CITY OF CARMEL-BY-THE-SEA
coastal hazards
LOCAL COASTAL PROGRAM UPDATE

integral consulting inc.

Coastal Hazards
Local Coastal Program Update

Community Workshop

City Hall | Council Chambers
4pm-6pm
May 15, 2025

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Agenda

4:00 pm – 4:30 pm	Project background and presentation on beach width changes and sea level rise
4:30 pm – 5:00 pm	Breakout groups – Round 1
5:00 pm – 5:30 pm	Presentation on Adaptation Strategies
5:30 pm – 6:00 pm	Breakout groups – Round 2; Closing

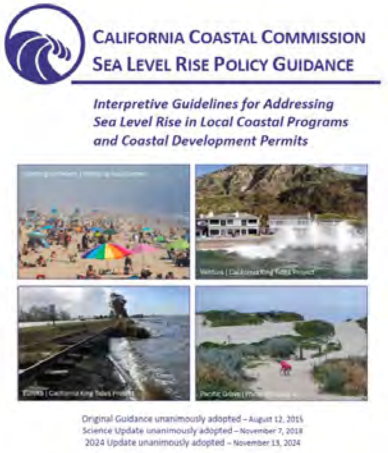
Background

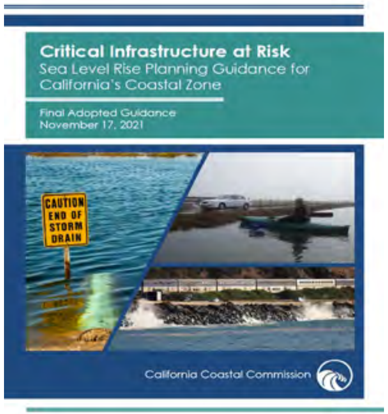
What is a Local Coastal Program?

- City’s planning document for development in the Coastal Zone

Why the Local Coastal Program (LCP) Update?

- Coastal Commission requires that LCPs be updated to consider sea level rise
- Current LCP does not consider SLR or include adaptation policies





Coastal Hazards Local Coastal Program Update Process

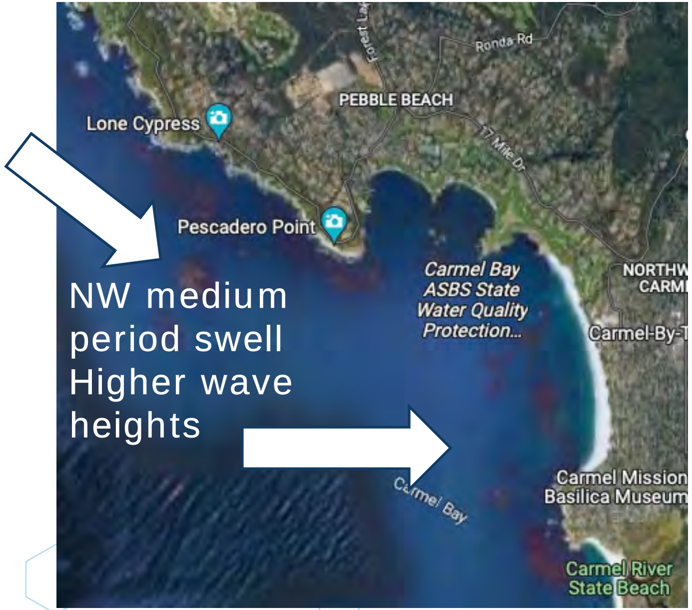
Meeting Objectives

- Provide the community with information on seasonal and long-term beach changes; sea-level rise projections; and coastal hazards at Carmel Beach
- Provide the community with information on strategies the City can take to mitigate the impacts of storm events and sea level rise on coastal erosion, beach width, beach access, and infrastructure
- Receive feedback from community on potential adaptation strategies

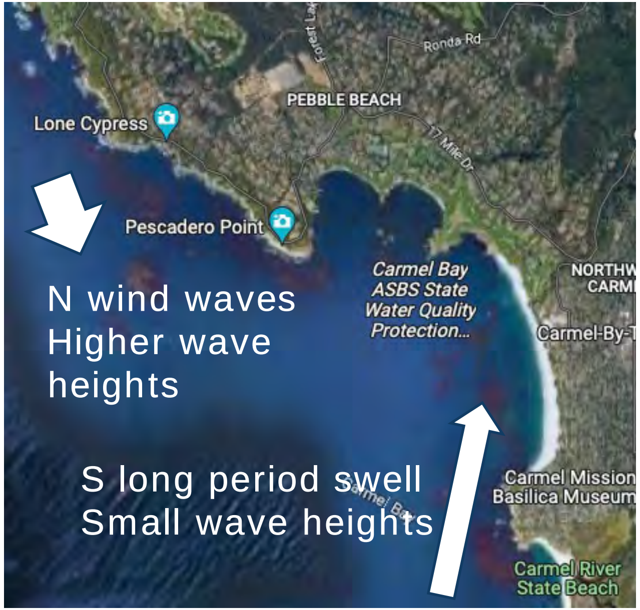
Seasonal Beach Width Changes and Sea-Level Rise

Winter vs Spring Waves

Winter
Erosion Dominant



Spring
Accretion Dominant



Processes Driving Erosion

Coastal Processes:

- Tide level
- Breaking wave run up
- Wave reflection
- Wave overtopping

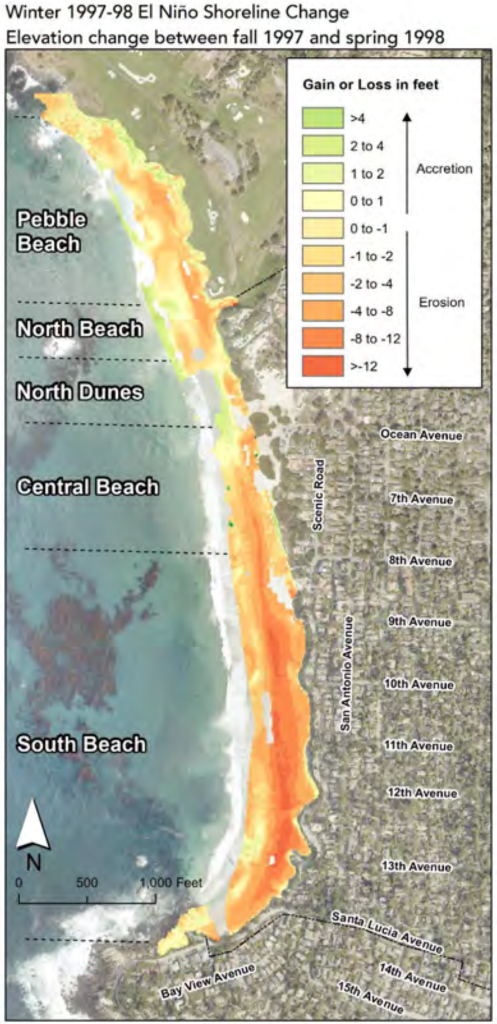
Local Conditions:

