# ARTIFICIAL REEFS FOR MITIGATION

## A Brief Summary

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# Types of Damage to Coral Reefs

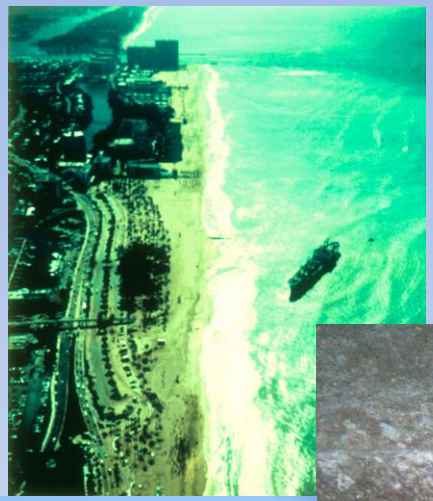
Anchor damage

Beach nourishment

Pipelines and cable

Vessel groundings

Water quality



# Mitigation vs. Restoration

Mitigation – Offset known impacts

Substrate ⟶ Artificial reefs

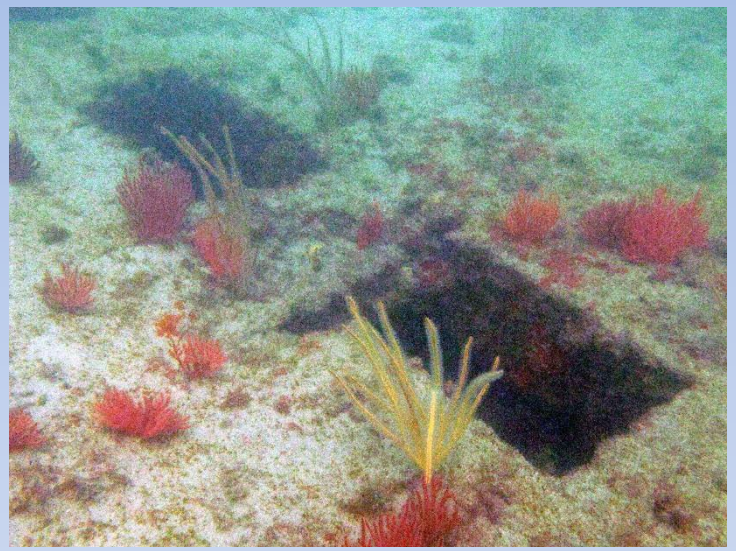
Biological community

Restoration – Create original condition

Substrate ⟶ Re-create framework

Biological community

# Mitigation in Martin County



- Beach nourishment project
- Deployed in 2000
- Material of opportunity (bridge)
- 3 sites
  - Reef A: 104 concrete & steel sections
  - Reef B: 150 concrete & steel sections
  - Reef C: 164 concrete & steel sections
- Single monitoring event

# Martin County Nearshore Artificial Reef

After 2 yrs soak time:

- Reef A
  - fish species – 15
  - benthic species – 7
- Reef B
  - fish species – 21
  - benthic species – none reported
- Reef C
  - fish species – 18 (1 goliath)
  - benthic species – 10

