2030 2050 2070 2090 2100
Carlsbad Action Scenarios

Carlsbad Action Scenario 2
Beach Nourishment, Seawalls/Revetments

Protect - Natural

Project - Engineered
Raise/Improve Seawalls and Revetments

Accommodate

Retreat
Carlsbad Action Scenarios

Carlsbad Action Scenario 3
Beach Nourishment Only

- Protect - Natural
- Project - Engineered
- Accommodate
- Retreat

2030, 2050, 2070, 2090, 2100

Beach Nourishment
Cost-Benefit Model

1. Monetized baseline risk primary and secondary impacts, which represent the maximum damages prevented, or the no action scenario

2. Monetized negative impacts resulting from action scenarios

3. Costs of adaptation strategies – action scenarios
The Model: Benefits

Primary Impacts
- City property and structures
- City public infrastructure
- City transportation infrastructure
- Residential property (structure and tax revenue)
- Commercial and industrial property (structure and tax revenue)
- Beaches

Secondary Impacts
- Loss of beach tourism revenue to businesses
- Loss of beach tourism city tax revenue due to chronic inundation
- City cleanup for flooding events
- Emergency response and/or traffic control for flooding events
## Net Benefits & Benefit-Cost Ratios

### North Beach Del Mar, CA

<table>
<thead>
<tr>
<th>Scenario</th>
<th>NPV of Total Benefits ($million)</th>
<th>NPV of Total Costs ($million)</th>
<th>NPV Benefits ($million)</th>
<th>Benefit-to-Cost Ratio</th>
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<tbody>
<tr>
<td>Scenario 1a</td>
<td>$2,843.2</td>
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<td>Scenario 1b</td>
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<td>Scenario 2</td>
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### Selected Study Area Planning Zone 1, Carlsbad, CA

<table>
<thead>
<tr>
<th>Scenario</th>
<th>NPV of Total Benefits ($million)</th>
<th>NPV of Total Costs ($million)</th>
<th>Net Benefits ($million)</th>
<th>Benefit-to-Cost Ratio</th>
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</thead>
<tbody>
<tr>
<td>Scenario 1</td>
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<td>$11.2</td>
<td>$806.5</td>
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<td>Scenario 2</td>
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<td>$25.7</td>
<td>$696.9</td>
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<td>Scenario 3</td>
<td>$817.7</td>
<td>$14.4</td>
<td>$803.3</td>
<td>56.97</td>
</tr>
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</table>
Sensitivity Analysis

Key parameters tested:

- Protection factor (effectiveness)
- Discount rate
Lessons Learned

1. The NOAA Framework: Adaptable, does not need to be implemented in a linear fashion

2. Project and site-specific information is necessary to provide more detailed cost estimates.

3. The value of GIS and parcel level information versus geographically aggregated approach

4. The value of “ground-truthing” and on-the-ground site inspection

5. The value of collaboration with appropriate agencies