Sea-level rise effects on salt marshes and endemic wildlife of San Francisco Bay

Low Tide

High Tide

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Salt Marsh Harvest Mouse
(Reithrodontomys raviventris)

U.S. Fish & Wildlife Service

Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California

$1.3B Recovery Plan

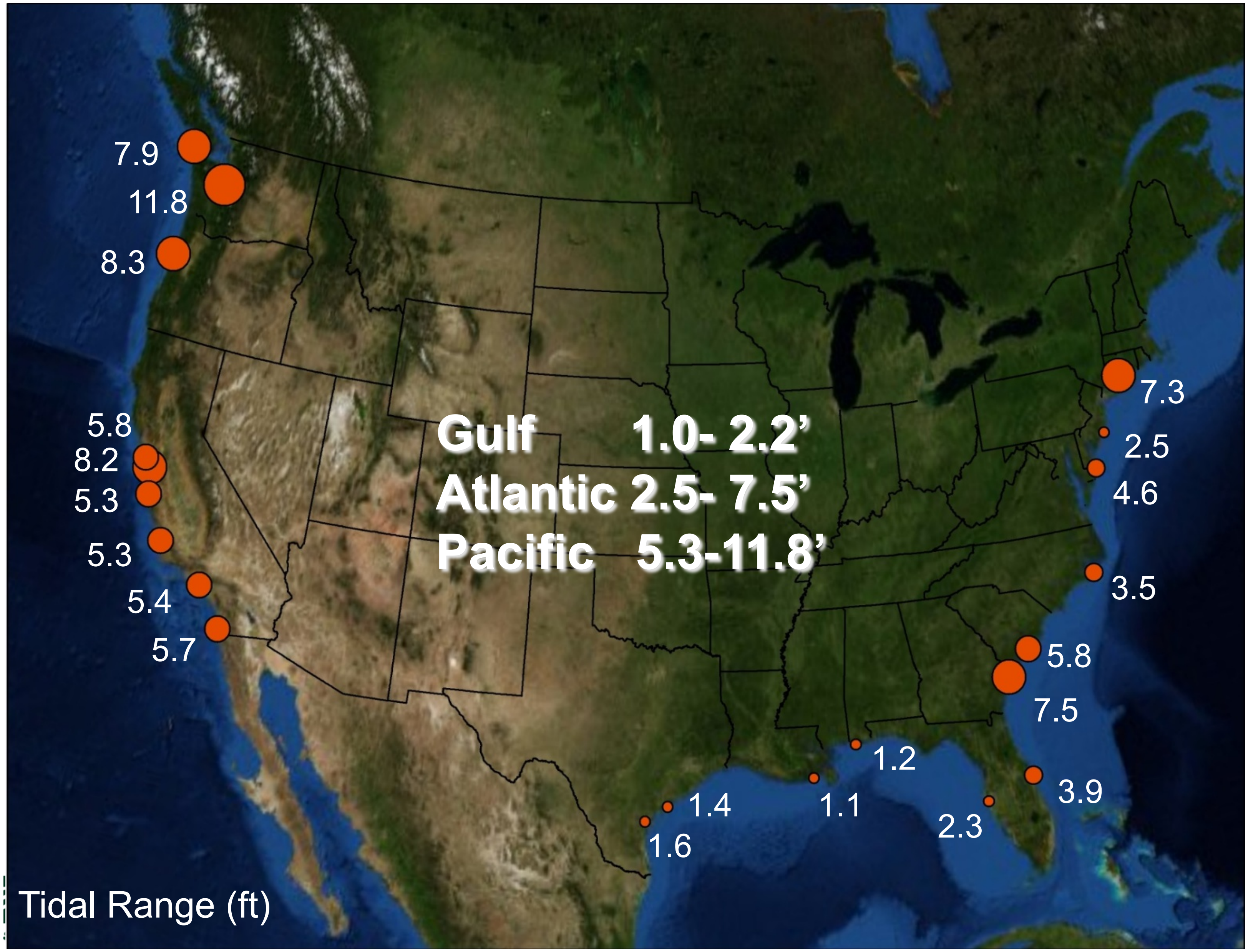
California Black Rail
(*Laterallus jamaicensis*)

California Clapper Rail
(Rallus longirostris obsoletus)

Outline

- **SLR in SFB Tidal Marshes**
- Challenges by Habitat Parcels
- Consequences for Endemic Vertebrates
- Adaptive Management Options

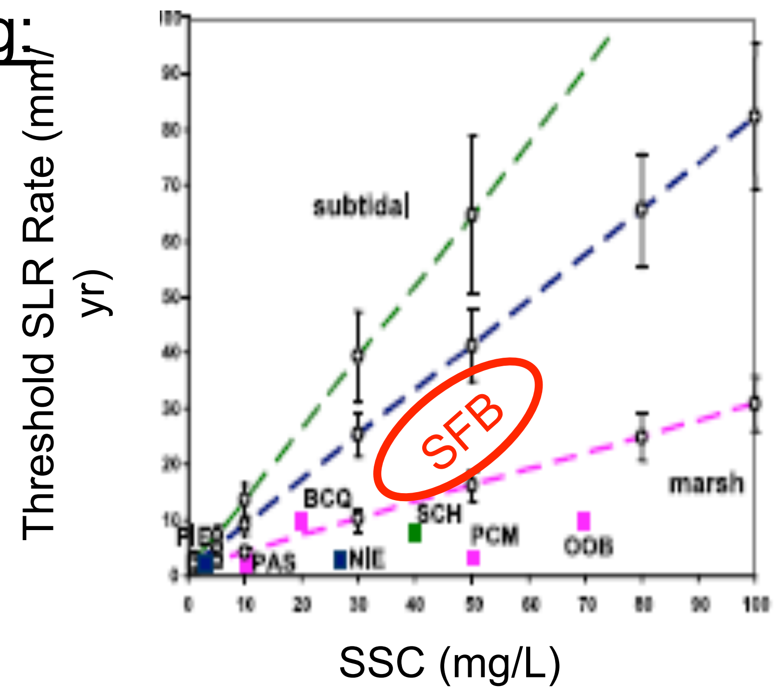
Continental Variation in Tidal Range



Threshold SLR Rates until Tidal Marsh “Drowns” or Becomes Subtidal

<u>Key Predictive Variables for Drowning:</u>
Small Tidal Range (TR)
Small Suspended Sediment Concentration (SSC)

<u>Details:</u>
Mean of 5 models
TR: 1m (pink), 3m (blue), 5m (green)
SSC: (0-100 mg/L) for 8 estuaries



PIE – Plum Island, MA
PAS – Pamlico Sound, NC
BCQ – Bayou Chitique, LA
NIE – North Inlet, SC
SCH -- Schekle, Netherlands
PCM – Phillips Creek, VA
OOB – Old Oyster Bay, LA

(Kirwan etal. 2010, Geophys. Res. Letters)

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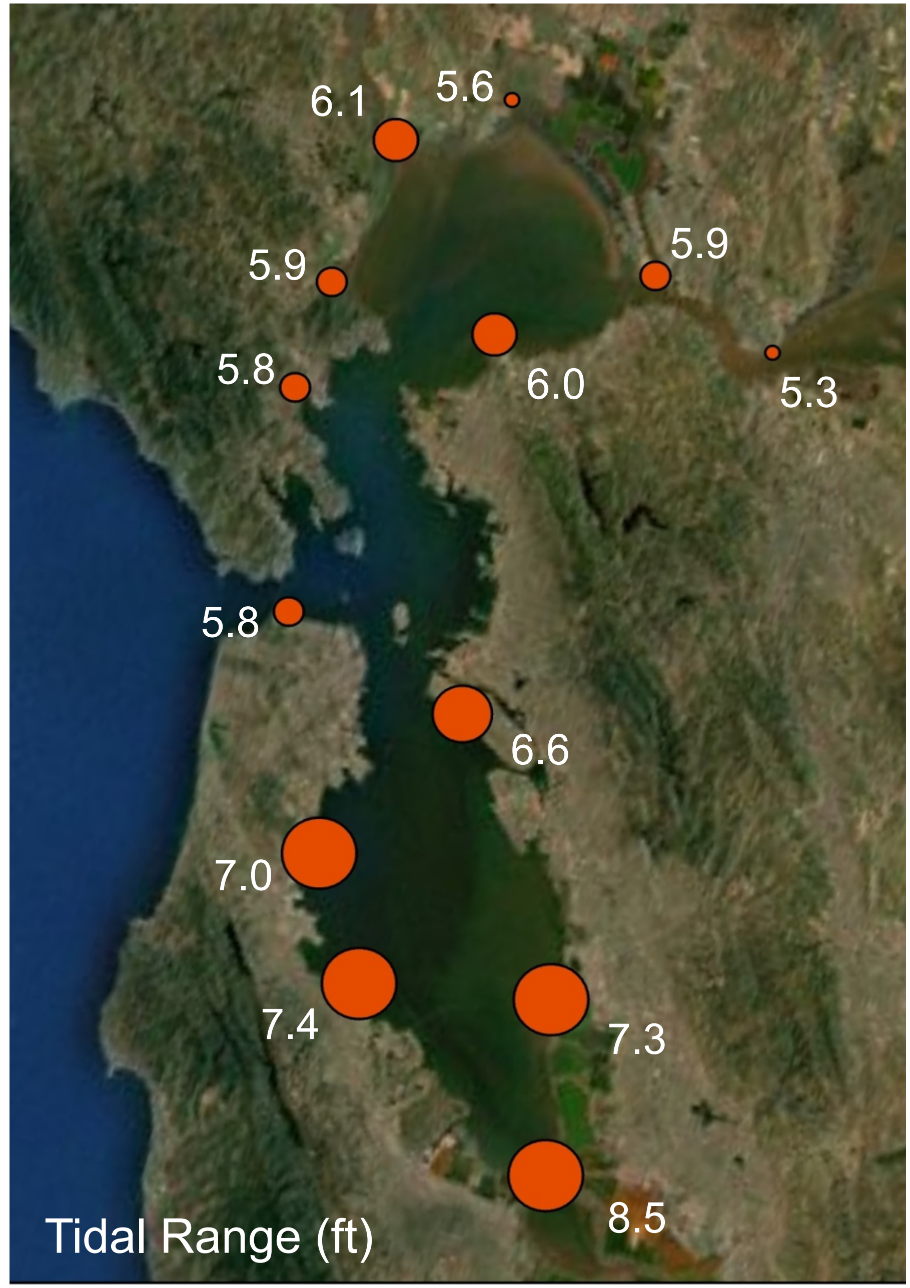
SFB Estuary Variation in Tidal Range

Tidal Range 5.3-8.5, Greater in South Bay

Suspended Sediment Concentration Range, (30-70 mg/L)