# Mitigation in Palm Beach County

**Beach nourishment projects**

Tequesta: 1 acre, $0.5 million

Diamond Head Radner: 3-4 acres, $2-3 million

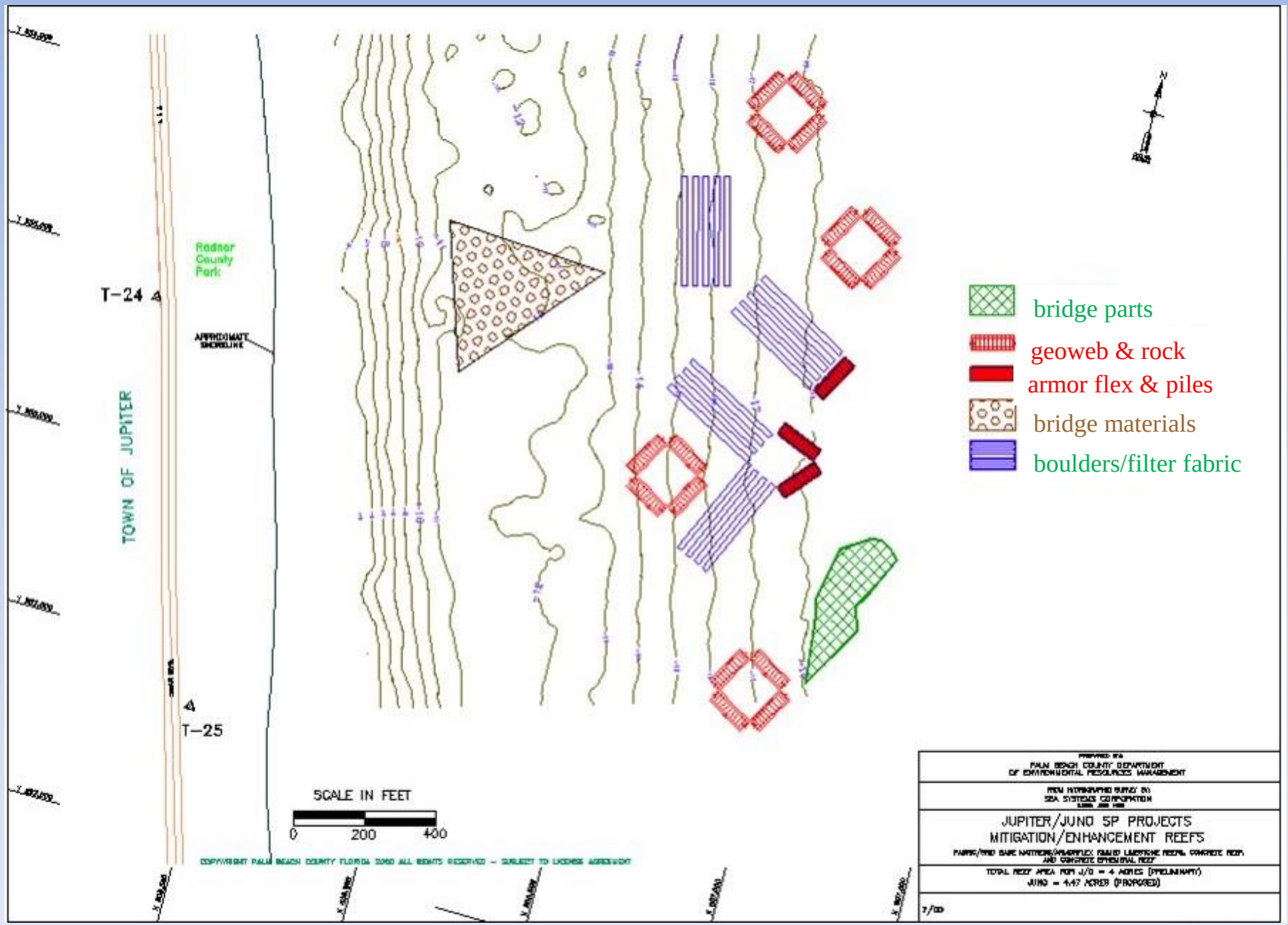
Singer Island: 2 acres, $1.2 million

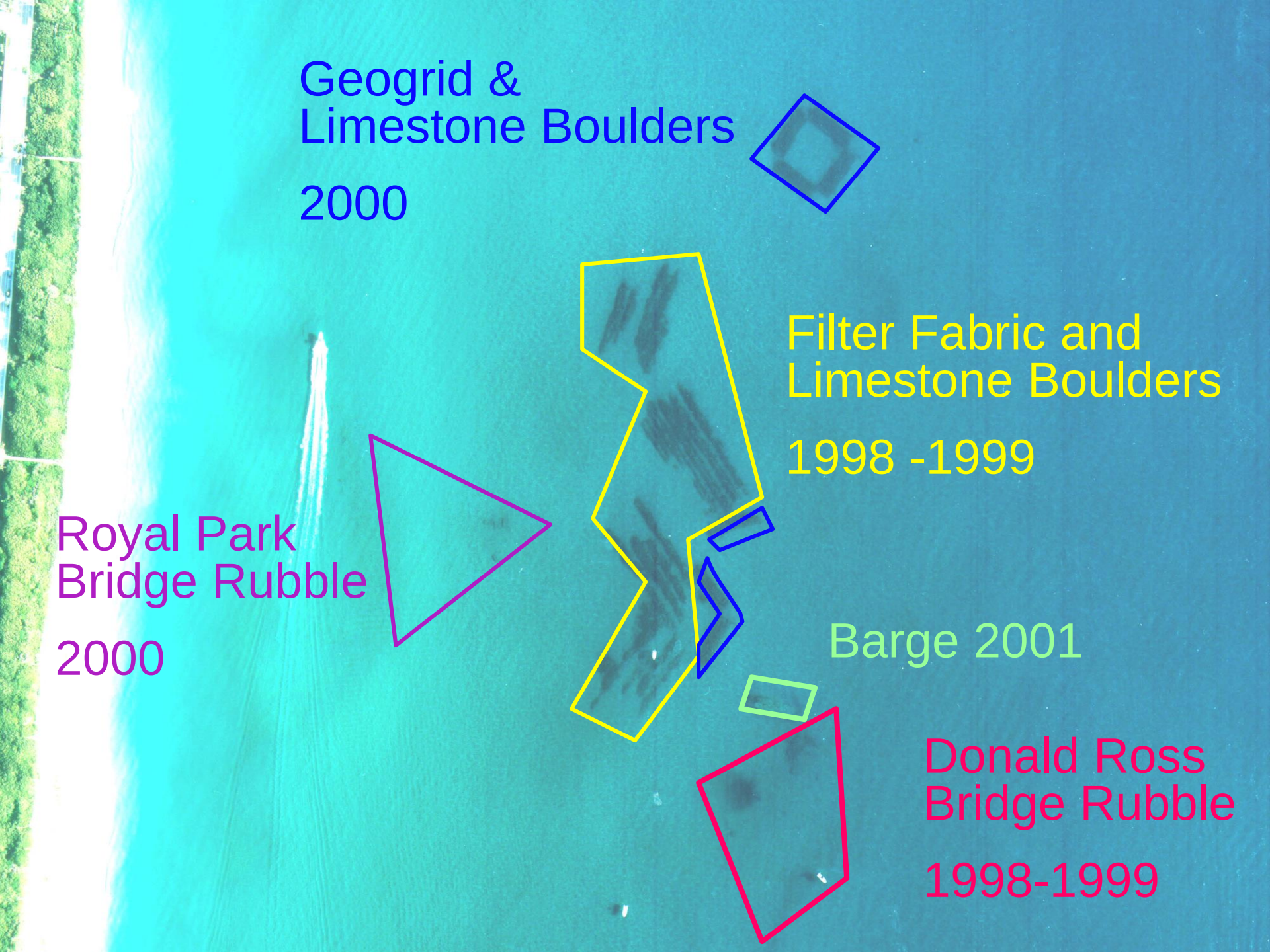
Ocean Ridge: 2.5 acres, $1.5 million

