Planning for the Future of Humboldt Bay:
Sea Level Rise, Sediment Management,
Sand Spits and Salt Marshes
• Introduction to Humboldt Bay
  – Setting
  – Economy, community, and environment
• Sediment Management
  – Sediment budget
  – Dredging and disposal
  – Sea level rise planning
  – Beneficial reuse: case studies
Setting
• Population: 80,000 (Eureka and Arcata)
• Economy: Timber, agriculture (marijuana), aquaculture, restoration, fisheries, recreation, education (HSU)
Balance of Many Uses in the Bay

- Working port
- Center for oyster culture
- Tourism/recreation
- Focus of biodiversity conservation
Watershed

- 4 major tributaries
- Small watershed for estuary of its size
Sediment Management: Eureka Littoral Cell

- 40 miles of coastline
- Eel, Mad and Little Rivers
- Coastal dune fields
Sediment Budget (per CRSMP)

<table>
<thead>
<tr>
<th>Source Name</th>
<th>Total Sand Volume (cy) (Sand&gt;0.0625 mm)</th>
<th>Beach Size Fraction (cy) (&gt;0.125 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rivers Discharging to Pacific Ocean</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little River</td>
<td>53,000</td>
<td>37,000</td>
</tr>
<tr>
<td>Mad River</td>
<td>690,000</td>
<td>486,000</td>
</tr>
<tr>
<td>Eel River</td>
<td>3,600,000</td>
<td>2,300,000</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>4,340,000</strong></td>
<td><strong>2,823,000</strong></td>
</tr>
<tr>
<td><strong>Rivers/Creeks Discharging to Humboldt Bay</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elk River, Freshwater Creek, Salmon Creek and Jacoby Creek</td>
<td>Unknown but small (total yield is ~36,000 cy, mostly silt)</td>
<td></td>
</tr>
</tbody>
</table>
## Maintenance Dredging

<table>
<thead>
<tr>
<th>Dredging Sponsor</th>
<th>Annual Volume (cy)</th>
<th>Disposal Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal (USACE)</td>
<td>1,203,300 (sand)</td>
<td>HOODS</td>
</tr>
<tr>
<td>Local (Harbor District, City of Eureka, Private)</td>
<td>25,000 (silt)</td>
<td>Various</td>
</tr>
</tbody>
</table>
Maintenance Dredged Navigation Channels in Humboldt Bay
Sediment Placement Sites - Past and Present
Historic Shoreline Mapping (1939-present)

- Humboldt Bay dunes appear stable except for hot spot on North Spit
- Sediment deficit apparent south of Eel River mouth
North Spit
Erosional Area

PRELIMINARY
# Marsh Accretion Rates vs. Relative Sea Level Rise

<table>
<thead>
<tr>
<th>Area</th>
<th>Accretion Rates (mm/yr)</th>
<th>RSLR* (mm/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>North Bay</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mad River Slough</td>
<td>3.60 ± 0.73</td>
<td>3.39</td>
</tr>
<tr>
<td>Jacoby Creek Marsh</td>
<td>3.33 ± 0.53</td>
<td></td>
</tr>
<tr>
<td><strong>South Bay</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Slough</td>
<td>2.21 ± 0.49</td>
<td></td>
</tr>
<tr>
<td>Hookton Slough</td>
<td>3.10 ± 0.99</td>
<td>5.84</td>
</tr>
</tbody>
</table>

*RSLR includes Vertical Land Motion, which is variable from North to South in Humboldt Bay (higher in the south).*
SLR Inundation Maps - Arcata Bay

Figure 3. Potential tidal inundation areas in Mad River Slough and Arcata Bay under existing conditions (EC) if shoreline structures are breached at MMMW (light blue), 1.0 meters (3.3 feet) (blue), and 2.0 meters (6.6 feet, dark blue, NHE 2014b).
SLR Inundation Maps - Eureka
SLR Inundation Maps - South Bay
Historical Conditions 1870

- Open Water 60% (15,800 ac)
- Salt Marsh 40% (10,500 ac)
- Shoreline 60 miles
Current Conditions 2014

- Open Water 90% (15,800 acres)
- Salt Marsh 10% (-9,000 acres)
- Shoreline 102 miles
- Artificial 75% (77 miles)
- Natural 25% (26 miles)
Shoreline Structure

- **Dike = 53%, 41 miles**
- **Natural = 25 %, 25 miles**
- **Railroad = 14 %, 11 miles**
Shoreline Vulnerability

Red=High
Yellow=Moderate
Green=Low

Figure 10. North segment, shoreline vulnerability rating of the lower reach of Highway 101 on Arcata Bay: high (red), moderate (yellow), and low (green; Laird and Powell 2013).
U.S. Highway 101
Critical Regional Public Asset
Beneficial Sediment Reuse for Living Shorelines/Hwy 101 Protection
Arcata Bay Adaptation Measures
(City of Arcata)

Bolinas Lagoon Wetland Enhancement/SLR Adaptation
(Marin County Open Space)