- Geomorphology
- Coastal armoring
- Cliff/bluff substrate
- Localized currents generated by waves
- Other factors including stormwater runoff and anthropogenic factors

El Niño years typically have higher water levels and storminess resulting in more erosion

Summary of Beach Changes

- Beach volume - relatively stable over time
- Major El Niño years led to the largest beach width reductions (1992, 1998, 2009, 2011)
- In 1997-98
  - ~300,000 cubic yards of sand was moved offshore
  - Maximum beach scour was ~14 feet (in vertical loss)
- Variability is highest in South Beach section
- North Dunes area saw the smallest trend with sediment moving into the foreshore



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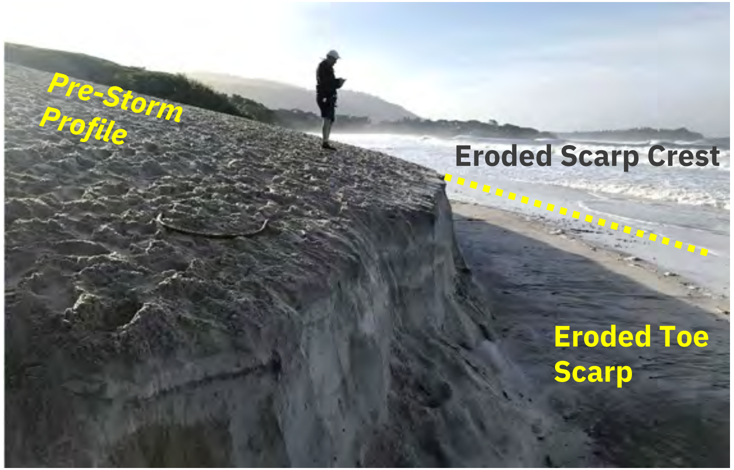
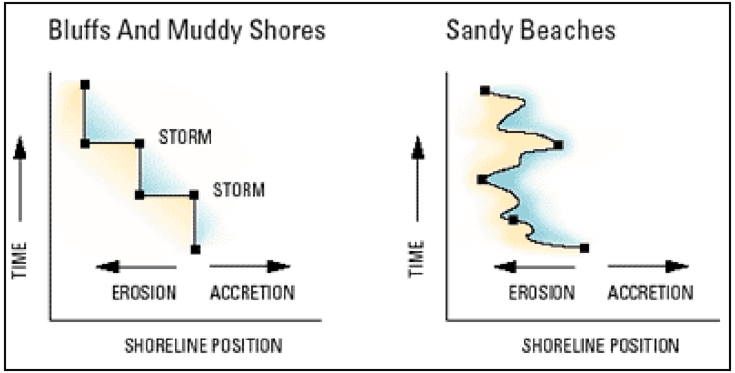
Cliff Erosion vs Dune Erosion

- Storm erosion differs based on backshore
- Bluffs and cliffs **do not recover**
- Dunes erode and **can recover**
- Carmel has a multitude of backshore conditions:
  - Del Mar Dunes and North Dunes
  - Unarmored cliffs
  - Seawalls and riprap, primarily south of 8th Street





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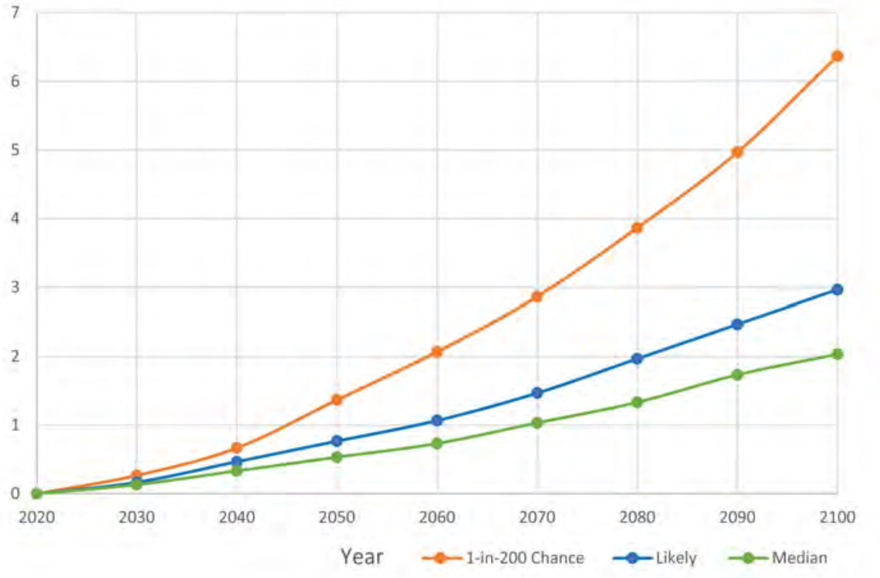
Sea Level Rise Scenarios

- Sea level rise projections are based on the State of California Sea Level Rise Guidance from 2018 and the 2024 update
- Sea level rise scenarios considered medium-high risk aversion (.5% likely) to low-risk aversion (66% likely):
  - Current conditions, **2020 baseline**
  - Near-term, **1** ft of SLR / **2045 - 2060**
  - Medium-term, **2** ft of SLR / **2060 – 2080**
  - Long-term, **4** ft of SLR / **2080 – 2100+**



Above: SLR curves from the (2018) OPC guidance

*Current (2024) guidance indicates 4.6’ of SLR by 2100 (Int-High Scenario)

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Beach Width Narrowing: Short term (2045 – 2060)

- A typical summer beach still exists
- Southern section becomes "squeezed" especially at 12th avenue headland
- By **1 ft** of sea level rise, typical summer dry sand beach reduced by **20%**

North

0 - 1 ft of SLR

South

0 - 1 ft of SLR

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Beach Width Narrowing: Medium-term (2060 - 2080)

- The northern beach section remains connected laterally
- Lateral access to areas south of 12th Avenue headland may be restricted
- By **2 ft** of sea level rise, reduced by **39%**, with loss of lateral beach access to areas south of the 12th Avenue headland

North

South

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Beach Width Narrowing : Long Term (2080 – 2100)