Red Reef Park: 0.25 acres, $500,000

South Boca: 2.5 acres, $1.0 million

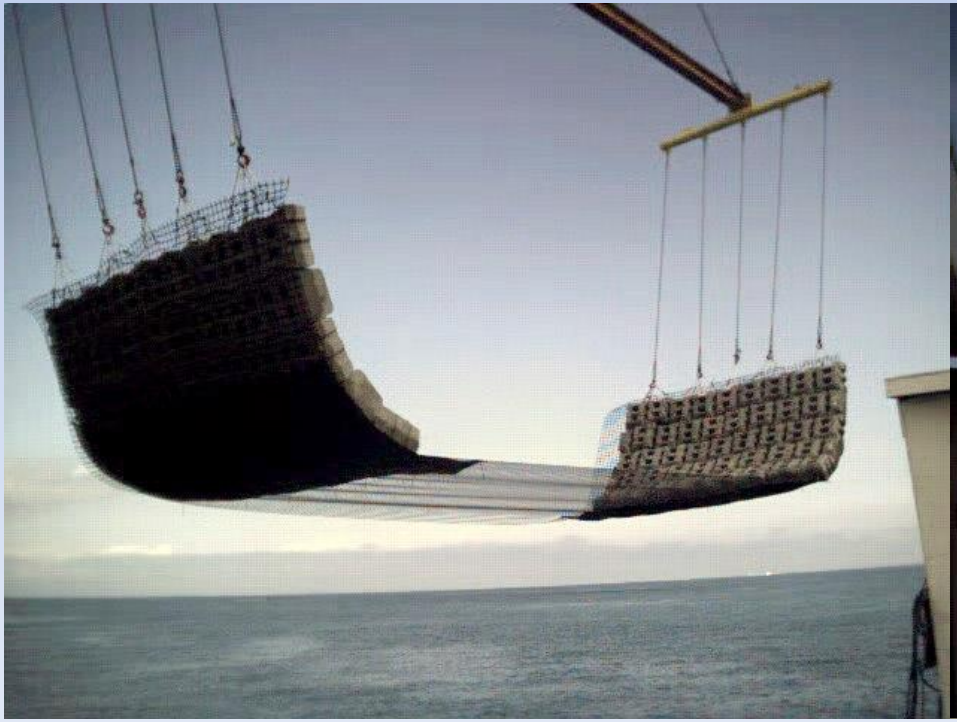
# Diamondhead Radnor Mitigation Reefs




Geogrid &
Limestone Boulders
2000
Filter Fabric and
Limestone Boulders
1998 -1999
Royal Park
Bridge Rubble
2000
Barge 2001
Donald Ross
Bridge Rubble
1998-1999

