Cost-Benefit Analysis for Sea Level Rise Adaptation Scenarios
Learning Session Agenda

- Webinar Logistics
- Brief overview of ARCCA
- Featured Presentation
- Participant Q&A
- Closing remarks
A network of leading regional collaboratives from across California that work together to advance adaptation statewide and increase local capacity to build community resilience.
Laura Engeman
Program Manager
Center for Climate Change Impacts & Adaptation
Scripps Institution of Oceanography

Amanda Lee
Principal Planner/Long Range Planning Manager
Planning and Community Development
City of Del Mar
Resilient Coastlines Project of Greater San Diego:
Connecting local governments, regional science and communities

Laura Engeman
March 20, 2018
11 Cities
5 Regional Agencies
4 Universities
4 Non-Profits
San Diego Gas & Electric
The San Diego Foundation
NOAA Award

$689,500

NOAA Regional Coastal Resilience Grant Program

Directly support community-based coastal hazard planning
14+ Coastal Resilience Projects Across San Diego County

City of Carlsbad Sea Level Rise, Local Coastal Program and Zoning Update

The city of Carlsbad’s Vulnerability Assessment presents a Carlsbad-specific sea level rise analysis to support and update the city’s Local Coastal Program and Zoning Ordinance. The assessment evaluates the degree to which important community assets are susceptible to, and unable to, accommodate adverse effects of projected sea level rise. The assessment identifies the assets that are likely to be impacted and the causes and components of each asset’s vulnerability.
Regional Work Group

- State / Navy Engagement
- Local Science
- Regional Consistency & Coordination
- Regional Needs & Opportunities
Comparing Sea Level Rise Adaptation Strategies in San Diego:
An Application of the NOAA Cost-Benefit Framework
The Approach: A Comparative Study

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

June 2013

Eastern Research Group, Inc.

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

NOAA Coastal Services Center
1305 East-West Highway
Silver Spring, MD 20910

NOAA Coastal Services Center
LEADING GLOBAL INFORMATION AND TECHNOLOGY
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
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>
</tr>
</thead>
<tbody>
<tr>
<td>SLR (ft):</td>
<td>120'</td>
<td>80'</td>
<td>35'</td>
<td>0'</td>
<td>0'</td>
</tr>
<tr>
<td>Summer</td>
<td>65'</td>
<td>25'</td>
<td>0'</td>
<td>0'</td>
<td>0'</td>
</tr>
<tr>
<td>Winter</td>
<td>1%</td>
<td>5%</td>
<td>15%</td>
<td>50%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Beach Width**

<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>
</tr>
</thead>
<tbody>
<tr>
<td>Protect - Natural</td>
<td>Beach Nourishment</td>
<td>Groins</td>
<td>Raise Structures</td>
<td>Remove Structures</td>
</tr>
<tr>
<td>Project - Engineered</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accommodate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retreat</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Del Mar Action Scenarios

## Del Mar Action Scenario 1b
Beach Nourishment, Seawalls/Revetments, Raise Structures, Remove Structures

<table>
<thead>
<tr>
<th>TRIGGERS</th>
<th>SLR (ft)</th>
<th>0'</th>
<th>1'</th>
<th>2'</th>
<th>3'</th>
<th>5.5'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>Beach Width</td>
<td>120'</td>
<td>80'</td>
<td>35'</td>
<td>0'</td>
<td>0'</td>
</tr>
<tr>
<td>Winter</td>
<td>*Risk:</td>
<td>65'</td>
<td>25'</td>
<td>0'</td>
<td>0'</td>
<td>0'</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

<table>
<thead>
<tr>
<th>TRIGGERS</th>
<th>0'</th>
<th>1'</th>
<th>2'</th>
<th>3'</th>
<th>5.5'</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLR (ft):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<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>
<td>0'</td>
</tr>
<tr>
<td>*Risk:</td>
<td>1%</td>
<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, Remove Structures
- **Accommodate**: 15-20 years, Remove Structures
- **Retreat**: 15-20 years, Remove Structures
1. Monetized NO ACTION SCENARIO: baseline risk primary and secondary impacts, which represent the maximum damages prevented