- Only continuous dry sand beach is between the northern sand ramps to Pescadero Canyon
- Two small pockets between 8th avenue and 11th avenue (~1.5 acres each)
- By **4 ft** of sea level rise, reduced by **78%**, with two small pocket beaches remaining in the south, but dry beach remaining north of the sand ramps

North

South

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Beach Width Narrowing with up to 5’ of SLR

Sea Level Rise Elevation (ft)	Acres of Dry Sand Beach (summer)	Percentage
0	34.2	100%
1	27.4	80%
2	20.7	61%
3	14.1	41%
4	7.6	22%
5	2.6	8%

Assumes existing coastal armoring is maintained

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North

South

Cliff and Dune Overtopping and Erosion
With Coastal Armoring

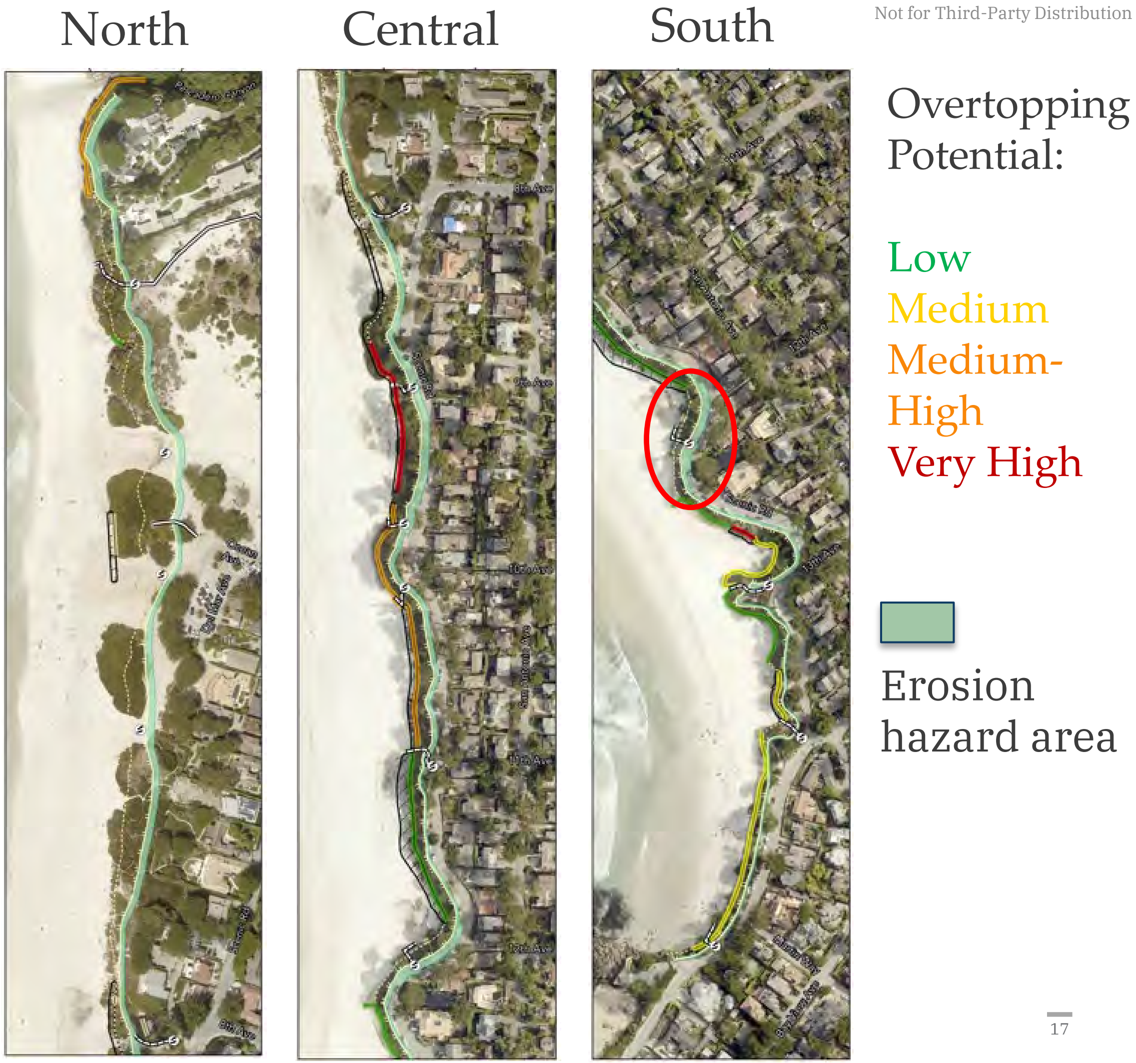
Erosion and Overtopping Short Term (1 ft: 2045 - 2060)

Overtopping:

- Highest risk between 8th and 10th Avenues

Erosion:

- High risk area for erosion is at Central Carmel Beach between 8th and 12th Avenues
- Red circle indicates an unarmored area of shoreline at Scenic Dr. and 12th Avenue



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Cliff and Dune Erosion Medium Term (2 ft: 2060 – 2080)

Overtopping:

- Overtopping is highest between 8th and 12th Avenues

Erosion:

- Projected erosion hazards in areas behind seawalls range ~ 20-40ft
- Erosion hazard zones are slightly higher along the dune-backed shoreline

North Central South

Overtopping Potential:

Low
Medium
Medium-High
Very High

Erosion hazard area

Cliff and Dune Erosion Long Term (4 ft: 2080 – 2100)

Overtopping:

- South Carmel Beach between Martin Way to 13th Avenue
- North Beach near Pescadero Canyon

Erosion:

- Highest erosion potential around 12th Avenue up to 150 ft (see red circle)

North | Central | South

Overtopping Potential:

Low
Medium
Medium-High
Very High

Erosion hazard area

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Current Vulnerabilities

- **Stormwater** conveyance
- All **beach access stairways** and the **Del Mar Overlook**
- **Restroom** near Santa Lucia Avenue, located at ~24 ft, same elevation of FEMA FIRM base flood elevation
- Wave splash (not green water associated with overtopping) may exceed the bluff crest of the armored coastline at multiple locations:
  - Between 9th and 12th Aves
  - 13th Ave to Martin Way
  - At the private seawall near Pescadero Canyon

Stormwater infrastructure

Restroom near Santa Lucia Ave

Short Term (1 ft SLR, 2045 - 2060)

- **Scenic Road** is exposed in 6 locations from 8th Avenue to 11th Avenue
- **Wastewater mains** are exposed at:
  - Martin Way
  - Between 9th and 10th Avenues
  - Under the dunes between 7th and 8th Aves
- **Dune ramps** may be at risk
- 0.2 acres of **North Dunes Habitat** potentially eroded
- During large storms wave splash could be more frequent between 8th Avenue and 11th Avenue