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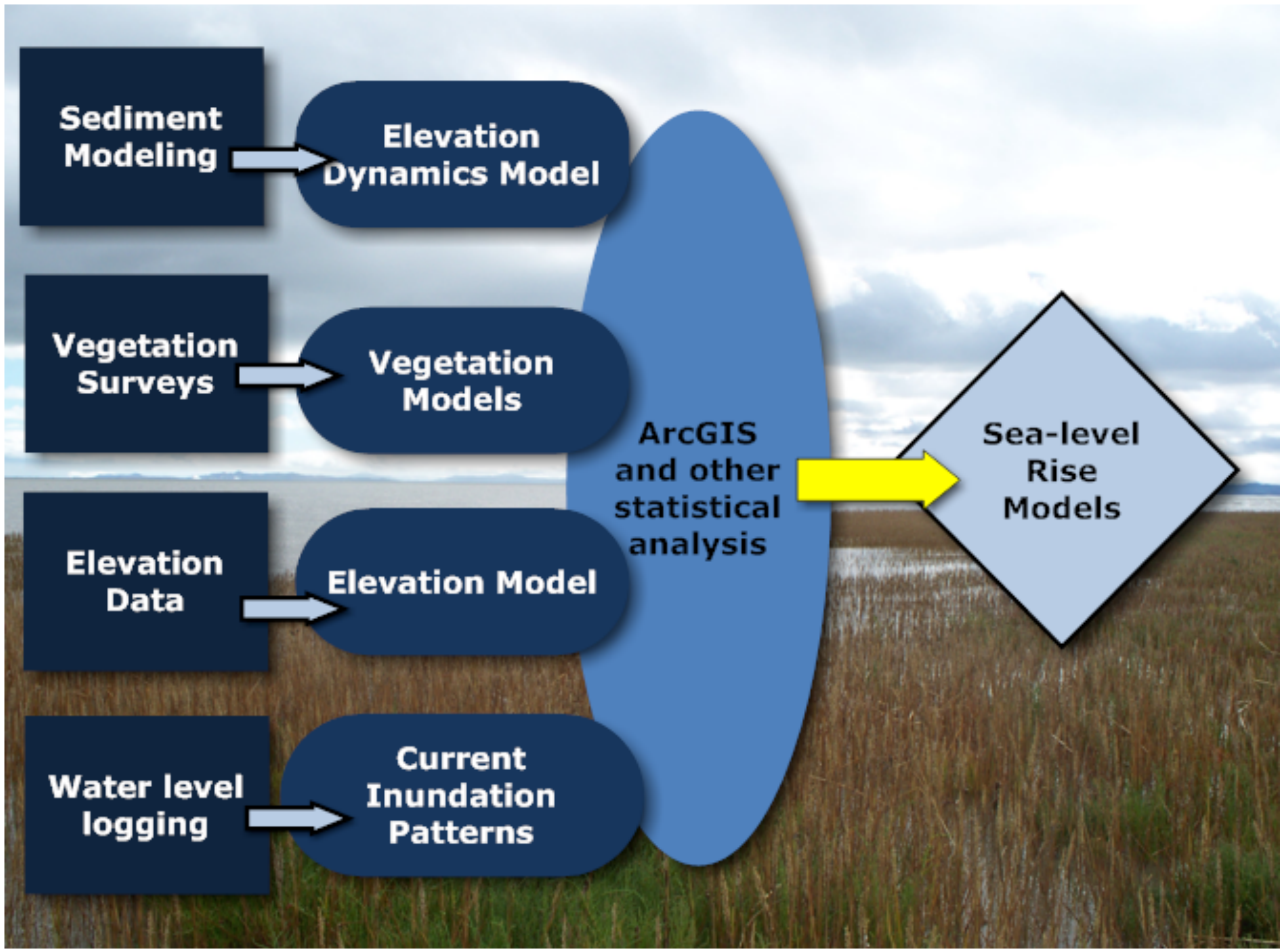
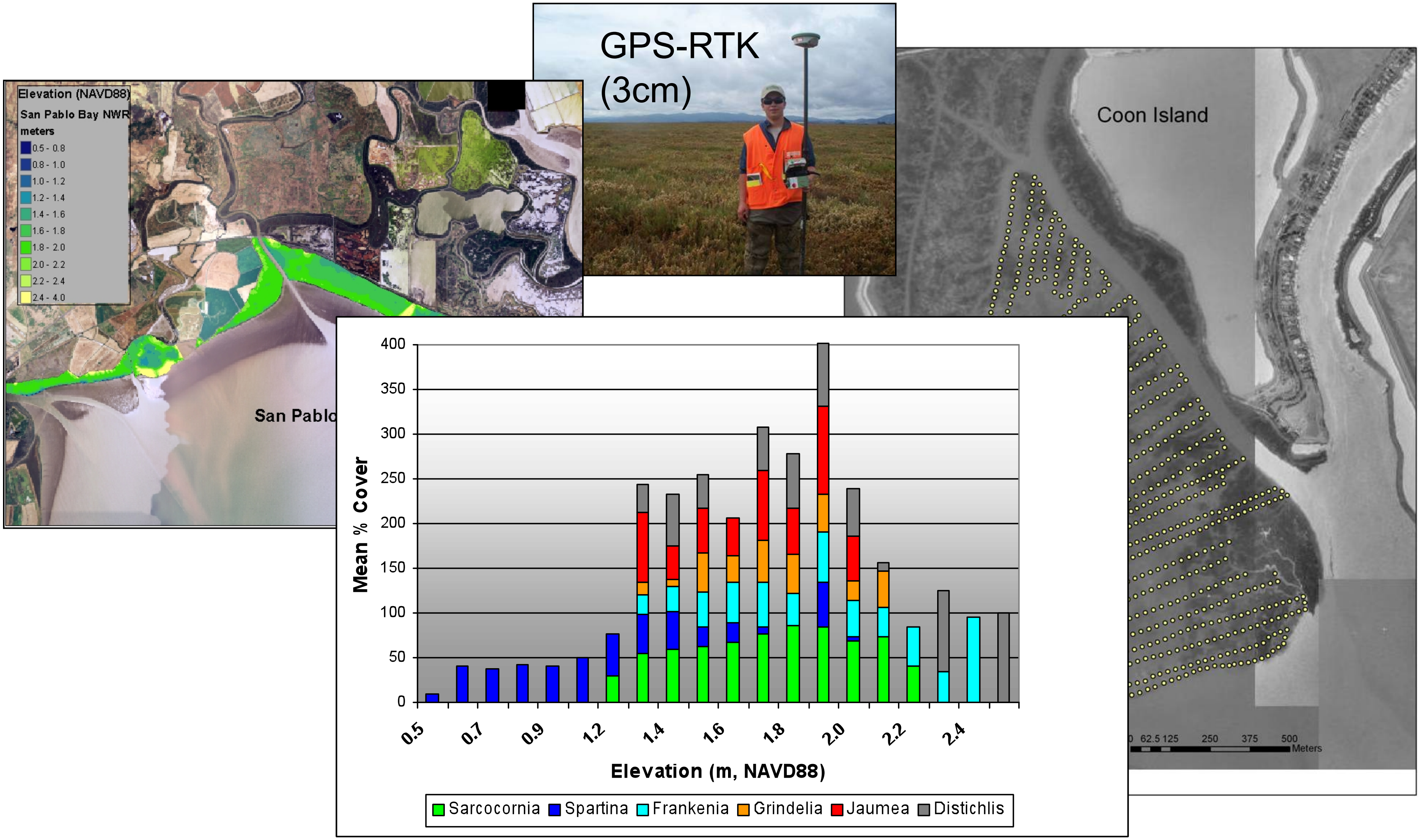
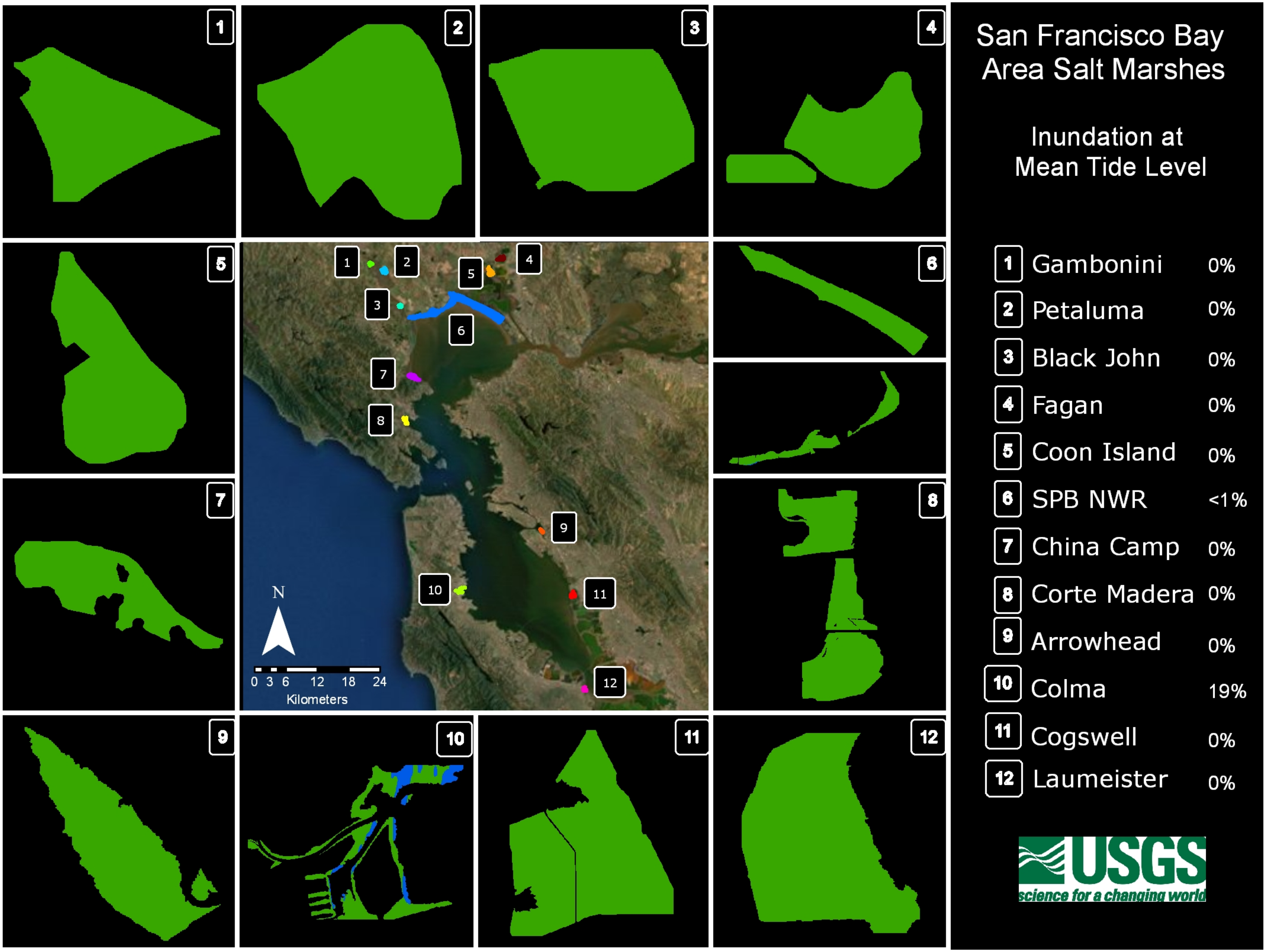
Tidal Marsh Parcel-based Management Model