2. Monetized LOSSES IN SCENARIOS: negative impacts resulting from action scenarios (i.e. property tax revenues)

3. Costs of adaptation strategies

4. Benefits of each action scenario

5. Capital and maintenance costs
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

<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>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1a</td>
<td>$2,470.2</td>
<td>$335.4</td>
<td>$2,134.8</td>
<td>7.36</td>
</tr>
<tr>
<td>Scenario 1b</td>
<td>$2,228.2</td>
<td>$363.2</td>
<td>$1,865.0</td>
<td>6.14</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>$2,432.2</td>
<td>$567.3</td>
<td>$1,864.8</td>
<td>4.29</td>
</tr>
</tbody>
</table>

**KEY MESSAGES**
- Not just comparing Strategy A to Strategy B
- Ratio reflects benefits of all strategies to NO Action
- These are NET PRESENT VALUES
Sensitivity Analysis
Varied Effectiveness Assumption

![Graph showing sensitivity analysis with varied effectiveness assumption.](image)
Sensitivity Analysis
Varied Discount Rates

![Graph showing the relationship between Benefit-Cost Ratio and Discount Rate for Scenario 1a, Scenario 1b, and Scenario 2. The graph indicates that as the discount rate increases, the Benefit-Cost Ratio also increases.](image)
Lessons Learned

1. The NOAA Framework: Adaptable, but assumes strategies applied in a linear fashion, not overlapping

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

3. Different methods for evaluating impacts: FEMA HAZUS = Broad, but high value in investing in GIS and parcel level information for more precise info

4. The value of “ground-truthing” and on-the-ground site inspection – Don’t depend on Desktop tools!

5. The value of collaboration with appropriate agencies
info@sdclimatecollaborative.org
Or Dani Boudreau dboudreau@trnerr.org
Laura Engeman – lengeman@ucsd.edu

www.resilientcoastlines.org
www.resilientcoastlines.org/leadership
City of Del Mar
Sea Level Rise Adaptation & Coastal Resiliency Planning

Amanda Lee, Principal Planner
Alee@delmar.ca.us
March 21, 2018
Del Mar, California

- Small beach city in San Diego County
- Less than 2 square miles; ~4,200 people
- Millions of visitors annually
- Walkable beach end-to-end
- San Dieguito Lagoon
- State Fairgrounds/Racetrack
- Beach-level neighborhood (North Beach)
- Development atop coastal bluffs

Photos: Kenneth & Gabrielle Adelman; californiacostline.org
Adaptation Planning- In Process

- Phased, long-term approach & strong technical basis
- Range of options/flexibility to address local hazards
Background

- **City awarded two State Grants 2014/2016 ($311,220)**
  - Technical reports and to amend Local Coastal Program
  - Environmental Science Associates- technical consultant

- **Established Technical Advisory Committee**
  - Public forum for recommendations to City Council
  - Robust outreach- over 20 public meetings since July 2015

- **Prepared local Vulnerability & Risk Assessment (2016)**
  - Del Mar is vulnerable along ocean interface & Lagoon
What are City’s Vulnerabilities?

Projections through year 2100 (5.5 ft of SLR):
- Narrowing of beach
- Erosion of coastal bluffs
- Increased flooding frequency/damage
- Conversion & loss of Lagoon habitat
- Flooded roads, storm drains, utilities
- Service impacts: fire, public works, sewer, beach access
Extreme Floods like Del Mar-1980

Followed up with Adaptation Plan

- Resiliency planning for future of Del Mar

- To help property owners (public/private) prepare for projected flooding, erosion, and rising tides

- Align options with community goals & values
Why is Planning Needed?