# Diamondhead Radnor Mitigation Reefs

- 14-20 ft water depth
- 15,000 tons rock
- 3-4 acre area
- $2 - $3 million
- no rock underburden
- added armor flex with Kevlar mesh
- scouring continues



# Singer Island Mitigation Reef - 2009

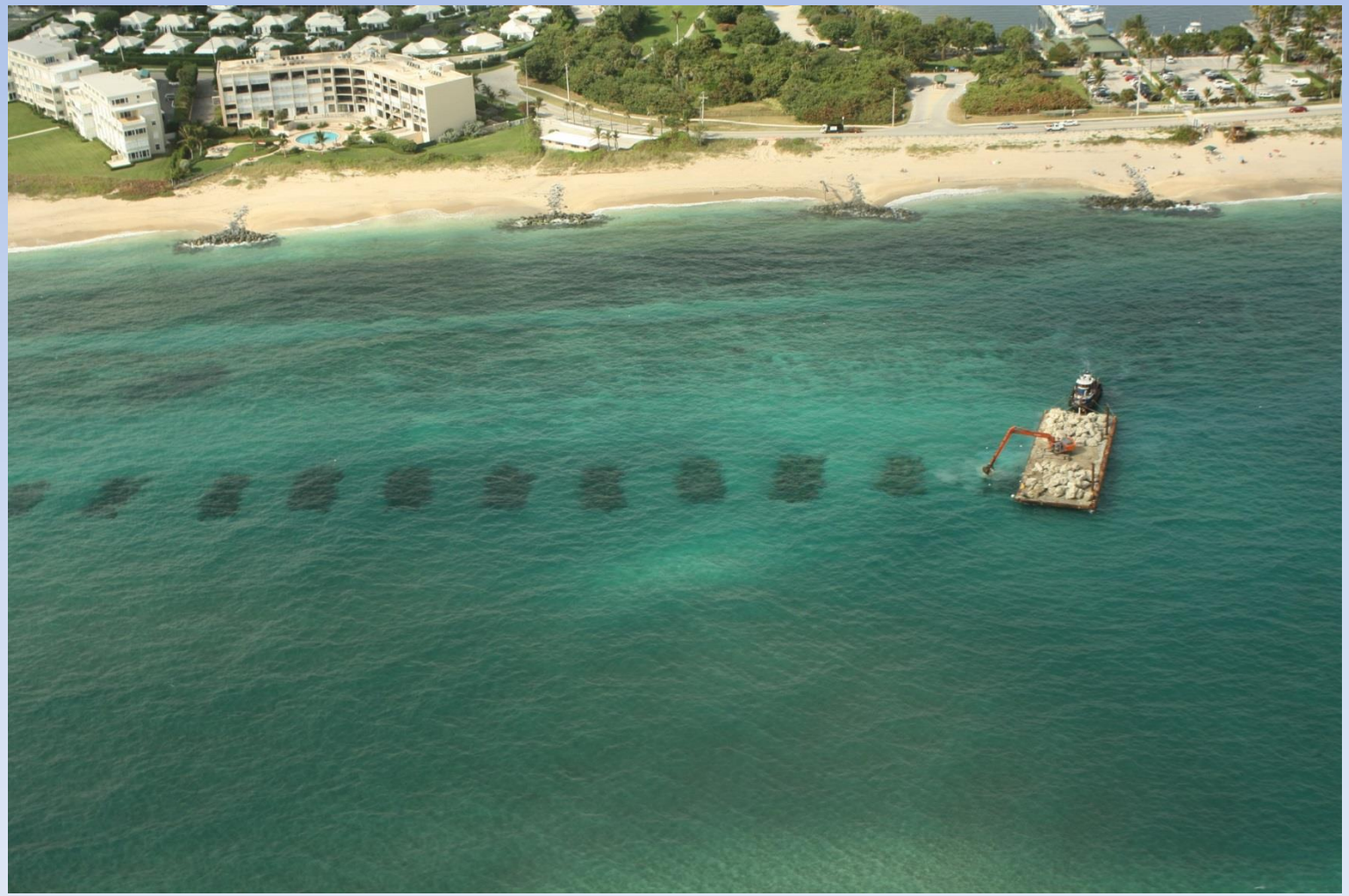
Nearshore impact due to beach nourishment