Develop tidal marsh parcel-based high resolution elevation and plant models




San Francisco Bay Area Salt Marshes
Inundation at Mean Tide Level
1 Gambonini 0%
2 Petaluma 0%
3 Black John 0%
4 Fagan 0%
5 Coon Island 0%
6 SPB NWR <1%
7 China Camp 0%
8 Corte Madera 0%
9 Arrowhead 0%
10 Colma 19%
11 Cogswell 0%
12 Laumeister 0%
N
0 3 6 12 18 24
Kilometers
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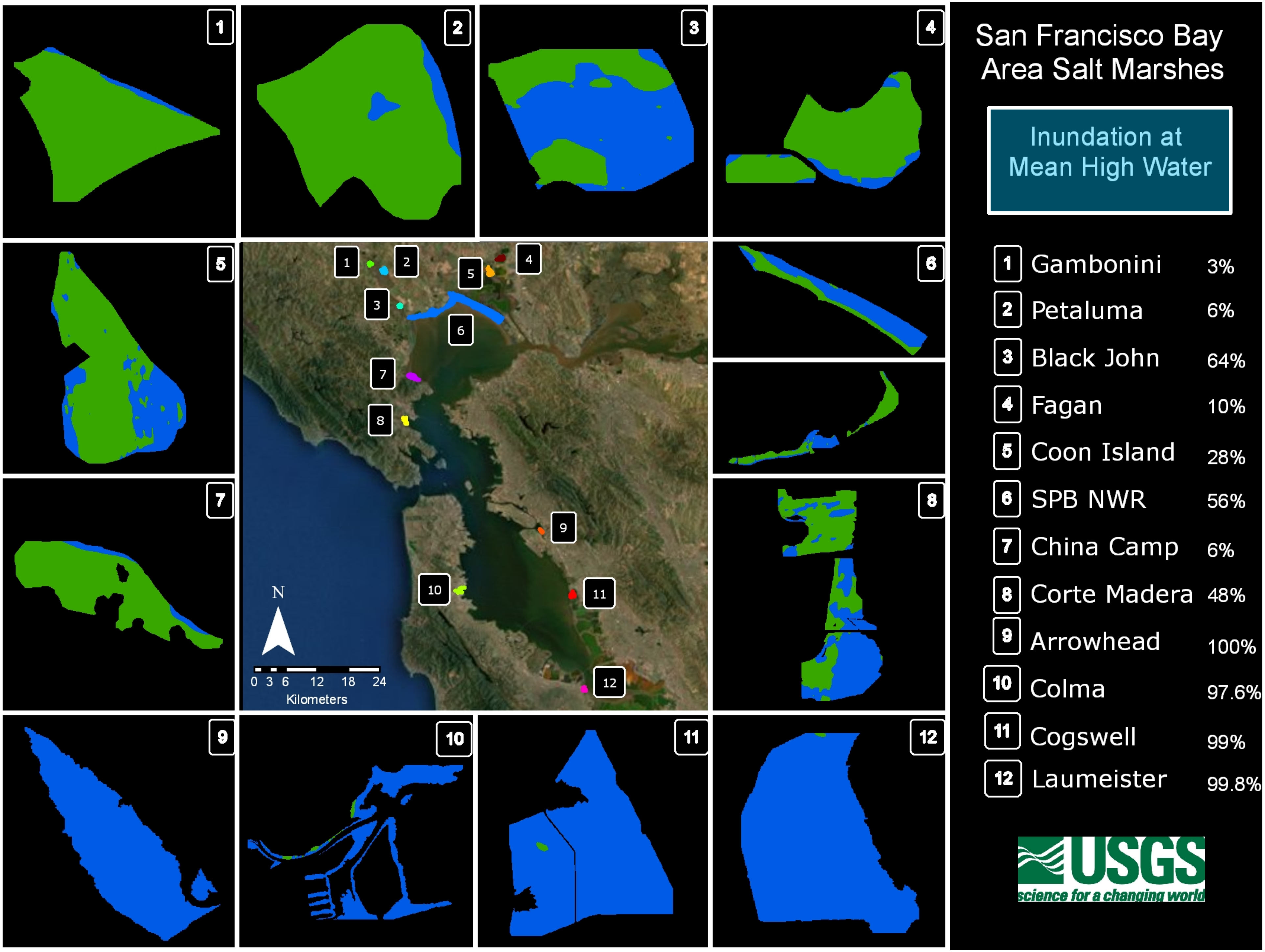
San Francisco Bay Area Salt Marshes
Inundation at Mean High Water
1 Gambonini 3%
2 Petaluma 6%
3 Black John 64%
4 Fagan 10%
5 Coon Island 28%
6 SPB NWR 56%
7 China Camp 6%
8 Corte Madera 48%
9 Arrowhead 100%
10 Colma 97.6%
11 Cogswell 99%
12 Laumeister 99.8%
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N
0 3 6 12 18 24
Kilometers
1
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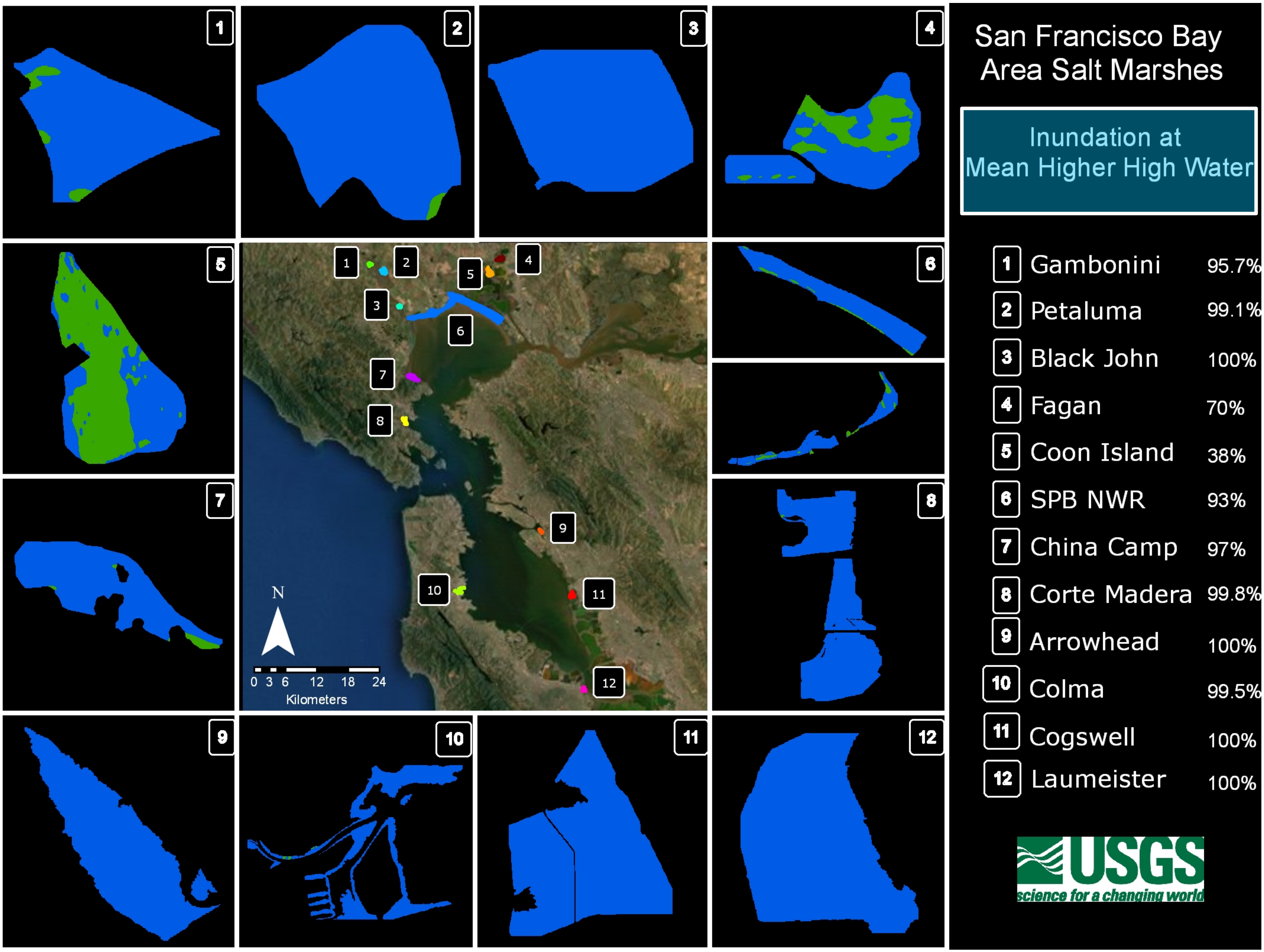
San Francisco Bay
Area Salt Marshes
Inundation at
Mean Higher High Water
1 Gambonini 95.7%
2 Petaluma 99.1%
3 Black John 100%
4 Fagan 70%
5 Coon Island 38%
6 SPB NWR 93%
7 China Camp 97%
8 Corte Madera 99.8%
9 Arrowhead 100%
10 Colma 99.5%
11 Cogswell 100%
12 Laumeister 100%
N
0 3 6 12 18 24
Kilometers
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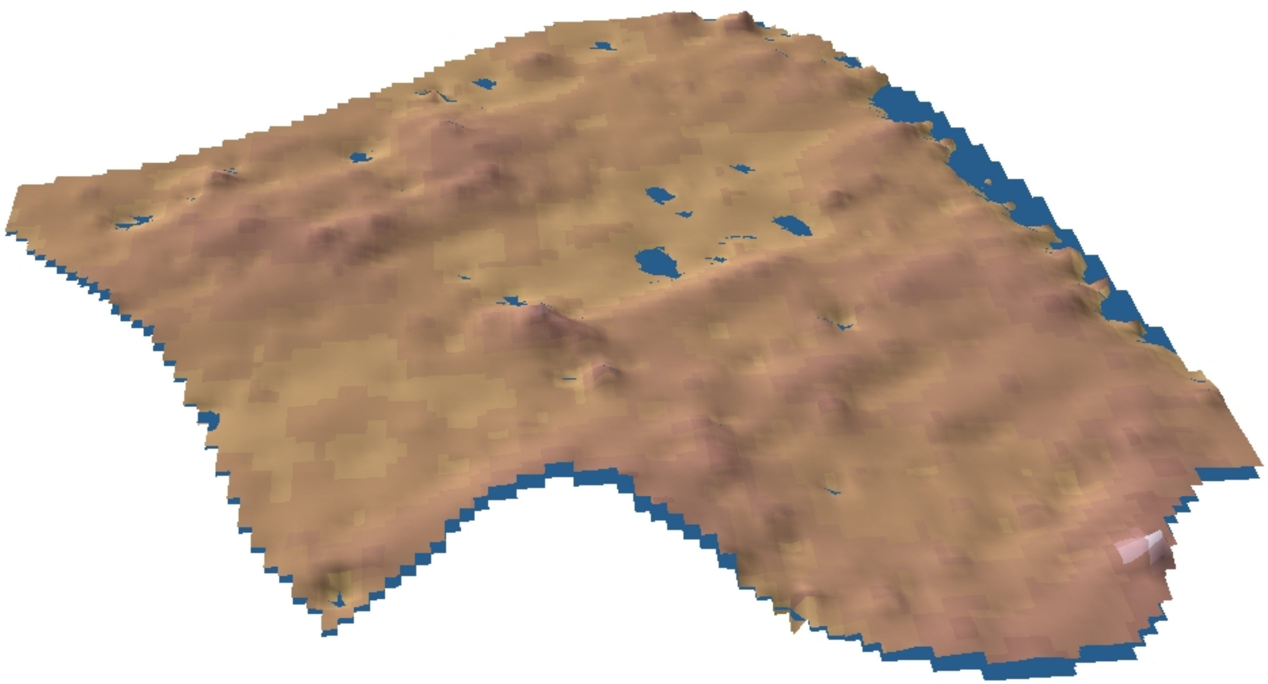
Petaluma Tidal Marsh
water level = 1.75 m