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Medium Term (2ft SLR, 2060 - 2080)

- **Scenic Road**: entire length exposed, including underground water and sewer infrastructure
- **Water main** between 8th and 10th Avenues
- An additional 0.3 acres of **dune habitat**
- During storms, a **wastewater lift station** located at ~24.5 ft may be exposed to wave flooding
- **5 homes** may be vulnerable under the *without armoring* scenario

Wastewater lift station near 8th Avenue

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Long Term (2-4ft SLR, 2060 - 2100)

- With armoring - 44 homes along Scenic Road and Pescadero Canyon
- Without armoring - 59 homes along Scenic Road and Pescadero Canyon
- Del Mar Parking Lot including two water storage tanks
- 0.6 acres of dune habitat is exposed to erosion, for a total of 1.16 acres
- Water main under Scenic Rd. at 13th Ave
- Sewer main at 8th Ave
- Wave overtopping during storm events is more frequent south of 8th Ave

Worst case high erosion scenario:

- Restroom at Del Mar Parking Lot
- Volleyball Courts

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Breakout Group - Round 1

Share out at 4:50pm
Circle back at 5pm

Adaptation Strategies

Range of Adaptation Choices

Do Nothing

Accommodate

Setback

Reduce Wave Energy

Hybrid

Grey

Green

Protect

Managed Retreat

Before - 2002

After -2005

Adaptation Projects vs. Policy Approaches
Green vs Grey

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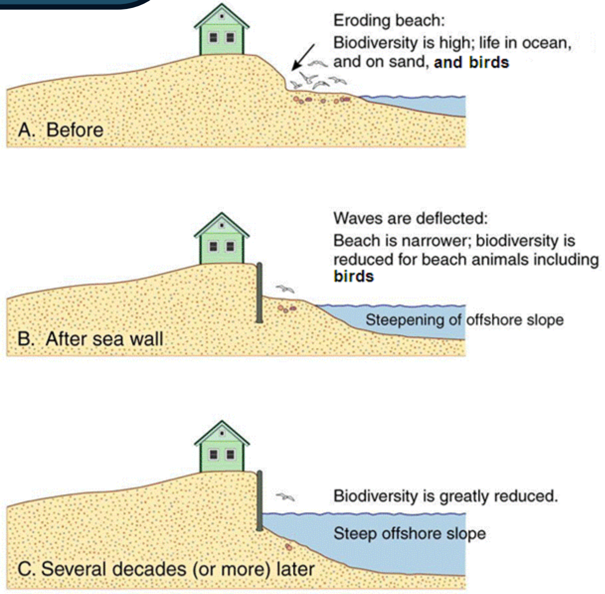
Secondary Consequences

- Construction Costs
- Escalating Maintenance Costs
- Access
- Ecology
- Recreation
- Views
- Aesthetics
- Loss of low-cost recreation
- Loss of tourism-related revenues
- Displacement of underrepresented communities

How should we adapt, and what are the trade-offs?



Source: Pilkey, O.H. and Dixon, K. L. 1996 (modified) *The Corps and the Shore*. Island Press, Washington, D.C.

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Full Range of Feasible Strategies

Based on professional experience and consultation with City and Coastal Commission Staff

Adaptation Areas

Stop, Reduce, or Avoid Erosion

Stop = loss of beach to protect upland – increasing costs
Reduce = balance beach and recreation – routine costs
Avoid = maintain beach, realign upland – high upfront costs

Adaptation Evaluation Criteria

Immediate, Short (5-20 yr), Medium (10-30 yr), Long (30+ yr)

- **Criteria includes:**
  - Reduce, Stop, or Avoid Erosion
  - Construction Cost/Maintenance of the Investment
  - Effectiveness
  - Regulatory Viability
- **Co-benefits and Secondary Consequences including:**
  - Beach widths
  - Water/surf/sand quality
  - Ecological impacts
  - Public access and safety

Short-term Management Strategies

	Priorities		Cost		Regulatory Viability	Secondary Impacts		
Strategy	Timing for Implementation	Priority Index Score (Balancing Effectiveness, Cost, and Other Criteria)	Construction	Maintenance (Including Cost Savings)		Beach Width Impacts	Environmental and Habitat Impacts: Water/Surf Quality and Ecological	Public Access and Safety
	Immediate, Short-term (5-20yr), Mid-term (10-30yr), Long-term (30yr +)	*Index Score (0 - 20)*	*Low - $, Medium - $$, High - $$$*	*None to Low - $, Medium - $$, High - $$$*	*Viable, Likely, Less Likely*	*Negative, No Effect, Positive*	*Negative, No Effect, Positive*	*Negative, No Effect, Positive*
Vegetation and landscaping to reinforce/protect terrace soil	**Immediate**	**18**	**$**	**$$**	**Viable**	=	+	=
Dune restoration	**Immediate**	**18**	**$**	**$$**	**Viable**	+	+	=
Beneficial reuse of sand	**Immediate**	**20**	**$**	**$$**	**Viable**	+	+	=
Living shorelines - utilize driftwood expanded dunes	**Immediate**	**19**	**$**	**$$**	**Viable**	+	+	+
Beach nourishment of upland dune ramps	**Short-term**	**20**	**$$**	**$$**	**Viable**	+	+	+
Beach nourishment	**Short-term**	**18**	**$$$**	**$$$**	***Depends***	+	+	+
Sacrificial berm	**Short-term**	**16**	**$**	**$$$**	**Likely**	+	+	+
Sand management/harvesting	**Short-term**	**15**	**$**	**$$$**	**Likely to Less Likely**	+	-	+