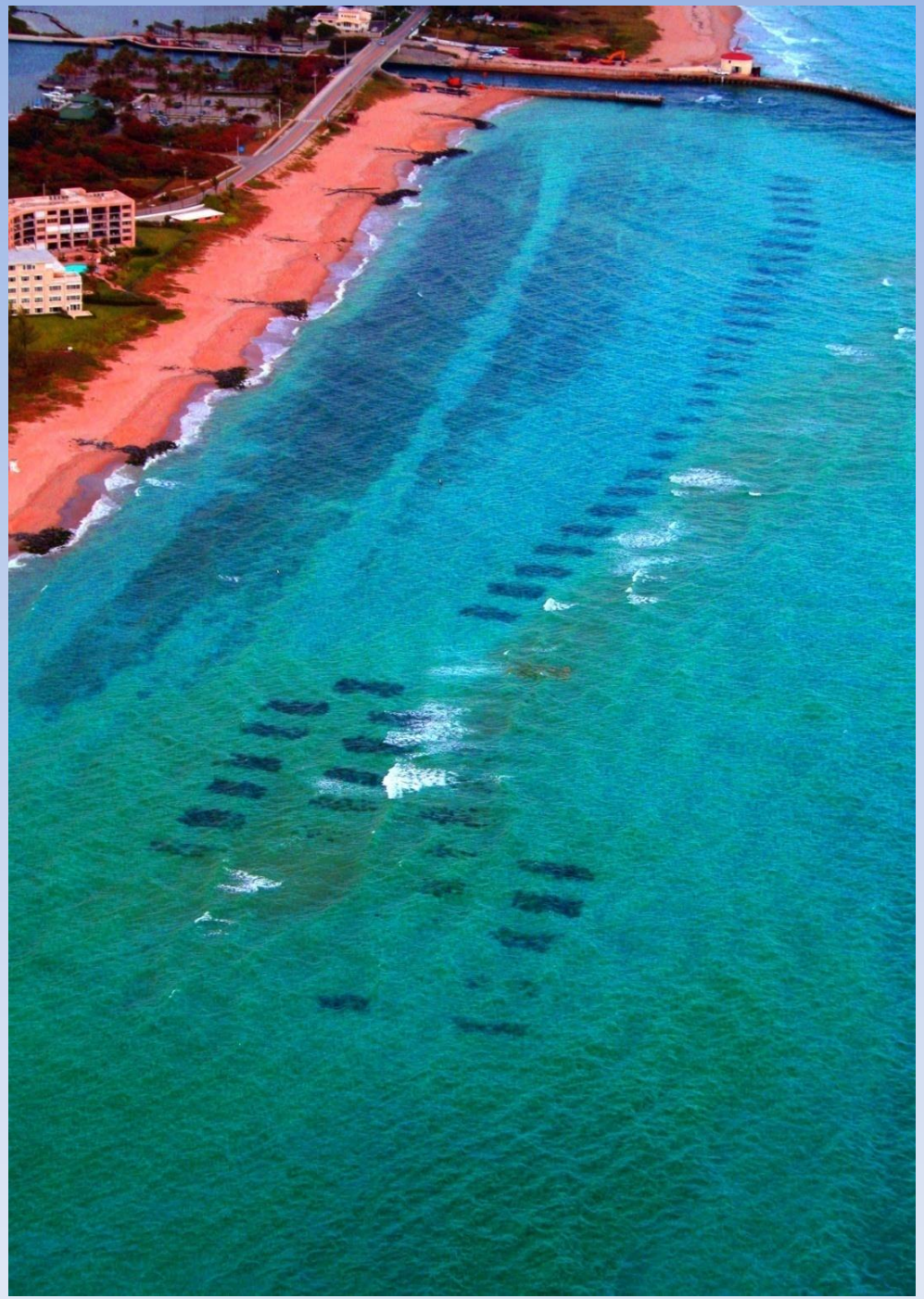
Ephemeral (50%) exposed at any time

- 45-50 reefs
- close to shore
- 2 acres
- $1.2 million

# Ocean Ridge - 2009

## Beach