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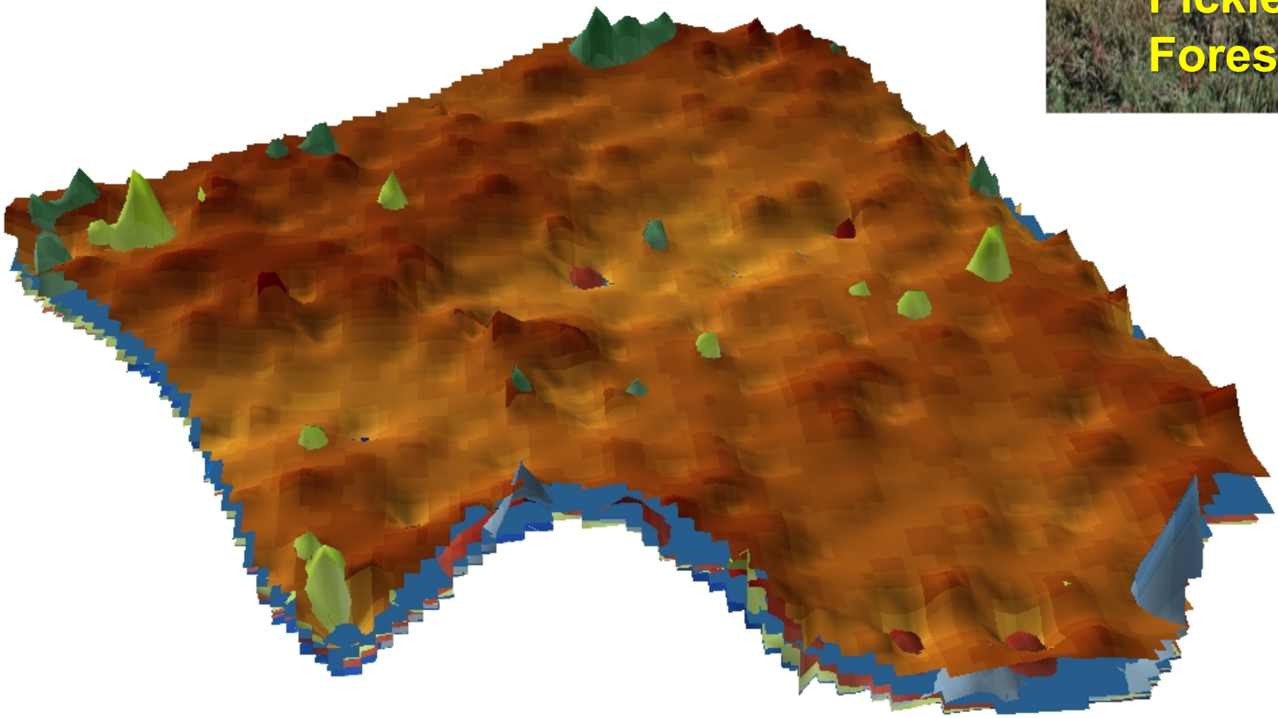
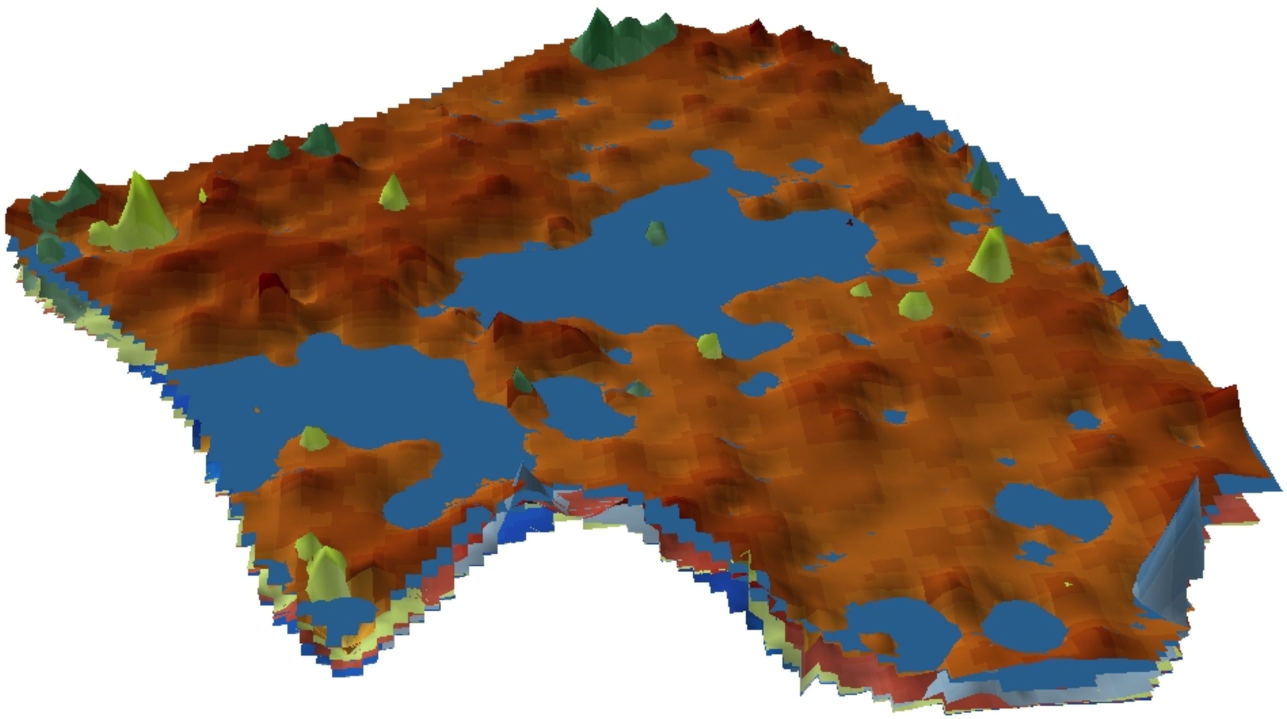
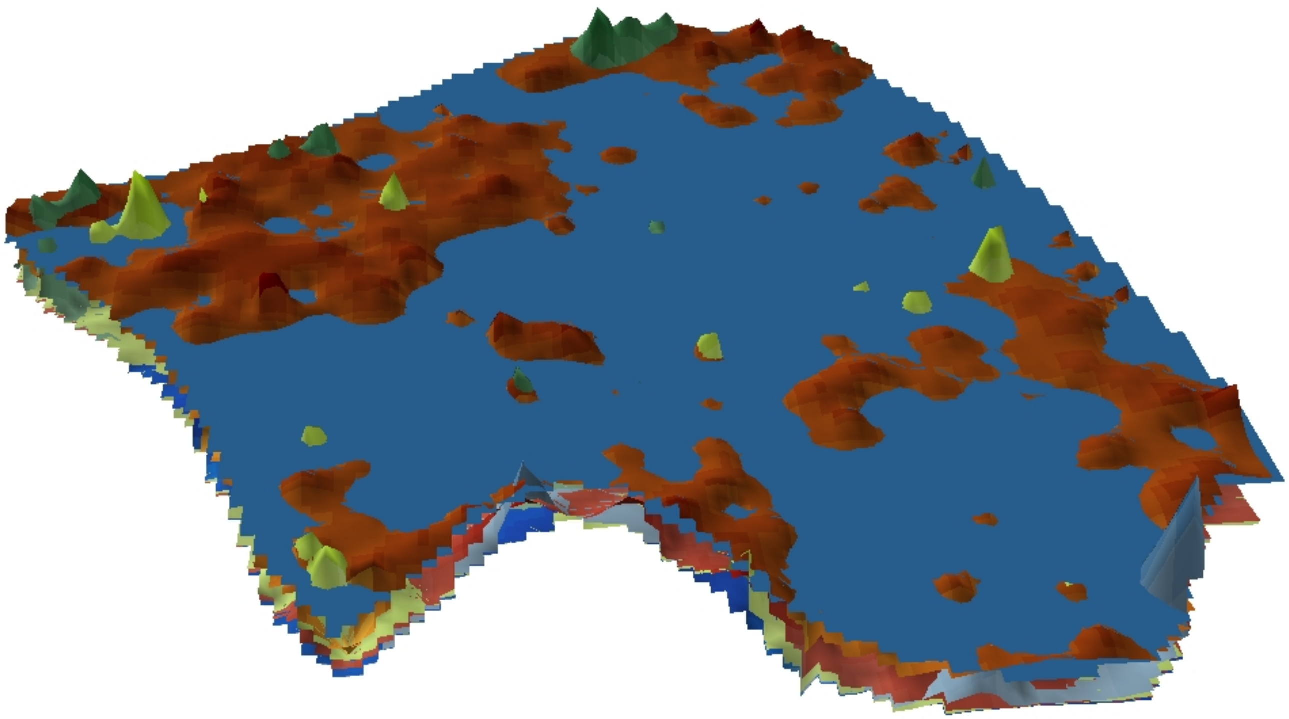
Petaluma Tidal Marsh
water level = 2.0 m
<1% inundated



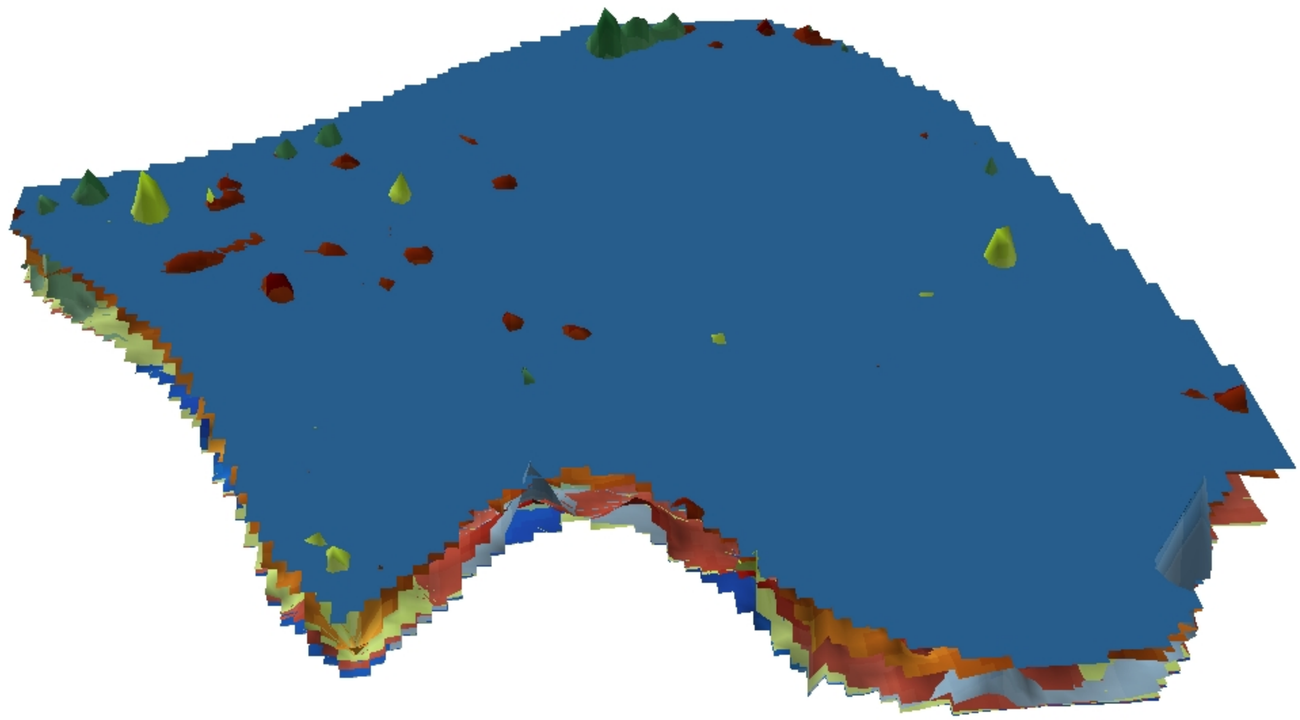
Petaluma Tidal Marsh
water level = 2.25 m
35% inundated