› Continue Monitoring and Maintenance of Existing Structures

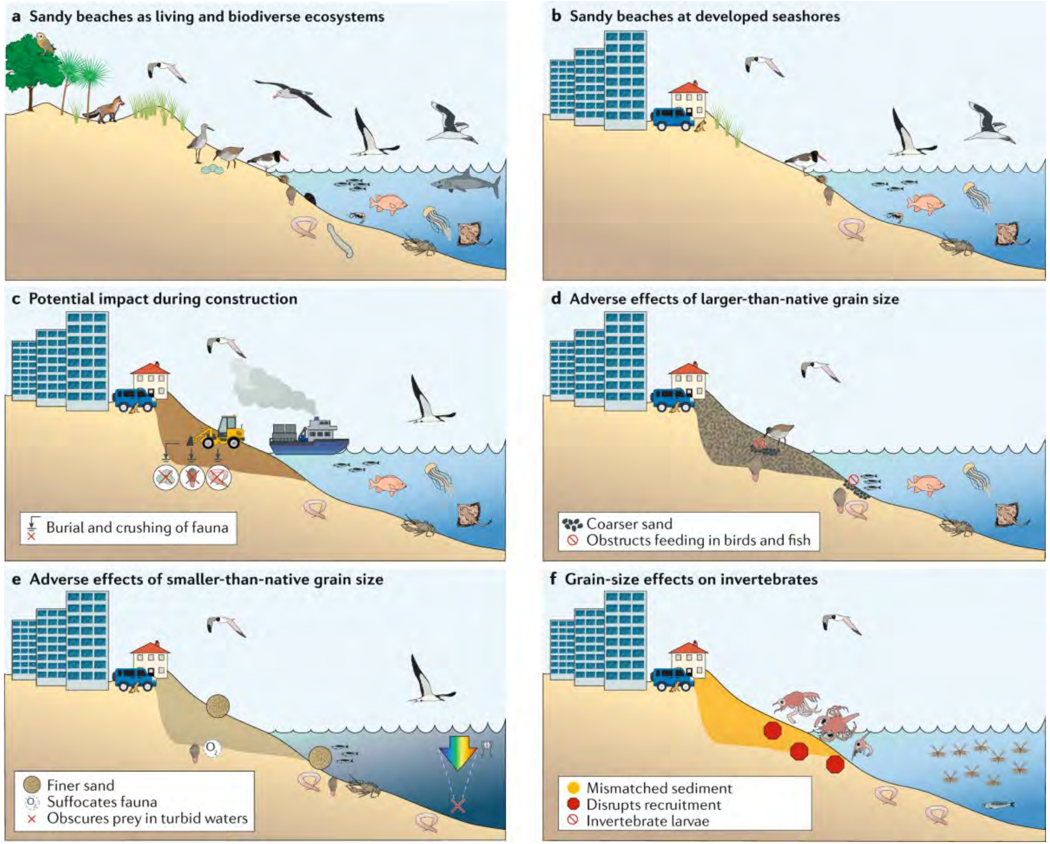
Vegetation, Dune, and Sand Management

- Sacrificial Winter Storm Berm
- Living Shorelines - Utilize Driftwood to Expand Dunes
- Dune Restoration
- Vegetation and landscaping to reinforce and protect terrace soils
- Beneficial Reuse of Sand or Opportunistic Beach Nourishment
- Sand Management/Harvesting
- Beach Nourishment
- Dune Ramp Nourishment

Challenges with Sand in Carmel

- Testing and Compatibility
  - Clean
  - Size, Color
- Placement methods
  - At once
  - Continuous
- Sorting
  - Different Grain Sizes
- Transporting
  - Truck
  - Dredge

size class	diameter range (mm)	microns
gravel	2.00 +	
v. coarse sand	1.0 - 2.0	
coarse sand	0.5 - 1.0	
medium sand	0.25 - 0.5	250 - 500
fine sand	0.125 - 0.25	125 - 250
v. fine sand	0.0625 - 0.125	63 - 125
coarse silt	0.031 - 0.0625	31 - 63
silt	0.0039 - 0.031	3.9 - 31
clay	< 0.0039	



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Sacrificial Winter Storm Berm

In the fall, construct a low berm along the backshore to reduce wave impacts at the back of the beach

Potential Location

At the **back beach** in areas without seawalls – along the dune-backed shoreline from 8th to 4th

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Living Shorelines - Utilize Driftwood to Expand Dunes

- Dunes with driftwood core and vegetation along existing dune-backed shoreline

Potential Location

Dune-backed areas, esp. at the 8th Avenue Sand Ramp Northern Sand Ramps

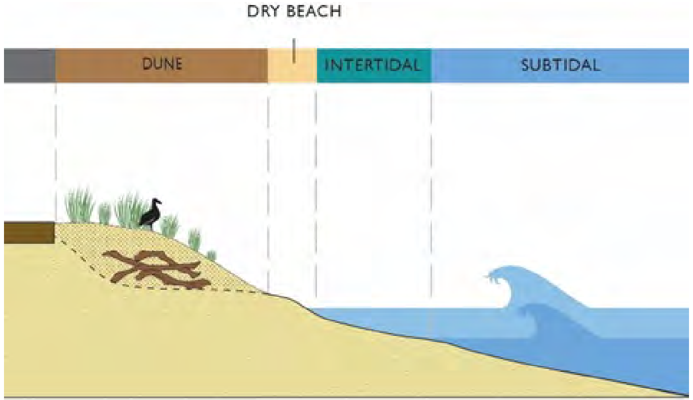
Living Shoreline Construction in Aptos

Dune Restoration

- Restoration of native dune areas.
- Low hummocky dunes along the existing dune-backed shoreline.
- Can correspond with a program for the beneficial reuse of sand from local sources and incorporate driftwood material.

Potential Location

Back beach area of the Del Mar Dunes



Dunes at Seabright Beach in Santa Cruz

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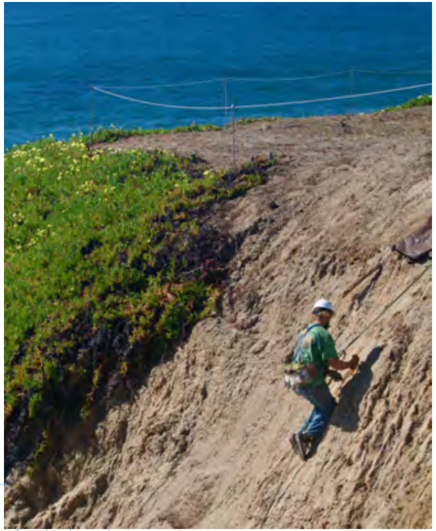
Vegetation and landscaping to reinforce and protect terrace soils



Planting and landscaping of bluff areas to hold soil in place and reduce bluff erosion. This may include terracing and the use of erosion fabric on the bluff with landscaping to retain soil

Potential Location

Along the **backshore** and terrace south of 8th Ave

These efforts can coincide with:

- Trail and access improvements
- Stormwater improvements
- Controlling access (signage, fencing etc.)