Nourishment Mitigation





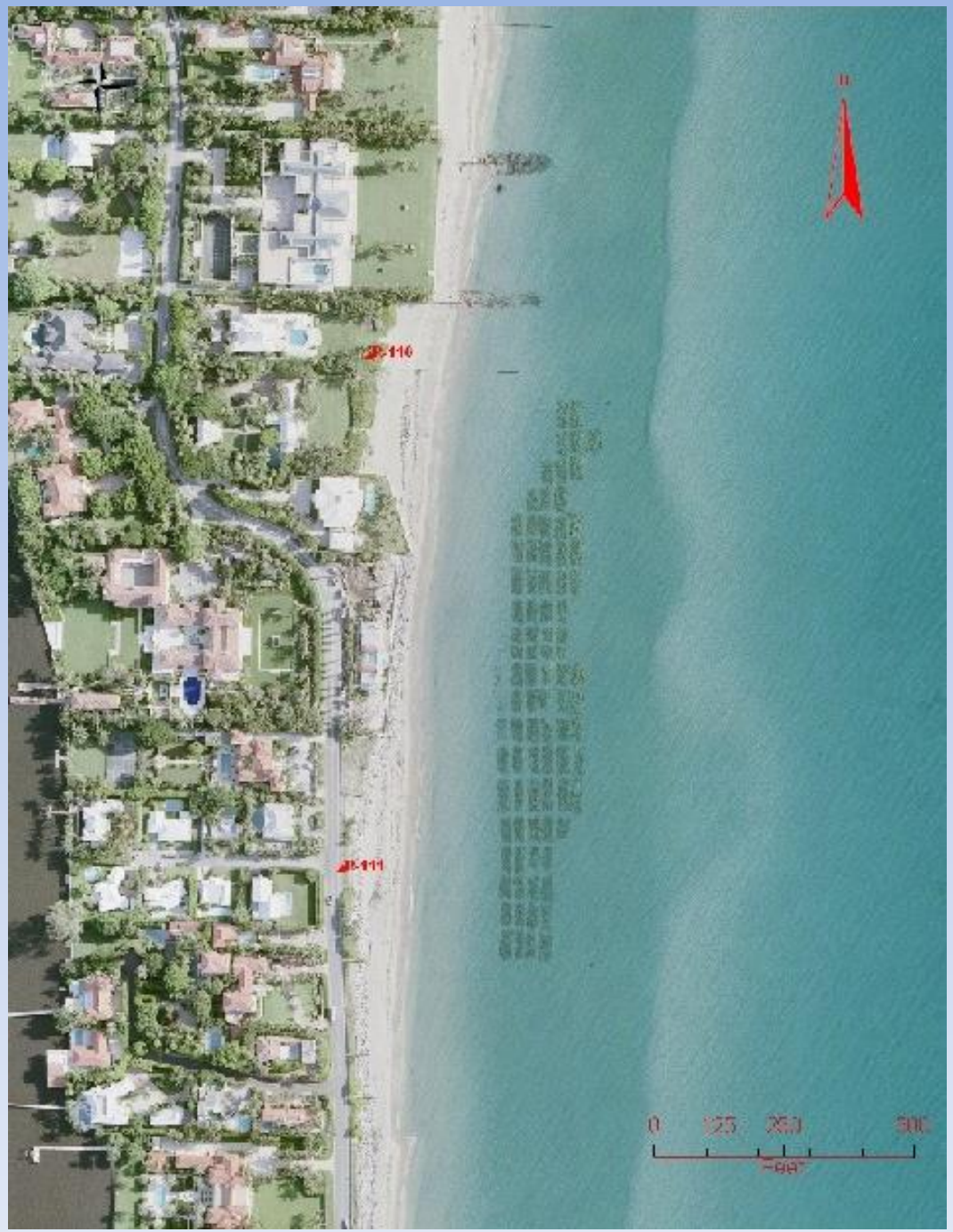
# Ocean Ridge Reefs

- 60 pods
- 2.5 acres
- $1.5 million

Each pod is approximately 20 ft. by 40 ft.