Seal Beach Sediment Augmentation
(Southwest Wetlands Interpretive Association)

White Slough Restoration
(SCC, USFWS)

South Bay Salt Ponds
(SCC and Partners)
Project Location

- Humboldt Bay
- Arcata Marsh & Wildlife Sanctuary Area
- Klopp Lake
- Arcata Wastewater Treatment Plant
- Wastewater Treatment Marshes
- "Living Shoreline" Project Area

1000 ft
Considering Local Conditions

Physical Elements

Habitat

Hardscape Infrastructure
Aesthetics/ Community
Benthic Habitat Distribution

Yellow=Marshes
Light Orange=Mudflat

Project site in mudflats
Narrow band of fringe marsh and mudflats
Barrier Heights Arcata Bay Range 3’ to 14+’

Upper Arcata Bay Reach Tidal Elevation 2015-2050
Living Shoreline Components

- Energy Attenuation
- Sediment Accretion
- Habitat Restoration/Enhancement

Living Shorelines
Design Exploration

Proposed new protective marsh next to existing levees
Rocks, oyster reefs

Coir logs

Large woody debris
Some Conceptual Designs

Concepts – Salt marsh veg / breakwater
Horizontal Levee variations

**Burrito Step Tide Pool Alternative**
- 7,800 ft² mudflat habitat raised
- 20% wave height attenuation
- $107,000
- Short project lifetime (<2 years)

**High-Low Marsh Alternative**
- 4,600 yd³ fill
- 6,000 ft² marshland created
- 46% wave height attenuation
- $282,000

**Extended Marsh Alternative**
- 2,600 yd³ fill
- 4,400 ft² marshland created
- 44% wave height attenuation
- $231,000
City of Arcata Living Shoreline Concept Design Plans (2016)

- Coir logs
- Oyster reefs
- Large wood
Adjacent Marsh Restoration Sites

Project site

McDaniel Slough

Jacoby Creek
White Slough Restoration

Subsided
40 acre
brackish
marsh
behind
failing
dikes
Project location

- Adjacent to Highway 101 and College of the Redwoods access road
Inundation with MMMW + 100 yr stillwater level (9.99 ft)
Pre-project Levee Breach
Existing topography
CREATE FLAT TIDE IN CALTRANS BASIN
(MAX WAVE SURFACE 1.5 FEET) BY INSTALLING
CULVERT THROUGH TIDAL RIDGE EQUIPPED
WITH FISH-FRIENDLY FLAP GATE

PLACE ELEVATION OF MARSH PLAIN (NORTH, SOUTH, AND
MIDDLE BASINS BETWEEN TIDAL CHANNELS AND
TIDAL RIDGE TO ELEVATION 0.0 TO 3.4 FEET.
PROPOSED PLOT TO FLOOR SHOWN ON SHEET 12.

LOWER EXISTING LEVEL SURFACE
TO ELEVATION 0.0 TO 3.0 FEET AS
INDICATED ON SHEET 12.
Post-Project Habitat Types

[Diagram showing various habitat types such as tidal channels, Chisum Creek, brackish ponds, freshwater wetlands, brackish marsh, muted brackish marsh, salt marsh, and levees.]

Legend:
- Tidal Channels
- Chisum Creek
- Brackish Ponds
- Freshwater Wetlands
- Brackish Marsh
- Muted Brackish Marsh
- Salt Marsh
- Levees
- Levee Breaches
- Lowered Levees
- Roosting Islands
White Slough Restoration: Phase 1
2015

September

Compromised north culvert

Failing AquaDam

November

Tidal Ridges complete

AquaDam removed
2017 Status

North Basin:
- 2017 fill volume: (in-place) 13,200 CY
- Tidal Ridge 1
- Tidal Ridge 2
- Drainage Cut
- Highway Route 3

South Basin:
- Fill completed south of outlet channel
- 2017 fill volume: (in-place) 5,300 CY

Tidal Ridge 3:
- Portion south of outlet channel completed 2017

New 24" Mipe Culvert with flap gate installed between Caltrans Basin and South Basin

Existing levee failing on north side in multiple locations; overtopped at least high tides

Temporary 15" Mipe placed under Tidal Ridge 2 to drain rainwater in south and middle basins to Caltrans Basin

North Basin Tidal Gate:
- Flap gate lost August 2017 allowing uncontrolled two-way flow through culvert pipe
Project constraints

- Caltrans engineering specs required a setback of the project
- Finding and permitting sediment for beneficial reuse is difficult and time consuming
Project benefits

• Marsh habitat

• Wave attenuation to protect highway embankment and access road

• Increased accretion
CONCLUSIONS

• Sea Level Rise Vulnerability
  – Tidal Marshes
  – Agricultural Land/Seasonal Wetlands
  – Human Communities

• Sediment Management
  – Exporting sediment from littoral cell
  – Need for beneficial reuse
  – Living Shorelines a promising approach
Thank you!

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