Petaluma Tidal Marsh
water level = 2.35 m
90% inundated



Petaluma Tidal Marsh
water level = 2.5 m
>99% inundated



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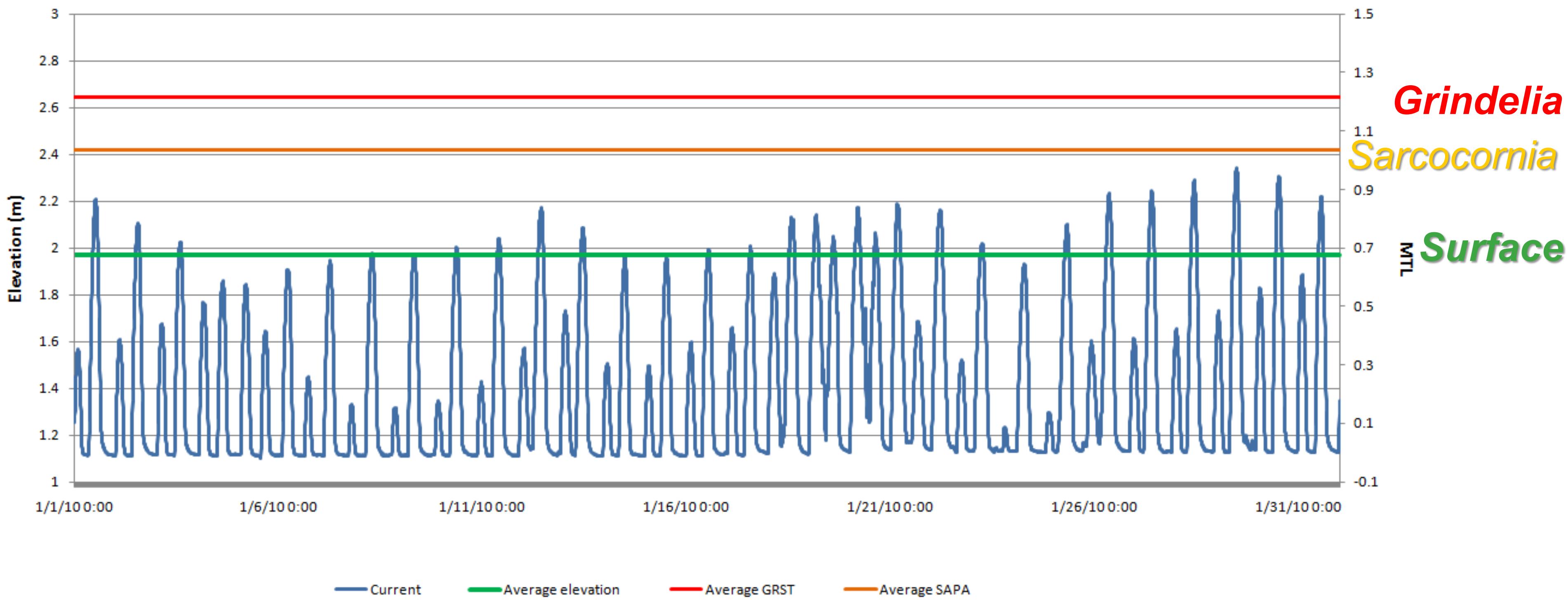
Water level data



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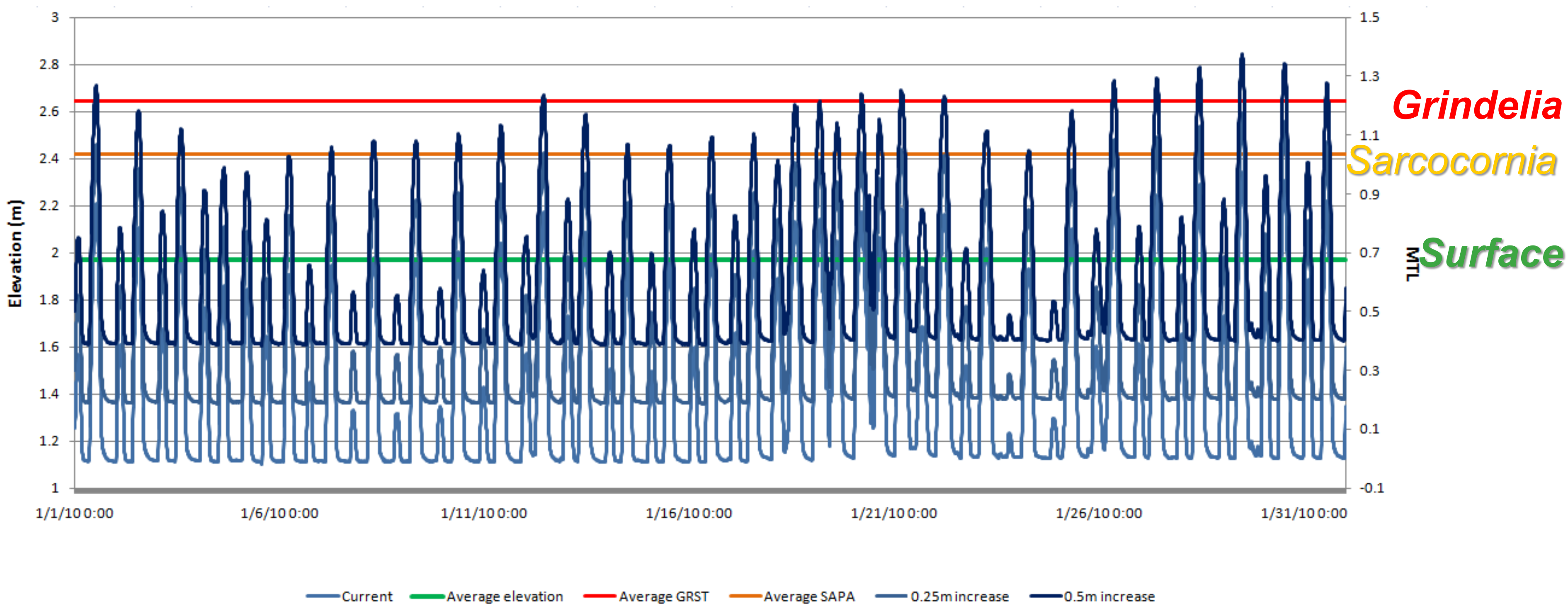
Water level data + 0.5 m SLR



"Potential Critical Threshold"

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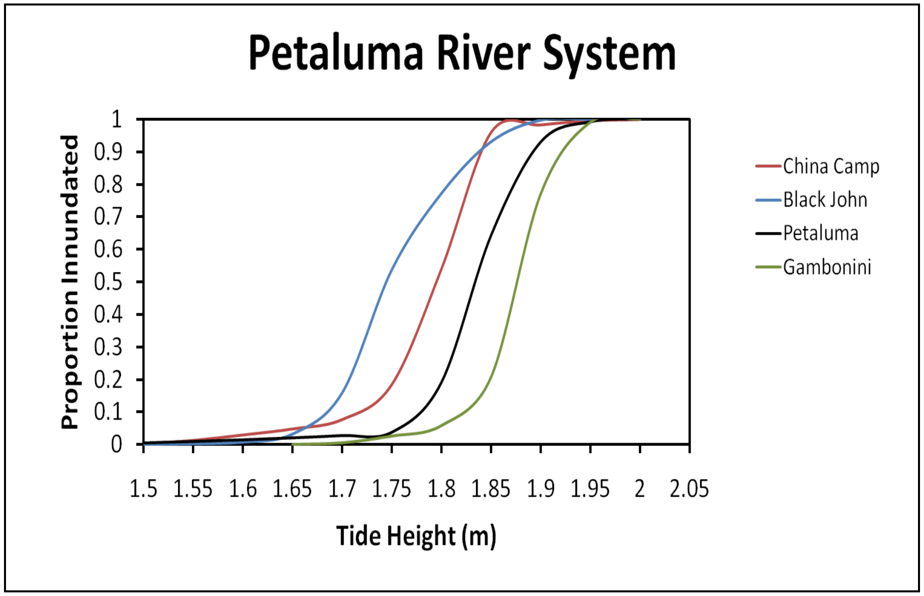
Integrated Application

- Can we anticipate the fate of a given wetland?
  - Will the wetland drown?
- What is the final inundation pattern?
  - Which species may be adversely affected and why?
  - Can we determine shifts in dominant vegetation type?



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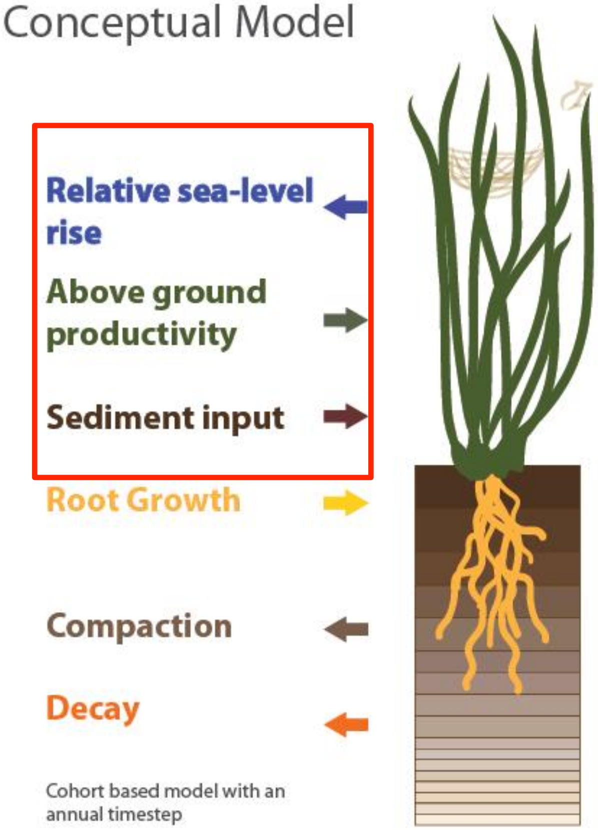
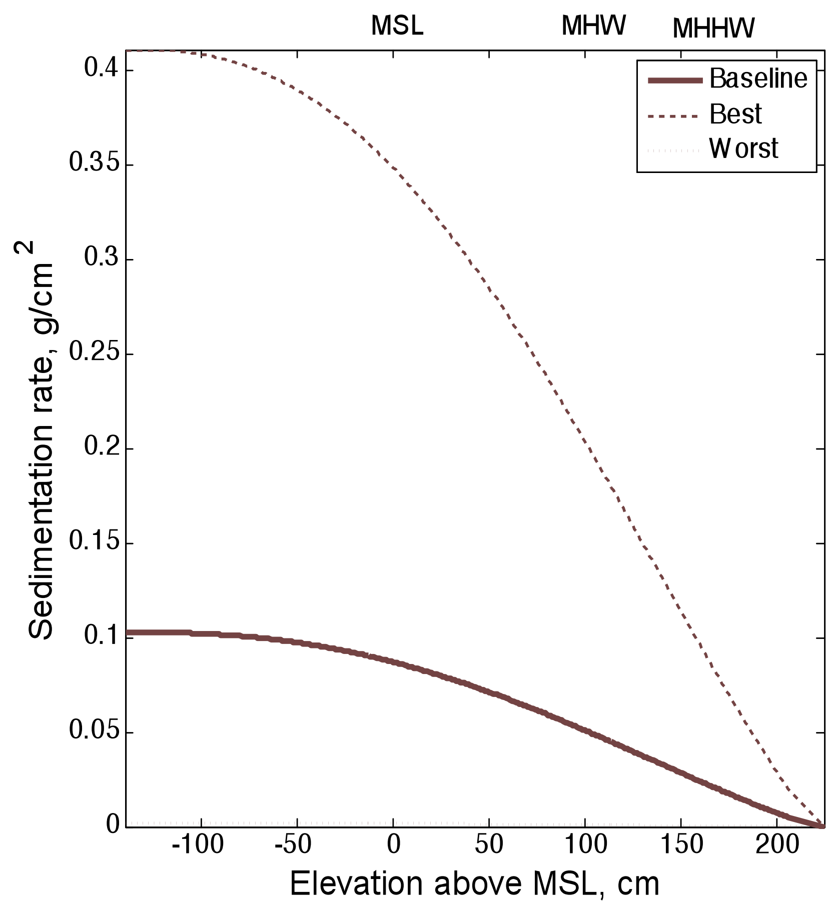
Wetland Accretion Rate Model of Ecosystem Resilience *(Swanson etal., in prep.)*