29 pods extend north to south

31 pods in a cluster at the south end




# Phipps Mitigation Reef

# Reef Mitigation in Broward County

Ship grounding site
- modules, boulders, formed concrete

Fiber-optic cable installations
- modules, coral transplantation

Hardbottom impacts from beach nourishment
- boulders, modules

Sea grass impacts from bridge construction
- boulders

# Grounding of the USS Memphis

1993, a nuclear submarine grounded on a reef (d=25 ft), leaving a deep trench, scraped substrate, and piles of rubble

# Grounding of the USS Memphis

- Preliminary mitigation plan was developed to determine funding requirements
  - Deploy a variety of artificial reef materials
  - Remove rock rubble
  - Stabilize reef framework fractures
  - Transplant coral colonies
  - Monitor grounding site and mitigation

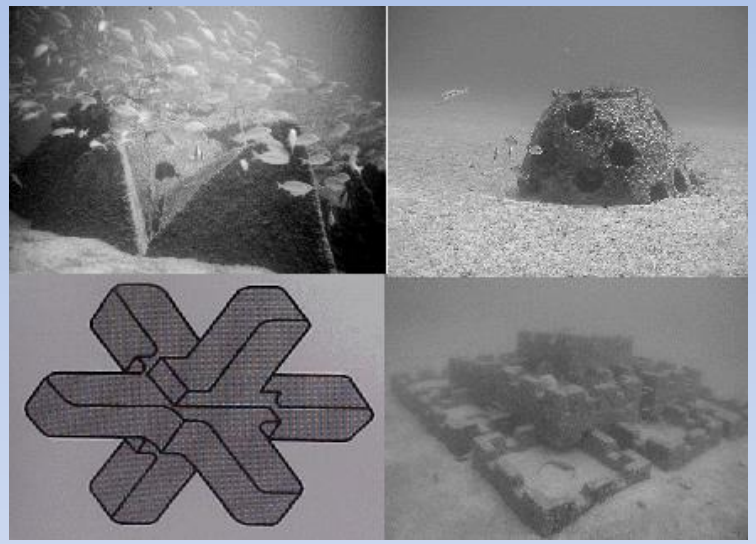
# Grounding of the USS Memphis

- Damage claim made by State against US Navy for $2 million
- Claim was a litigated for 4 yrs
- Final settlement of $750,000 was reached
- $520,000 set aside for mitigation

