Early Results and Guidance from a Coastal Habitat Restoration Project Twenty Years after the 1991 Gulf War Oil Spill

Christopher D. Cormack
Jason A. Hale,
Owen Langman,
Thomas G. Minter,
Michael J. Risk,
Linos Cotsapas,
Jacqueline Michel
Overview

- **Background** - 1991 Gulf Spill
- **Principles** - UNCC Restoration Program
- **Actions** - What are we doing, and why?
  - Channelization
  - Tilling
  - Planting
- **Guidance** – Lessons learned
Oil Spill

1991 Gulf War

- 10 M barrels
- 800 km KSA shoreline
Deepwater Horizon
The Consequences

• 20 years later: Little natural recovery
  – Heavy oil loading (physical + toxicity effects)
  – Low energy setting
  – Deep penetration into burrows
  – Physical alterations to habitat (disrupted hydrology by algal mats)
How do we go from heavily impacted marsh to healthy marsh?
Guiding Principles

- Adhering to Decision 258 and F4 panel principles; remediation activities aim to:
  - avoid techniques that pose unacceptable risks
  - result in more positive than negative results
  - facilitate natural recovery to the extent possible
  - rely on proven techniques
  - utilize adaptive management
  - be cost effective
  - consider short- and long-term effects and landscape connectivity
Approach

• Target “Ecological Restoration”

• Methods must include:
  – Adaptively managed
  – Understand and characterize conditions and site
  – Identify stressors
  – Design appropriate remediation activities
  – Test and monitor effects of remediation activities
Adaptive Management

Increasing Knowledge

Small-scale Studies

Pilot Projects

Demonstration Contracts

Increasing Scale and Complexity

Large-scale Remediation Contracts
Progression of Stress Part 1: Oil
Progression of Stress Part 2: Algal Mat
Progression of Stress Part 2: Algal Mat

What’s wrong with this picture…? Algal mat as a barrier…
Progression of Stress Part 3: Hydrology

What's wrong with this picture…?
How to Restore Salt Marsh Habitat?
Choosing Remediation Activities

- EXCAVATE - Refresh (existing) and/or excavate (new) tidal channels

- TILL – Remove algal mats/De-compact and aerate substrate in marsh and tidal flat habitats

- PLANT - Transplantation of mangroves/halophytes to rapidly increase the populations
Channel Excavation

What’s wrong with this picture…?
better…?
CRC1 Colonization – Two months post excavation

South Channel

North Channel

Nasima
Snails
Amphipods
CRC1 Colonization – Three months post excavation

South Channel

North Channel

Nasima
Snails
Amphipods
CRC1 Colonization – Four months post excavation

South Channel

North Channel

Nasima

Snails

Amphipods
CRC1 Colonization – Five months post excavation

South Channel

North Channel

Nasima
Snails
Amphipods

PANDION
CRC1 Colonization – Six months post excavation

South Channel

North Channel

Nasima
Snails
Amphipods

PANDION
CRC1 Colonization – Seven months post excavation

South Channel

North Channel

Nasima
Snails
Amphipods
CRC1 Colonization – Eight months post excavation

South Channel

North Channel

Nasima
Snails
Amphipods
CRC1 Colonization – Nine months post excavation

South Channel

North Channel

Nasima
Snails
Amphipods
CRC1 Colonization – Ten months post excavation

South Channel

North Channel

Nasima
Snails
Amphipods
CRC1 Colonization – Eleven months post excavation

South Channel

North Channel

Nasima
Snails
Amphipods
CRC1 Colonization – Twelve months post excavation

South Channel

North Channel

Nasima
Snails
Amphipods
Excavation of Tidal Channels
Monitoring Results To Date

Number of Burrows present in channel along 10 m transect

- Low Elevation
- Mid Elevation
- High Elevation
Natural Channel Development
Natural Channel Development
Natural Channel Development
Natural Channel Development
Natural Channel Development
Tilling

- Three alternative marsh surface treatments:
  - Tilling
  - Algal mat removal
  - Algal mat removal followed by tilling
- Treatment directly adjacent to channel excavation in 5 x 5 m plots
CRC1 Alternative Treatment Plots - 0 Months

South Channel

North Channel

- Till
- Remove Algal Mat
- Remove Mat and Till
CRC1 Alternative Treatment Plots – 3 Months

South Channel

North Channel

- Till
- Remove Algal Mat
- Remove Mat and Till
- Colonized by *Nasima*
CRC1 Alternative Treatment Plots – 6 Months

South Channel

North Channel

- Till
- Remove Algal Mat
- Remove Mat and Till
- Colonized by *Nasima*
CRC1 Alternative Treatment Plots – 9 Months

South Channel

North Channel

- Till
- Remove Algal Mat
- Remove Mat and Till
- Colonized by *Nasima*
CRC1 Alternative Treatment Plots – 15 Months

South Channel

North Channel

- Till
- Remove Algal Mat
- Remove Mat and Till
- Colonized by *Nasima*
Tilling/Algal Mat Removal

- **Algal mat Removal**
- **Algal mat Removal and Tilling**
- **Tilling Only**
- **Control - No Surface Treatment**

Average number of Nasima burrows per m² ± SE
Planting
Planting

• Mangroves
  – *Avicennia marina*

• Perennial Halophytes
  – *Halocnemum strobilaceum*
  – *Arthrocnemum macrostachyum*
Mangroves

Observable changes (same plant)

after 2 months  after 6 months  after 1 year
• **Observations:**
  
  – **Majority of previously surviving plants continue to grow**
  
  – **Overall plant height has not increased, however, branch density and leaf count is increasing**
Monitoring Results To Date

Average number of healthy leaves per plant

C1
C2
C3
Natural B channel
Mangroves

• Transplanting mangroves in oiled sediments can be successful

• Poor survival in areas lacking drainage, having high oil concentration, and high algal mat cover

• Highest survival on banks of newly excavated channels. Linkage between excavation and planting
Adaptive Restoration Process

- Small studies
- Pilot Projects
- Demonstration Contracts
- Large Scale Remediation Contracts

Increasing Knowledge

Increasing Scale

Meters to Hectares
Lessons Learned

• Rapid increases in colonization can occur in areas of remediation until balanced state is achieved

• Abundance of organisms colonizing areas may follow seasonal trends

• Channels not expected to fill or slump

• Planting success is species dependant
Guidance – Lessons Learned

Channel Excavation

- Efficient method in low energy environment to increase tidal flushing and promote recolonization.
Channel Excavation

- Efficient method in low energy environment to increase tidal flushing and promote recolonization.
- Channels will continue to be the primary method of remediation of the salt marsh habitats.
Guidance – Lessons Learned

Tilling

• Effective at reducing oil residues and de-compact areas covered by barrier increasing potential for recolonization
Guidance – Lessons Learned

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• Increased areas of tilling have been incorporated into future contracts
Guidance – Lessons Learned

Planting

- Recommended for species that are slow to recruit and grow but also able to survive and establish following transplanting
Guidance – Lessons Learned

Planting

• Recommended for species that are slow to recruit and grow but also able to survive and establish following transplanting

  – Mangroves are to be included along the banks of the channels in all future contracts

  – Other halophytes remain limited to small scale/demonstration tests until successful methods can be determined
Adaptive Restoration Process

- Increasing Knowledge
- Small studies
- Pilot Projects
- Demonstration Contracts
- Other Remediation Projects

Increasing Scale

Meters → Hectares
Thank You