- To help prepare and mitigate/avoid the worst effects
  - Protect people from risk of harm
  - Help owners plan/protect development per Coastal Act

- Maintain community’s desired high quality of life
  - Protect valued assets: beaches, parks, bluffs, Lagoon

- Ensure future of Del Mar will be viable
  - Maintain public infrastructure and essential services
Worst Case Scenario
(without adaptation)
Strong Technical/Scientific Basis

- **Best available science** - National Research Council (2012)
- **Coastal Commission Guidance** (2015)
- **Local Vulnerability and Risk Assessment** (2016)
- **Cost Benefit & Legal Risk Analyses** (2017)
  - Nexus Planning & Research - Cost Benefit Analysis
  - Environmental Law Institute - Legal Risk Analysis
Cost to City of “No Action”

- Risk of harm to individuals (flood/erosion hazards)
- Risk of damage to public assets and infrastructure
- Risk of damage to private property/reduced tax base
- Risk of legal challenges over public trust lands
- Risk of penalties for default on commitment to grant funds
- Risk of reduced municipal bond rating
Nexus Research Study Findings

- Highest Cost to the City of Del Mar:
  - No action

- Next Highest Cost:
  - Planned retreat of North Beach neighborhood

- Highest Return on Investment:
  - Combination of beach nourishment and sand retention
Del Mar AP Strategies

- Beach nourishment
- Sand retention: reefs, groins, breakwater
- Dune restoration
- River channel dredging
- Living levees along river banks
- Elevate/improve sea walls per BPI
- Flood proof, elevate, setback structures
- Relocate highly vulnerable facilities & public infrastructure (essential services)
- Accommodate wetland habitat migration
- Min setbacks from erosion/flood hazards
Sediment Management Plan

Volumes of sand needed- 5 ft SLR
- 900,000 cubic yards/10-11 yrs

Sand nourishment cost estimate
- $20-25 per cubic yard
- $9 million every 10 yrs near term
- $20 million/ 10 yrs long term

Report also includes:
- River channel dredging plan
Wetland Habitat Migration Plan

- Addresses migration/loss of Lagoon habitat
  - SLAMM model: Sea level rise affecting marshes
  - Identifies habitat changes & conservation strategies

- Wetlands have carbon sequestration benefits
  - Atmospheric CO₂ is held in biomass and soils
  - Degree of benefit changes when habitat type converts
  - Implications for City’s greenhouse gas accounting
Challenges of Adaptation

- Evolving and uncertain nature of climate science

- Change in conditions must be monitored
  - Beach width (sandy beach)
  - Bluff edge (bluff edge to development)
  - Frequency/extent of flood damage (repetitive loss)

- All options have extensive costs (no perfect solution)
  - Untested area of law; limited examples
  - Lack of long term funding source

- Planned retreat was the most controversial issue
Rationale for No Planned Retreat in Del Mar’s North Beach

- Conflict w/ Community Plan- century old neighborhood
- Conflict with 1988 voter initiative and certified LCP protections for public beach and property owners
- No confidence retreat can achieve quality beach and access
- High land value makes public acquisition cost prohibitive
- Alternative locations not available for those displaced
- High threat of legal risk if retreat is planned now
Del Mar’s Adaptation Plan

- Follows State guidance and Coastal Act requirements
- Uses best available science - strong technical basis
- Addresses identified local vulnerabilities and risks
- Process involved robust public outreach
- Plan includes wide range of adaptation options
- Explains how City approach best meets goals & priorities
Amanda Lee, Principal Planner
Alee@delmar.ca.us
March 21, 2018
Thank You!

• Resilient Coastlines Project of Greater San Diego
  – resilientcoastlines.org

• Upcoming ARCCA Learning Sessions
  – Navigating Coastal Resilience Strategy Development (3/30)
  – Adaptation Clearinghouse Beta Testing (4/18)
  – Learn more at arccacalifornia.org/resources/learning-sessions

• New ARCCA Resources
  – 2018 Legislative Tracking: arccacalifornia.org/2018-legislative-tracking
  – Roadmap to Transportation Resilience: arccacalifornia.org/roadmap-to-resilience