Conceptual Model

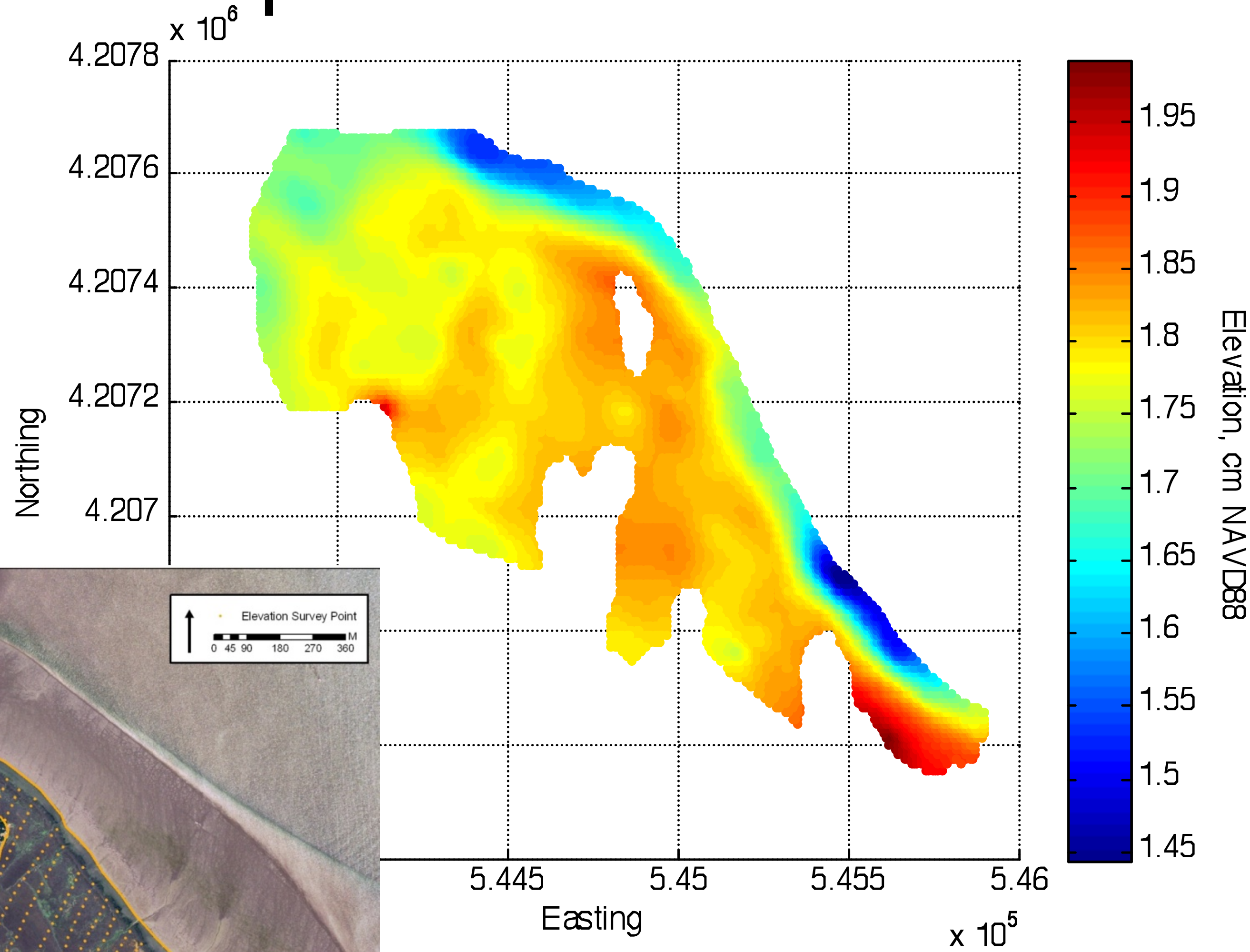


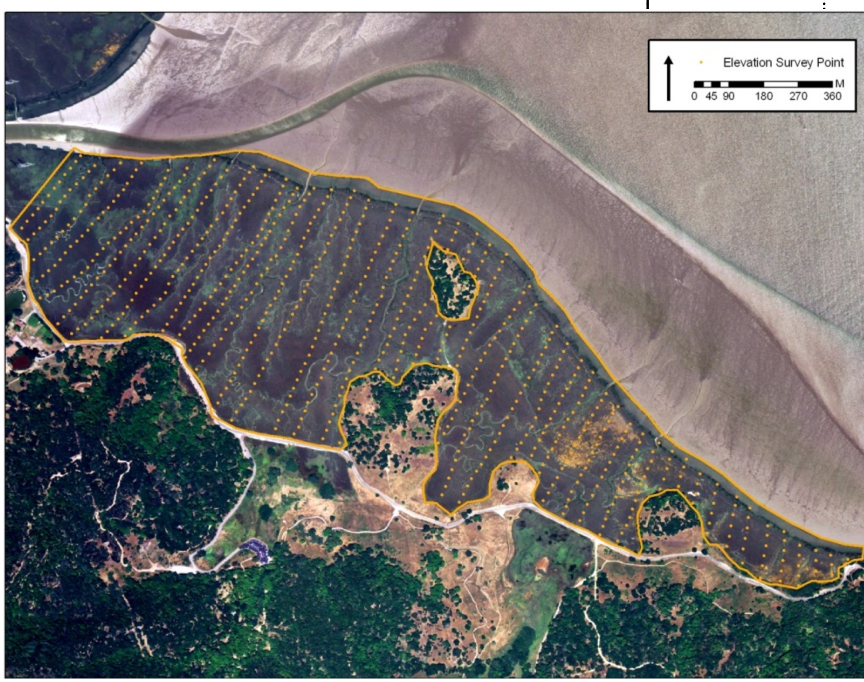
(modified from Callaway et al. 1996)

Sediment Input



China Camp Elevation Model





(Swanson etal., in prep.)

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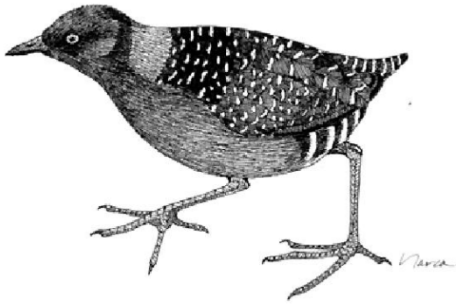
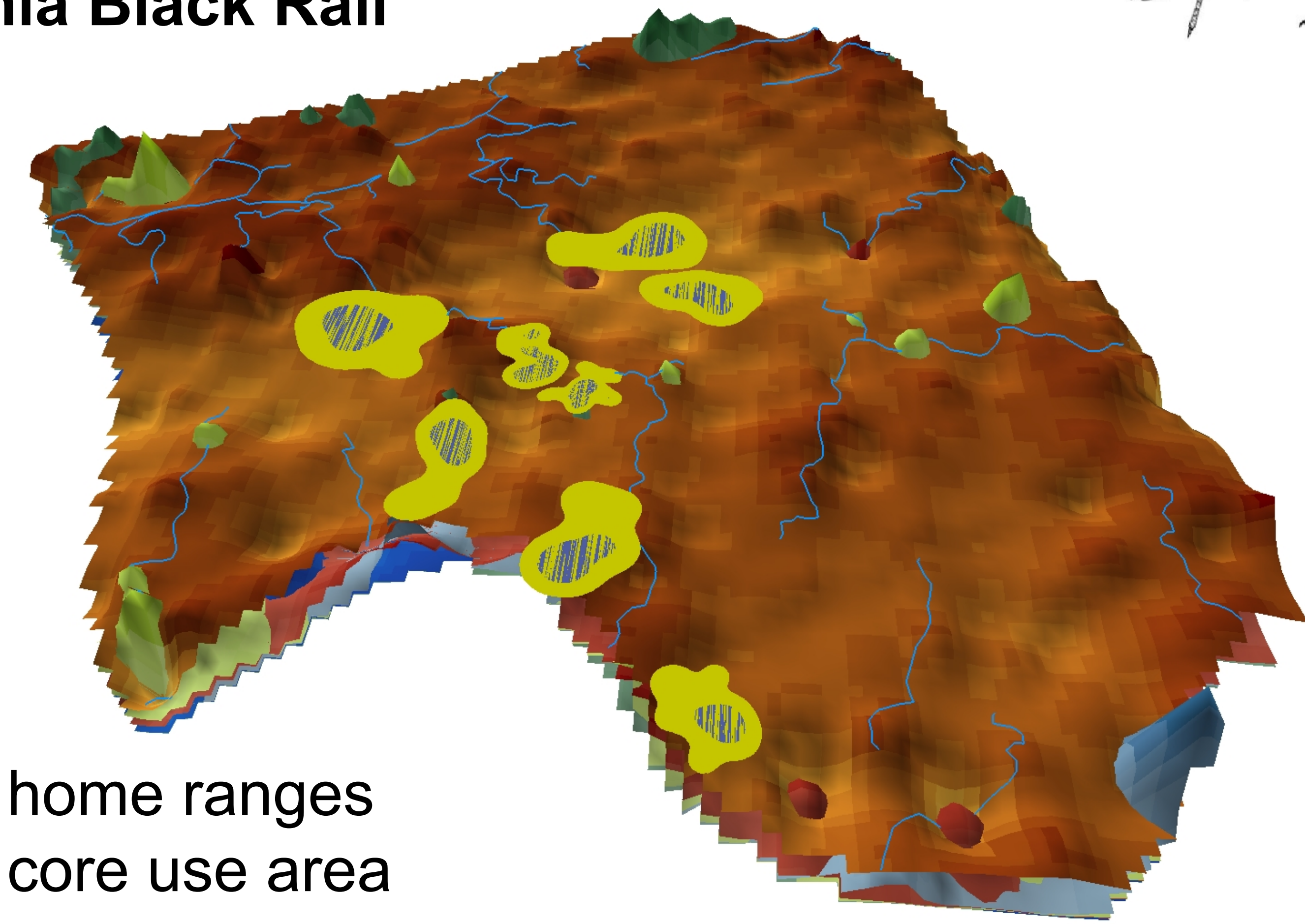
SLR Consequences for Endemic Vertebrates in Tidal Marsh Parcels
• Distribution – endemic vertebrates emigrate or are lost
• Survival – individual survival decreases
• Reproduction – productivity declines

