The Game of Floods

SEA LEVEL RISE IS COMING
3 feet of SLR or 100-year storm

1 foot of SLR or King Tide
### Major adaptation strategies

#### Protect
- **HARD**
  - Build dikes, seawalls
  - Install tide gates
  - Raise grades
  - Increase pumping
- **SOFT**
  - Natural beach systems
  - Tidal wetlands
  - Horizontal levees

#### Manage Retreat
- Land and structure acquisition/relocation
- Building/Planning code and regulation changes
- Allow erosion/migration of natural areas

#### Accommodate
- Elevate buildings and infrastructure
- Floodproof critical structures
- Floodable buildings/tiered developments

...and combinations of any above
Famous adaptors throughout history…
Dutch Boy built protection
Moses implemented managed retreat
Noah went for accommodation (floodable structures)
Major adaptation strategies

Hard
- Flood/sea walls
- Levees/dikes
- High tide gates
- Rock rip-rap

Soft
- Wetlands creation/enhancement
- Engineered beaches shoreline

Infrastructure/Lifestyle
- Elevate structures
- Raise grades
- Lifestyle adaptation
- Zoning changes
- Planned retreat
PROTECT

Hard (traditional) engineering

- Traditional levee
- Tide gate
- Seawall/revetment
- Flood wall & pump station
Sea wall

Pros: Limited ROW required

Cons: Cost, Impacts

Bulkhead seawall in Seadrift neighborhood
Levee

**Pros:** Stability if maintained, Cost lower than wall

**Cons:** Large ROW required
Flood wall & pump station

**Pros:** Lower ROW than levees

**Cons:** Capital and maintenance costs
Tide gate

**Pros:** Temp solution to tidal riverine flooding

**Cons:** Cost, limited effectiveness over time
Major adaptation strategies

**Hard**
- Flood/sea walls
- Levees/dikes
- High tide gates
- Rock rip-rap

**Soft**
- Ecotone Levees
- Wetlands creation/enhancement
- Engineered beaches shoreline

**Infrastructure/Lifestyle**
- Elevate structures
- Raise grades
- Lifestyle adaptation
- Zoning changes
- Planned retreat
PROTECT
Soft (nature-based) engineering

Horizontal levee

Dune restoration & Beach maintenance

Wetland/ shoreline vegetation

Offshore structure
Horizontal levee

**Pros:** Uses landscape to attenuate waves, provides habitat

**Cons:** Cost for earthwork, larger ROW
Wetland/ shoreline vegetation

**Pros:** Habitat improvement and flood reduction

**Cons:** Large ROW required
Dune restoration & beach maintenance

**Pros:** Recreation and flood reduction benefits

**Cons:** Costs for replenishment
Aramburu sandy foreshore construction 2012
Placing larger wood groins – eucalyptus logs
Aramburu engineered bay beach spring-summer 2013

Winter storm gravel and shell berm persists

Sand beachface slope accretes, steepens

Sand partially buries winter storm berm
Offshore structures

**Pros:** Reduces waves impacts – more when structure is higher

**Cons:** Costs to construct, maintain and limited effectiveness for SLR
Major adaptation strategies

**Hard**
- Flood/sea walls
- Levees/dikes
- High tide gates
- Rock rip-rap

**Soft**
- Wetlands creation/enhancement
- Engineered beaches shoreline
- T-zone creation

**Infrastructure/Lifestyle**
- Elevate structures
- Raise grades
- Lifestyle adaptation
- Zoning changes
- Planned retreat
ACCOMMODATE

New floodable development

Elevate buildings

New/ elevated road
Elevate buildings

**Pros:** Effective for storm flooding

**Cons:** Costs, not effective for permanent tidal flooding
Floodable development

**Pros:** Potential solution that generates revenue

**Cons:** Impacts from more development – higher density to pay for costs
New/elevated road

Pros: Protects roads when designed correctly

Cons: Very high cost, ROW
RETREAT

- Retreat
- Post-storm prohibitions
- Rebuild here
- Stricter land use zoning
Managed Retreat

Pros: Lower costs if no buyout
Cons: Costs for buy-out and community impacts, new infrastructure
Post Storm Restrictions and Stricter Land Use Zoning

- No or restricted rebuilding after storms?
- Rolling easements
- Extra technical studies
- Use of stricter codes (FEMA V)
Communities of North Bay Island

- Downtown Norbay
- Eroding Cliff Heights
- Mudflat Manors
- Desolation Court
- Shoreline Marina
- Twig Cove
- Seaspray Homes
Downtown Norbay

- Commercial hub of the island
- Protected by undersize levees and vulnerable to both riverine and tidal flooding
Eroding Cliff Heights

- Residential community threatened by cliff erosion
- Zoning and shoreline protection challenges
Mudflat Manor

- Large residential community threatened by SLR
- Vocal community of property owners demanding protection
Desolation Court

- Small poor isolated community threatened by SLR
- In danger of being cut-off from services
Shoreline Marina

- Water-based commercial business and associated businesses threatened by SLR
- In danger of being cut-off from road access at high tides
Curvey Cove

- Historic Ag based community with access and crops threatened by SLR
- In danger of being cut-off from road access at high tides
Seaspray Estates

• Large vacation and second home community with access and homes threatened by SLR
• In danger of being cut-off from road access at high tides
Real World – costs are messy and depend on many factors
+ planning & engineering
+ permitting
+ mitigation
+ maintenance & repair

Game World – costs are simpler one-time costs and given to you per unit (i.e. mile or # of buildings)
Suggestions for the game

• Start with one community: what’s at risk and what infrastructure is essential?
• What must be protected to allow the community to function. What other options exist?
• Adaptation options: discuss pros and cons of measures alone and combined - phasing
• Consider: mitigation, permits, and funding; options that span more than one community
• Add up the costs and stick your group’s measures on the board
Game over?

1) Who in your organization is planning/strategizing around sea level rise?

2) What other organizations are also planning/strategizing that you may need to coordinate with?

3) What are the benefits or drawbacks of interagency discussion/planning/strategizing?

4) Any improvements or suggestions?
Thank You

Visit www.MarinSLR.org for more information

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Novato Creek at Highway 101. Credit: Marin County staff