Opportunistic Beach Nourishment or Beneficial Reuse

- Placement of small volumes of sand acquired from nearby sources during construction or flood control maintenance activities and placed directly on the beach (Placement is usually by truck)
- Policy recommendation - Develop a program requiring beach compatible sand to be placed on beach or upland dune ramps

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Sand Management/Harvesting

Active harvesting and movement of sand from the foreshore to the back beach and backshore to widen the beach

Potential Location

The entire **beach**. Conducted at high-priority access locations including those at 4th Ave and the Del Mar Sand Ramps

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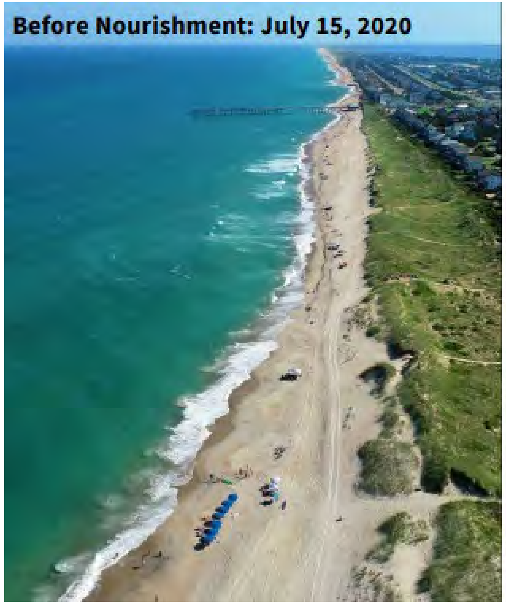
Beach Nourishment

- Large volume of sand usually from an offshore source and pumped to the beach



Dune Ramp Nourishment

- Placement of sand at the top of the existing sand ramps, avoids many of the permitting and regulatory hurdles with sand delivered to the beach during erosion events

Potential Location

Sand ramps at Del Mar and 8th Ave

Engineered Infrastructure

- Stop or Reduce Erosion
  - Riprap and Seawall Improvements
  - Raise Crest of Existing Structures
  - Protect Upper Bluff Terrace
  - Replace Riprap with Vertical Seawalls
  - Low Crested Structures to Reduce Erosion and Scour
  - Shore Platform Enhancement
  - Integrate Wave Deflectors in Access Improvements
  - Nearshore Reefs
- Requires monitoring and maintenance
- Challenging to permit but feasible if tied to protecting public infrastructure or improving/maintaining access
- Easier to permit if multiple benefits – access, habitat, recreation

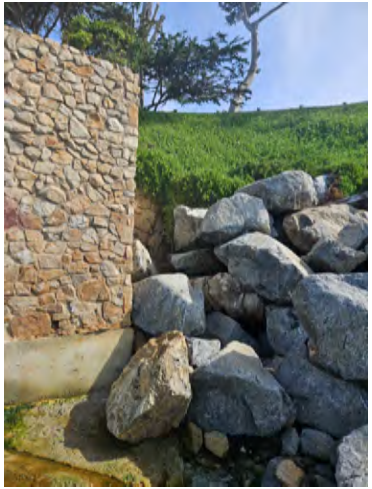
Short to Medium Term Engineered Strategies

- **Stop** erosion vs **reduce** erosive processes
  - **Stop** erosion likely to protect upland longer but cause beach loss faster
  - **Reduce** erosion likely supports longer beach and recreation

	Priorities		Cost		Regulatory Viability	Secondary Impacts		
Strategy Description	Timing for Implementation	Priority Index Score (Balancing Effectiveness, Cost, and Other Criteria)	Construction	Maintenance (Including Cost Savings)		Beach Width Impacts	Environmental and Habitat Impacts: Water/Surf Quality and Ecological	Public Access and Safety
	Immediate, Short-term (5-20yr), Mid-term (10-30yr), Long-term (30yr +)	*Index Score (0 - 20)*	*Low - $, Medium - $$, High - $$$*	*None to Low - $, Medium - $$, High - $$$*	*Viable, Likely, Less Likely*	*Negative, No Effect, Positive*	*Negative, No Effect, Positive*	*Negative, No Effect, Positive*
Monitoring and maintenance of existing structures	Immediate	17	$	$$$	Viable	-	-	+
Integrate wave deflectors into access improvements	Short-term	17	$$	$$	Likely	=	-	+
Replace revetments with seawalls	Mid-term	16	$$$	$$	Likely	+	=	=
Wave tripping low structures on bedrock	Mid-term	13	$$	$$$	Less Likely	=	-	+
Raise crest and redesign of seawalls	Mid-term	12	$$$	$$$	Likely	-	-	+
Wave cut terrace augmentation	Mid-term	12	$$	$$	Less Likely	-	-	Depends
Raise riprap	Mid-term	11.5	$$$	$$$	Likely	-	-	+
Infill seawalls	Mid-term	12	$$$	$$	Less Likely	-	-	+
Soil nail wall or tie back wall to protect bluff terrace	Mid-term	12	$$$	$$	Less Likely	-	-	+
Nearshore reefs	Mid-term	13	$$$	$$$	Less Likely	+	=	+

Stop erosion

- Riprap and Seawall Improvements
- Raise Crest of Existing Structures
- Protect Upper Bluff Terrace
- Replace Riprap with Vertical Seawalls



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Riprap and Seawall Improvements

Includes restacking and raising riprap, raising the crest of seawalls, and building infill walls at unarmored backshore locations

Potential Location

From 8th Av south

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Soil nail wall or tie back wall to protect bluff terrace

Shotcrete textured wall similar to the one at Pebble Beach Golf Links

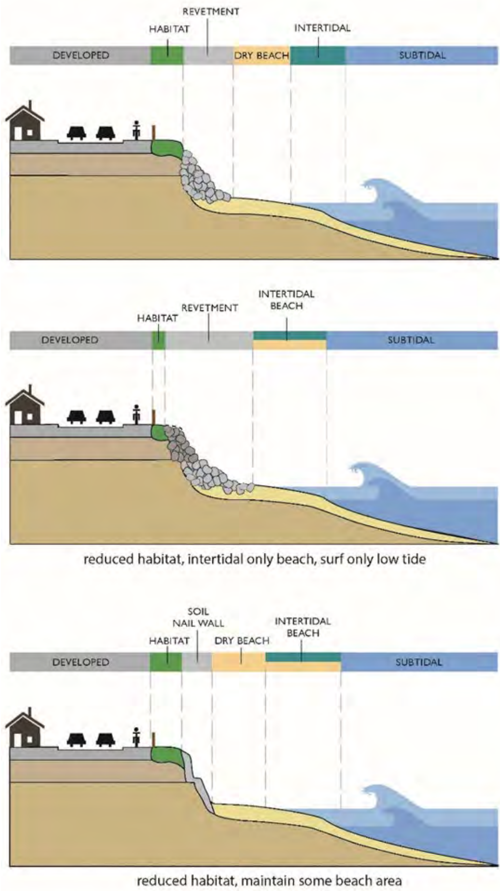
Potential Location

From 8th Av south. Especially where the terrace is more exposed to wave energy and where there are no conflicts with existing trees and vegetation.