Distribution –

Petaluma Tidal Marsh
California Black Rail

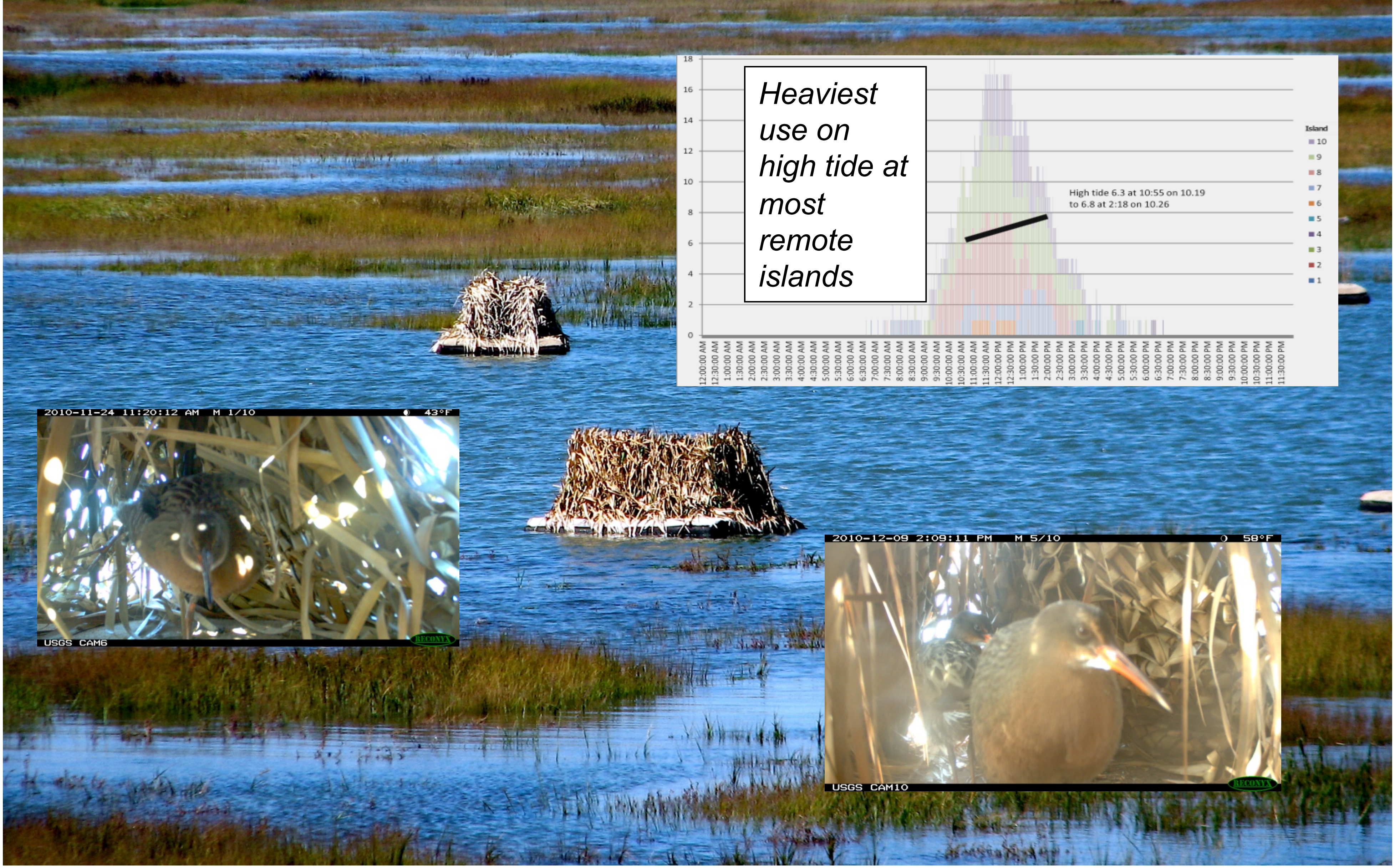




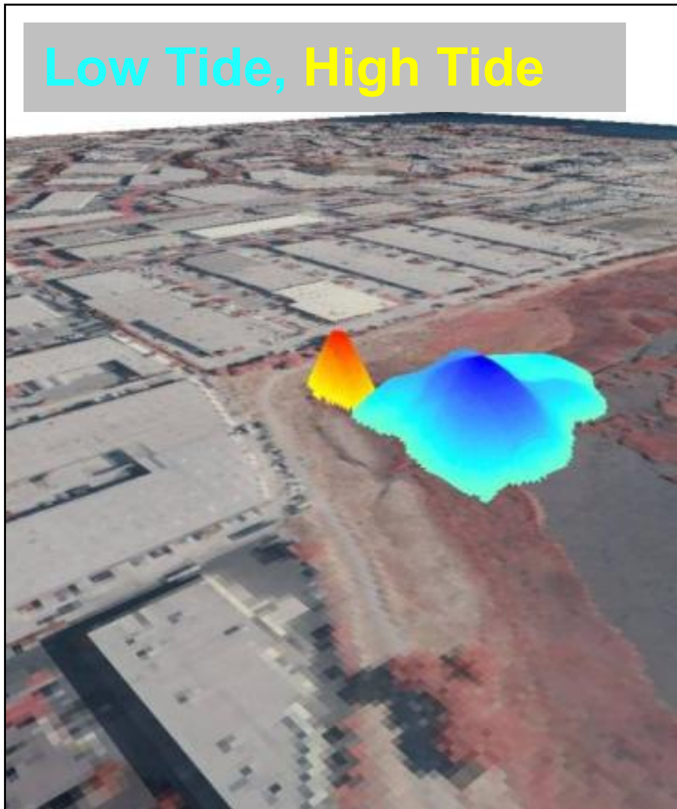
0.59 ha home ranges
0.14 ha core use area

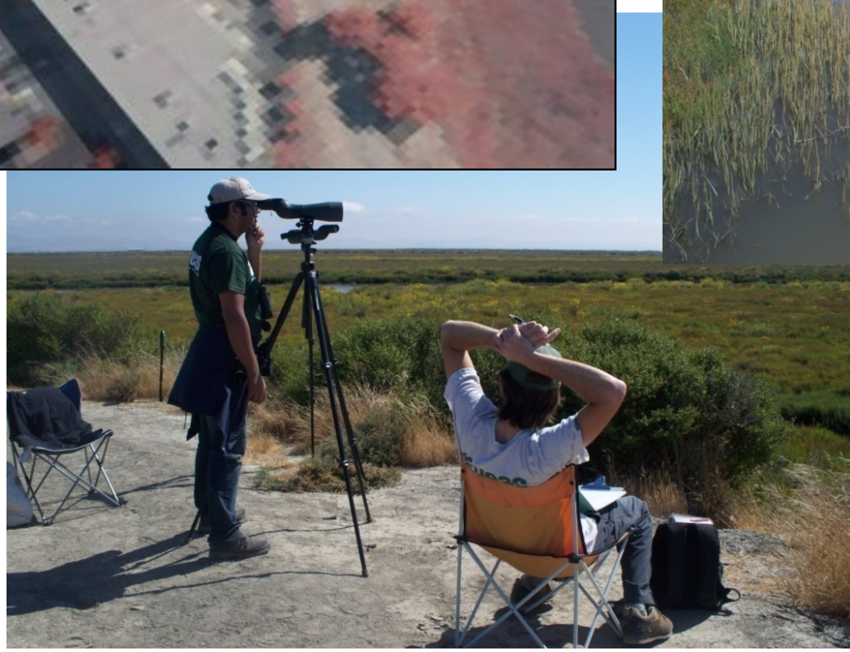
(Tsao et al. 2009, Condor 111:599-610)

Distribution -- *refugia within marshes, Arrowhead Marsh artificial islands*



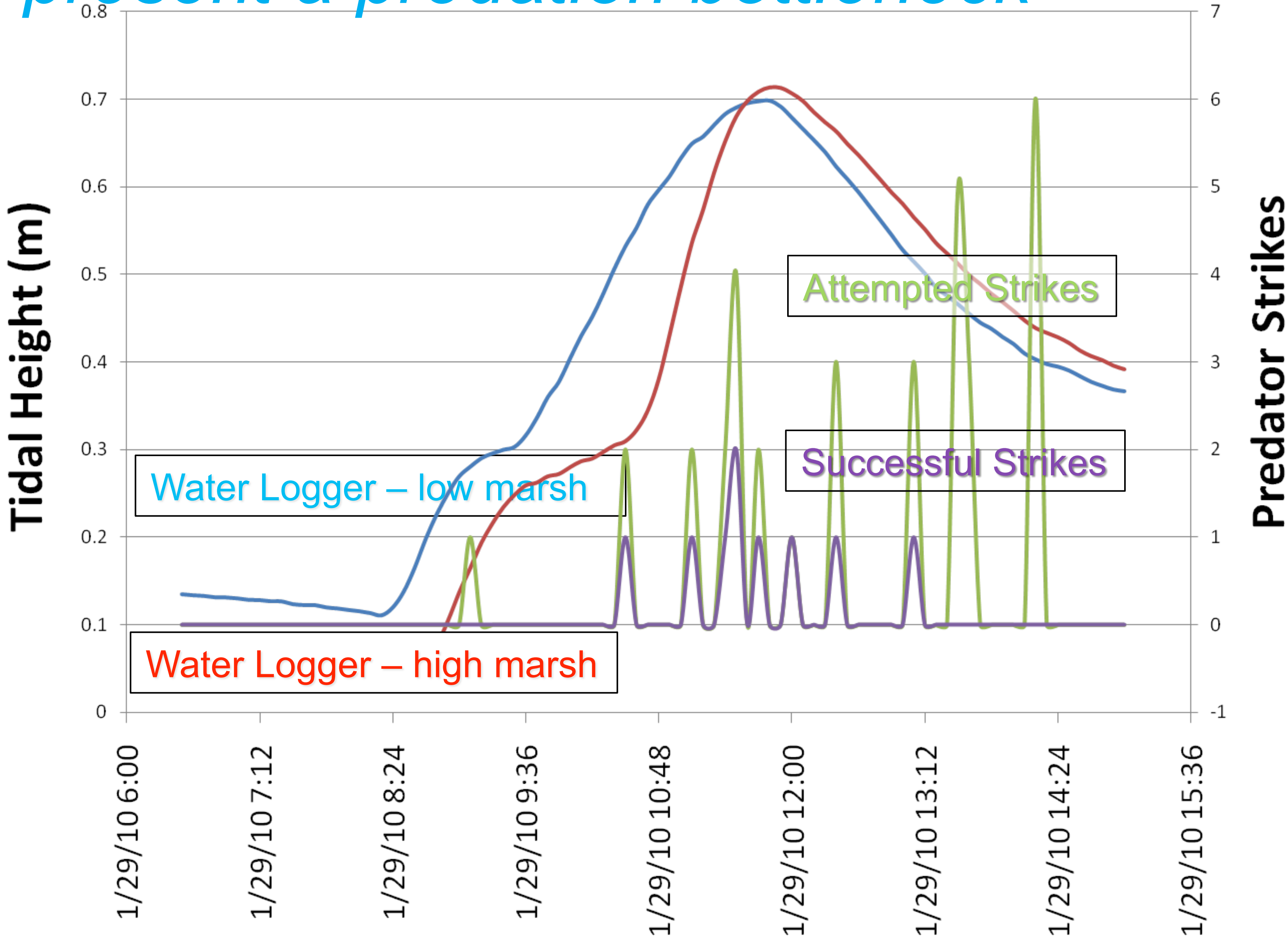
Survival -- King Tide Predation Surveys



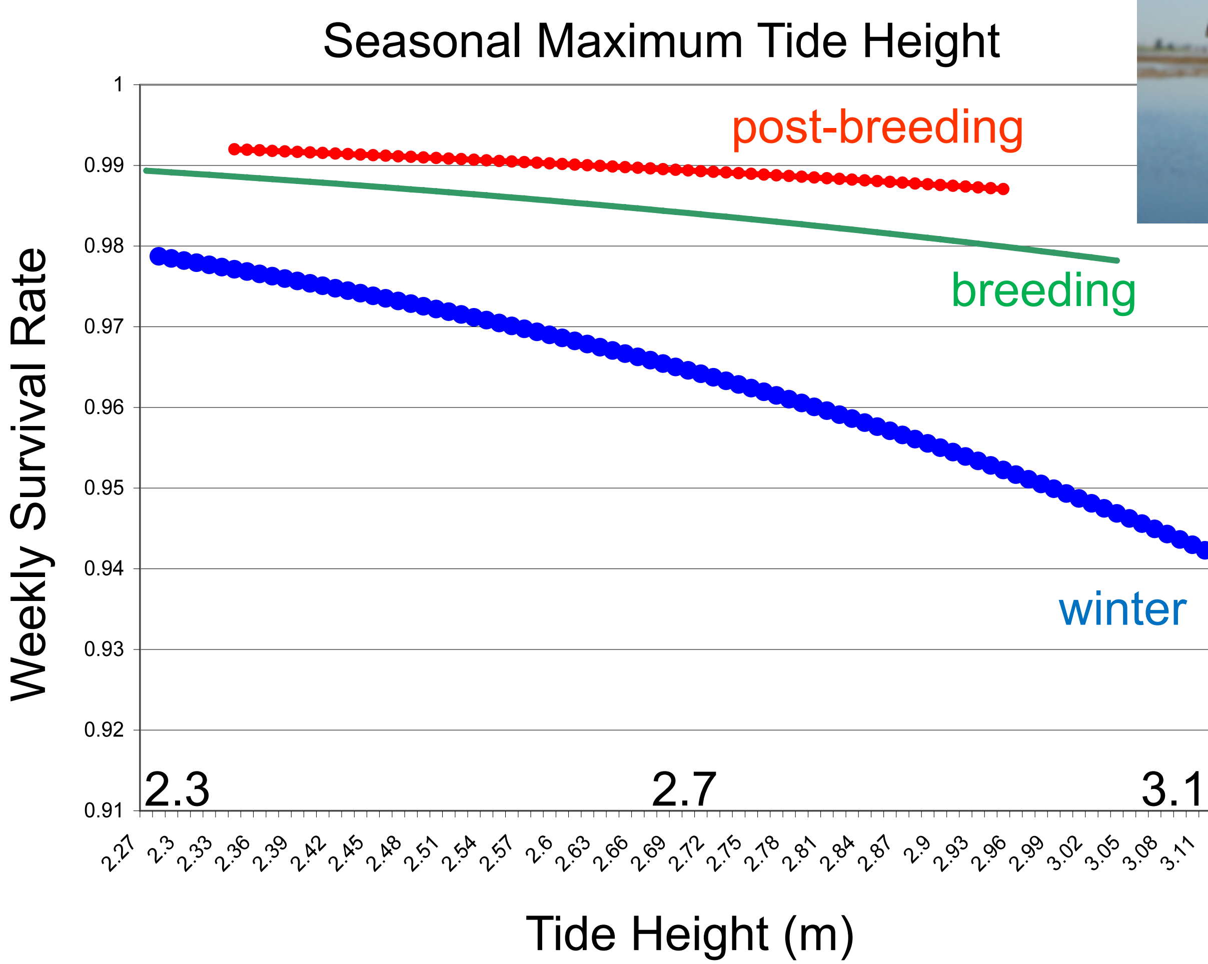


Spragens et al.

Survival – *increasing tides may present a predation bottleneck*



Survival -- Clapper Rail survival varies with seasonal tides

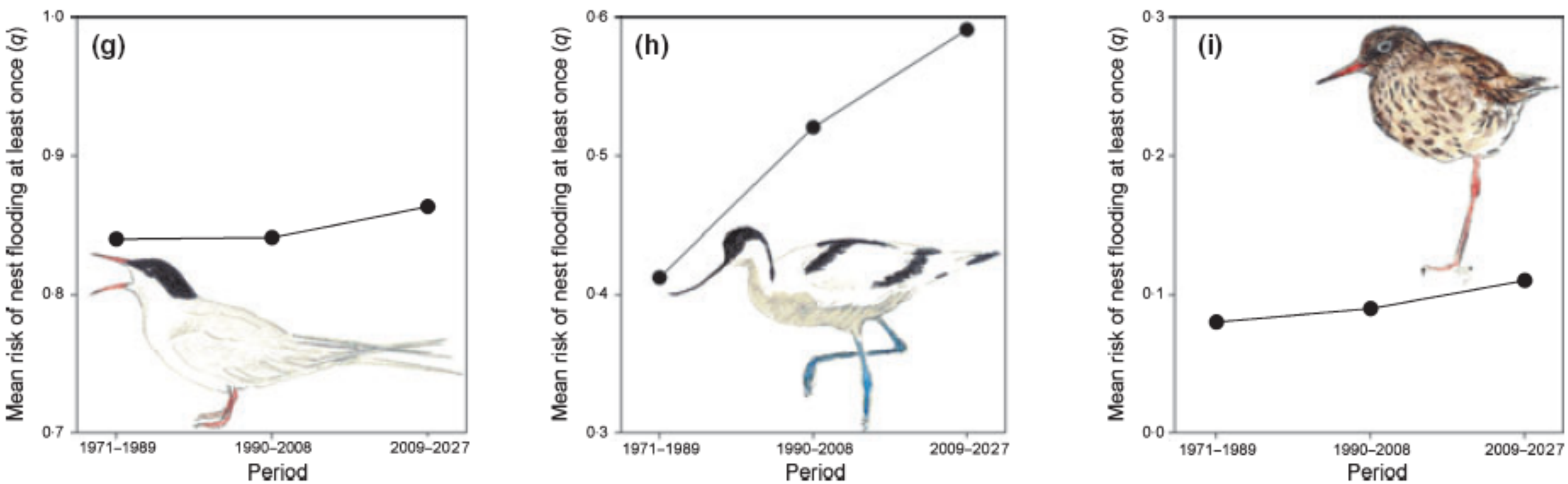


(C. Overton etal., in prep.)

Reproduction – *nesting birds*

- Max high tide increased 2x faster than mean high tide over 4 decades (0.8 vs. 0.4 cm/year) resulting in more frequent, catastrophic flooding of nests, especially at hatch
- Flooding risks increased for 6 species studied, leading to population decline in one (Eurasian oystercatcher)
- Birds benefit most from nesting in higher areas, but low marsh is favored for proximity to feeding – ecological trap?

(Van de Pol 2010 J. Appl. Ecol.)



Reproduction – *nesting Clapper Rail*

Success

Failure

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Response to Climate Change
"Adaptation is managing the unavoidable. Mitigation is avoiding the unmanageable."
(J. Lubchenko, NOAA Administrator)

On Decisions and Uncertainty

- Decisions are made difficult by uncertainty
- Uncertainty is pervasive and must be accommodated in informed decision processes

"The future's uncertain (and the end is always near)."

Roadhouse Blues (J. Morrison 1970)

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(Nichols etal., USGS Patuxent Wildlife Research Center)

What is uncertainty?

“…as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns -- the ones we don't know we don't know…"

(Nichols etal., USGS Patuxent Wildlife Research Center)

Integrated Approach to Management/Conservation

- Scientist and manager work together in the decision-making process (may involve optimization methods)
- Information collection is focused on precisely the information most useful to management decisions
- Science focuses on hypotheses about how the managed system responds to potential management actions

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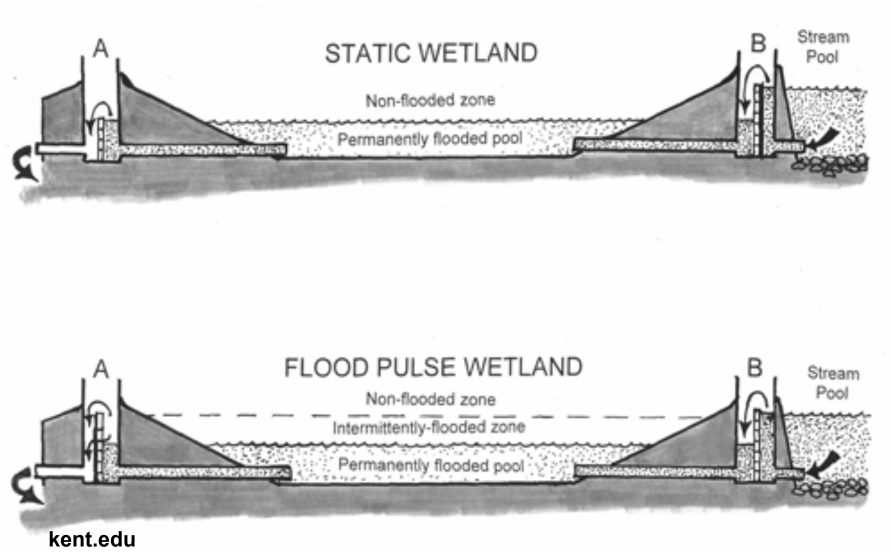
(Nichols etal., USGS Patuxent Wildlife Research Center)

Management Options

- Dynamic over static habitat management – (easements, leases over fee-title?)
- Protect wetlands with upland transition
- Restore wetlands with highest accretion potential
- Focus on wetlands with largest vertebrate populations
- Create refugia in marshes (elevated areas, artificial habitats)
- Retain levees and add water control



Summary

1. Tidal marsh vertebrates are limited by tidal marsh habitat availability in SFB.

2. With sea level rise, upslope movement of tidal marshes is constrained by urbanization and levees.

3. Habitat reduction with fewer refugia and increased frequency of storm events may result in an ecological bottleneck.

4. Adaptation strategies for tidal marsh recovery will require identifying specific marshes or habitat features critical to save fragmented vertebrate populations.

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USGS Western Ecological Research Center

USGS California Water Science Center

East Bay Regional Parks

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University of California, Davis

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