Shotcrete wall at Pebble Beach Golf Links

Replacement of Riprap with Vertical Seawalls

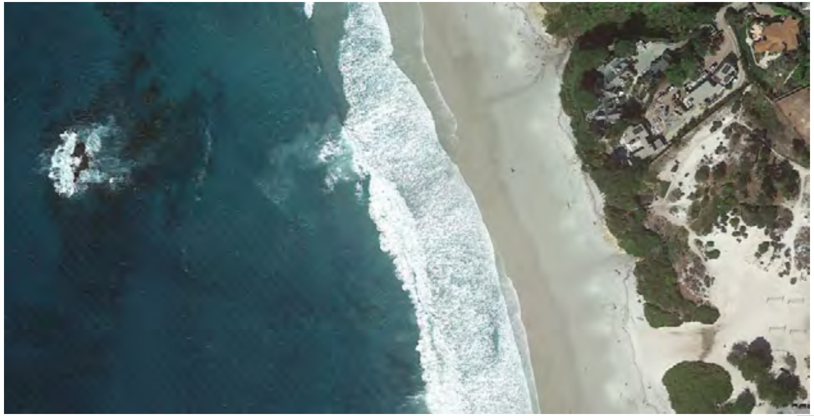
Revetment is about 40 feet high built at a 2: 1 slope. Footprint of the armoring occupies 80 feet of beach



Vertical seawalls or soil nail walls have a smaller footprint and temporarily widen the beach by removing a revetment

Reduce erosion

- Low Crested Structures to Reduce Erosion and Scour
- Shore Platform Enhancement
- Integrate Wave Deflectors in Access Improvements
- Nearshore Reefs



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Low Crested Structures to Reduce Erosion and Scour

Similar to a sill, built into exposed shore platforms to reduce currents and wave energy

Would consist of cemented sediments to retain the same color and material composition as the existing sandstone and mudstone outcroppings

Potential Location

In **back beach** areas with gaps in the shore platform where wave exposure is high

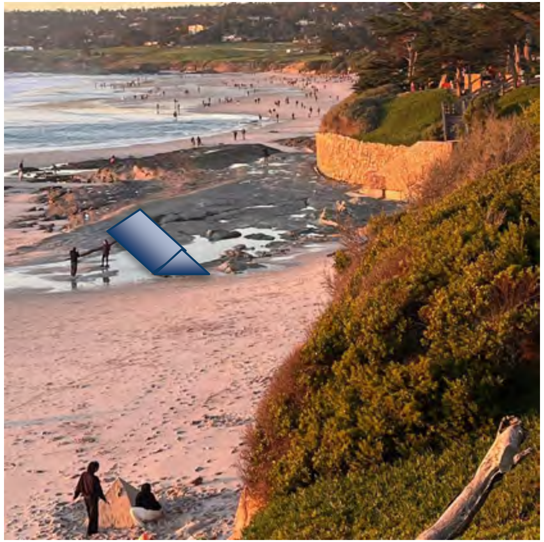
Shore Platform Enhancement

Augmentation and extension of shore platforms (or wave-cut terraces) to improve wave attenuation.

- Would consist of cemented sediments to retain the same color and material composition as the existing sandstone and mudstone outcroppings.

Potential Location

In **back beach** areas on top of shore platforms



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Integrate Wave Deflectors in Access Improvements

Concrete protrusions at the base of beach stair foundations to deflect wave energy

Potential Location

Beach stair accessways, primarily those subject to nearshore wave currents

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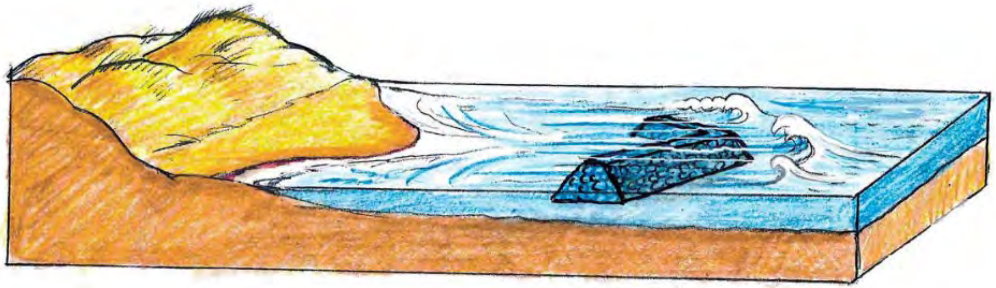
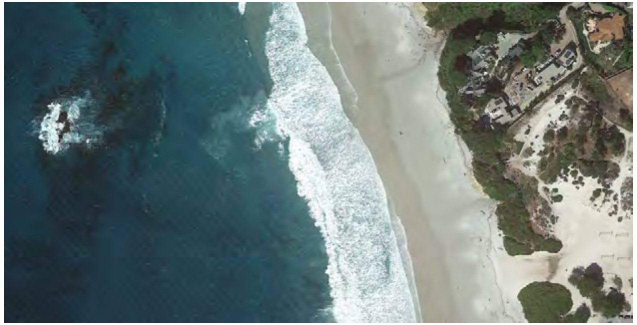
Nearshore Reefs

A rubble mound or concrete structure(s) with a crest below the water line to reduce wave energy

Potential Location

A nearshore reef is currently located offshore from 4th Ave. Could include a series of additional reefs.





Retreat and Relocation

Retreat and Relocation Strategies

	Priorities		Cost		Regulatory Viability	Secondary Impacts		
Strategy	**Timing for Implementation**	**Priority Index Score (Balancing Effectiveness, Cost, and Other Criteria)**	**Construction**	**Maintenance (Including Cost Savings)**		**Beach Width Impacts**	**Environmental and Habitat Impacts: Water/Surf Quality and Ecological**	**Public Access and Safety**
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Transportation Realignment (pedestrian path)	Long-term	17.5	Varies ($$)	$	Likely	+	+	+
Retreat/Relocation	Long-term	17	Varies ($$$+)	$	Likely	+	+	+

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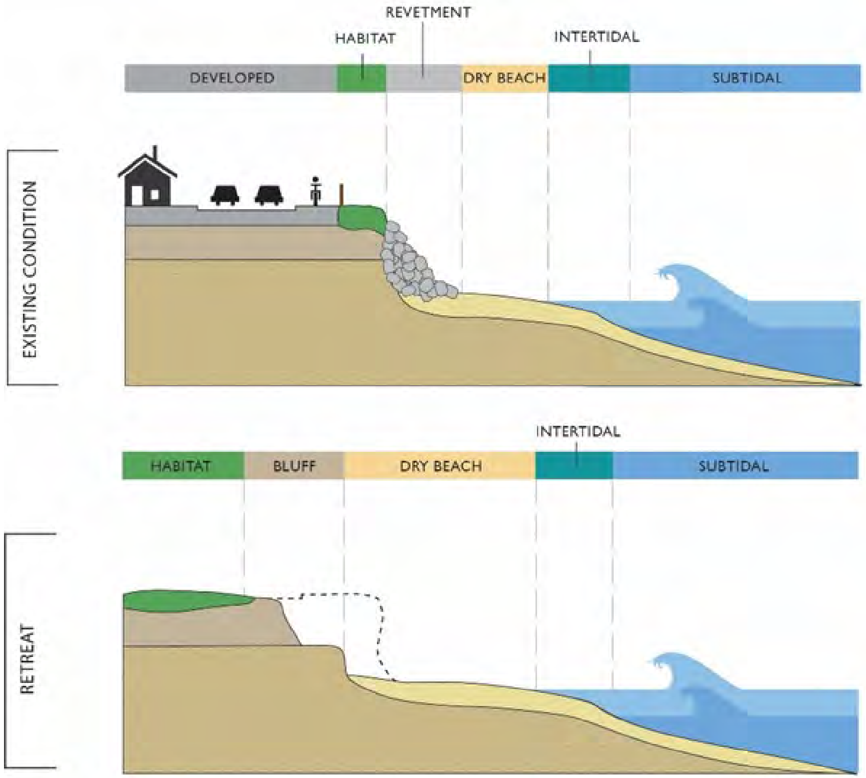
Retreat and Relocation

- Transportation Realignment
  - Accommodating erosion in relation to pedestrian and vehicular access along Scenic Rd.
- Retreat and Relocation
  - Phased relocation of infrastructure, parking lots, access ways, roadways, and homes from vulnerable locations



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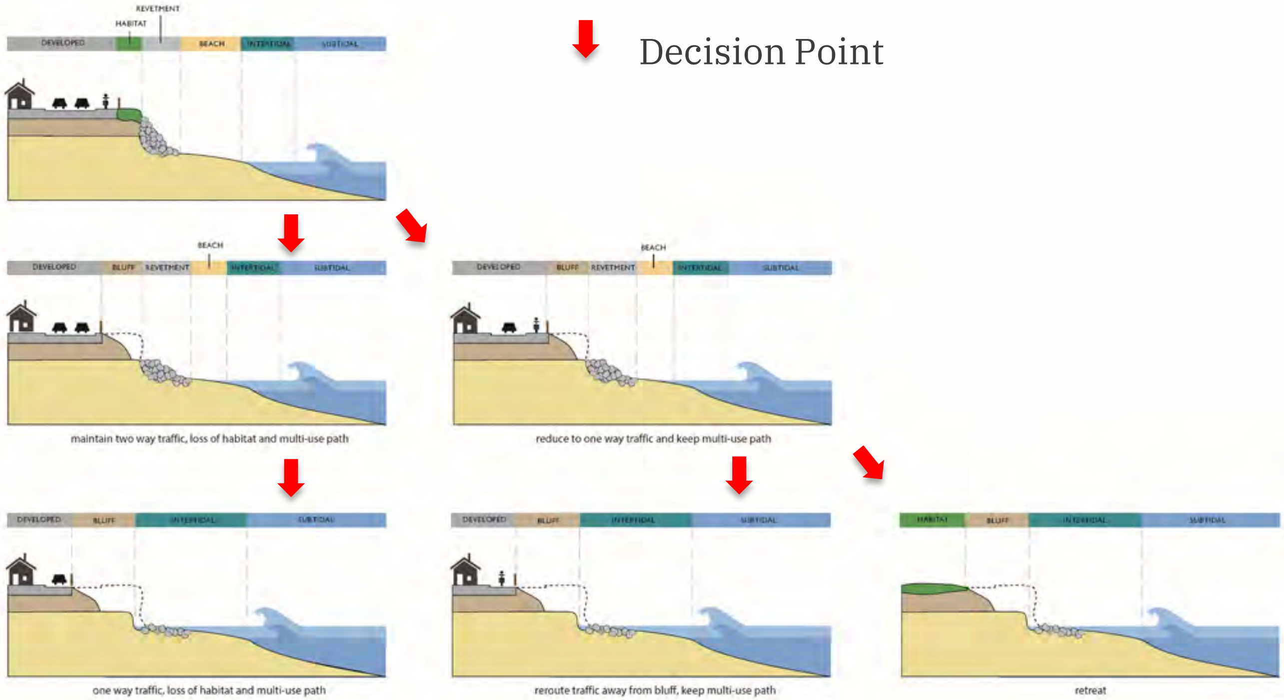
Retreat and Relocation

- Transportation Realignment
  - Cars vs multi-modal uses
  - Residential access
  - Emergency access
  - Coastal Access
- Relocation of Critical Infrastructure
  - Wastewater infrastructure (sewer lines, and pump stations)



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Important Considerations

- Vision for the Future – How important is the beach vs the current upland?
- What kind of adaptation strategies is the City willing to consider?
- When to transition from one adaptation strategy to the next?
  - Lead time, Monitoring, Triggers
- Beach and Sand Management
  - Carmel Beach sand is unique and difficult to find. If the beach disappears with sea level rise, at what point will a change in sand quality become palatable?
- How to move away from the ocean gracefully?
  - Relocating critical infrastructure
  - Rerouting Scenic Rd, Del Mar Parking Lot
- How is the City going to pay for adaptation over time?

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Breakout Group - Round 2

Share out at 5:50 pm

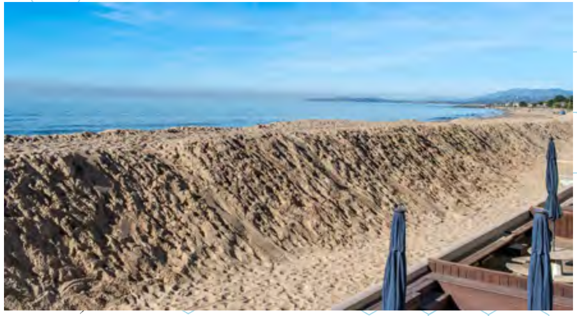
Adaptation Strategies

Driftwood expanded dunes

Sand Management

Wave Deflectors

Sacrificial Winter Berm



Adaptation Strategies cont.

Seawall

Rip Rap Revetment

Wave tripping structure on bedrock

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Thank you for participating!