Final mitigation plan scaled back due to funding

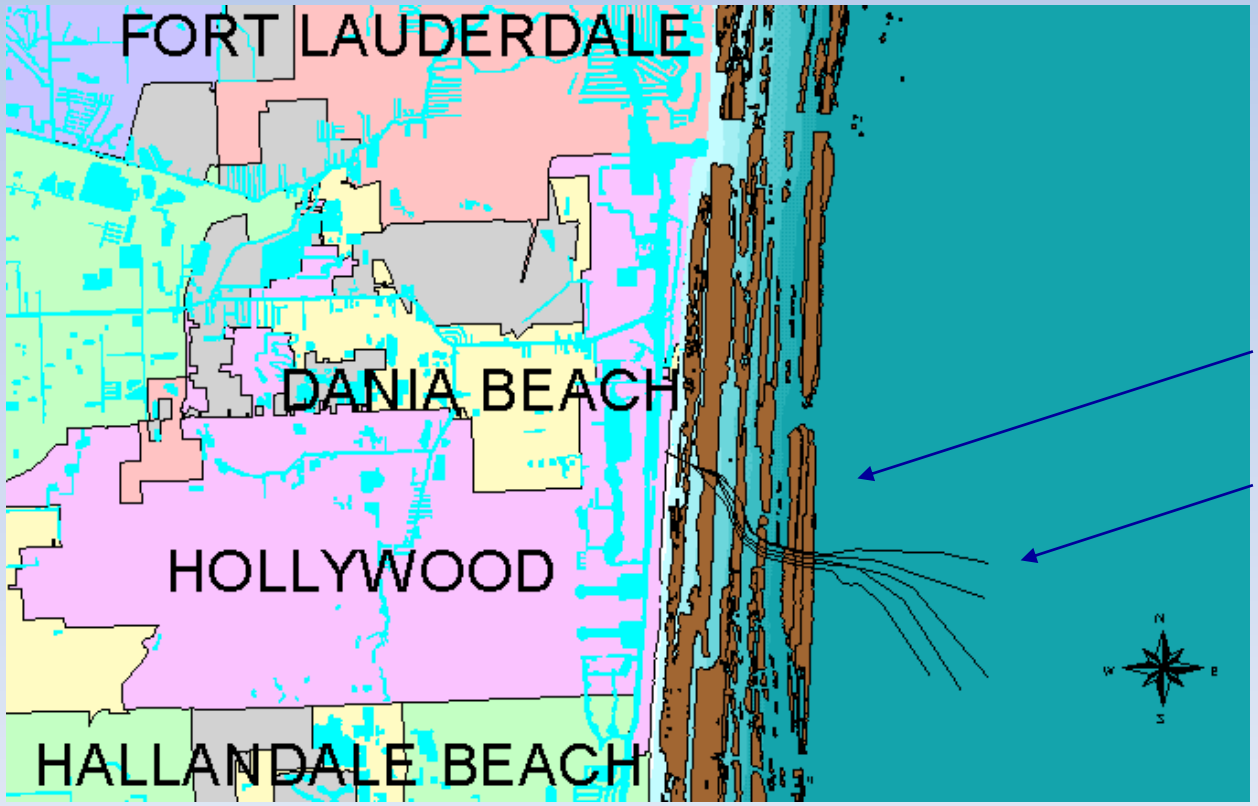
# Grounding of the USS Memphis

- Deploy 300 tons of limestone boulders (Mt. Dania),
- 150 tons of concrete tetrahedrons,
- 50 Warren Modules,
- 100 Ajacks,
- 160 Reef Balls (for research),
- Research program and monitoring



# Reef Impacts from Installation of Fiber-optic Cables

5 fiber-optic cables installed over parallel reef tracts

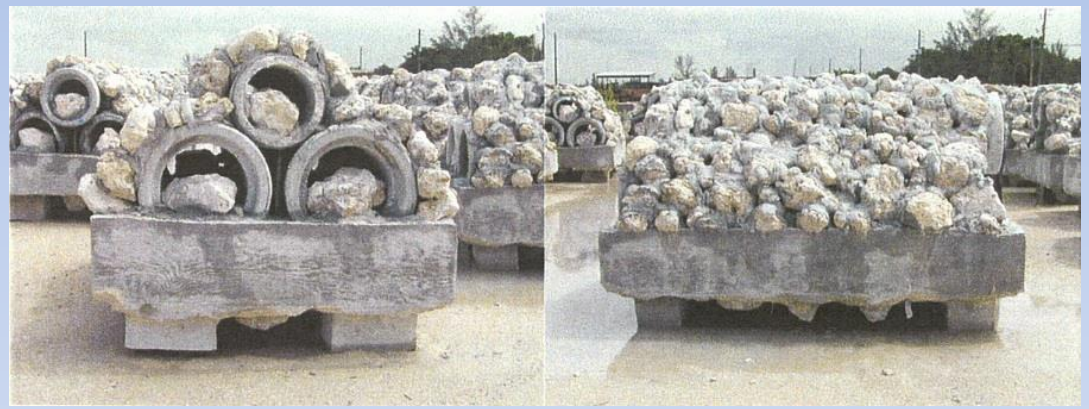


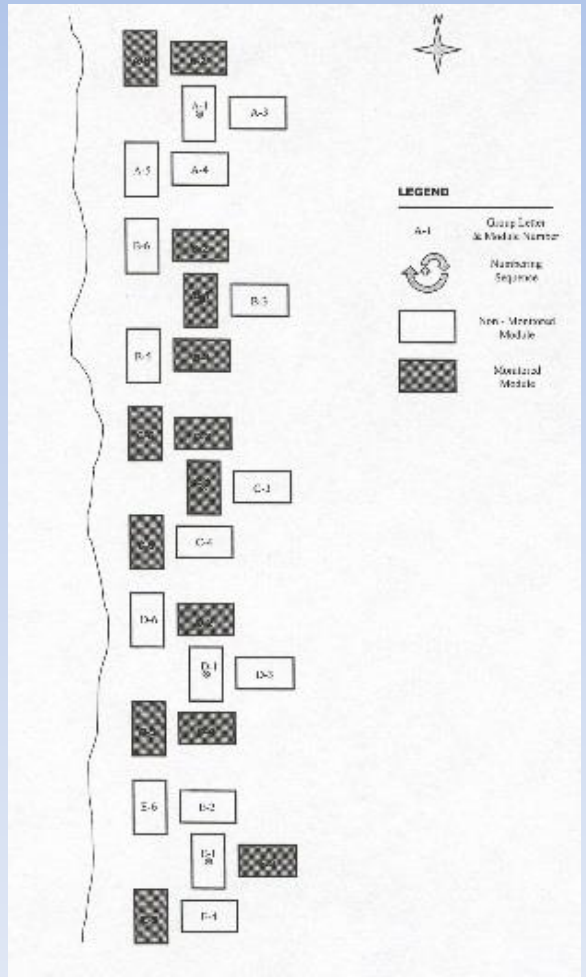

reef

fiber-optic cables

# Reef Impacts from Installation of Fiber-optic Cables

30 DERM Modules deployed to mitigate for lost colonies






160 loose coral colonies were re-attached

# Reef Impacts from Installation of Fiber-optic Cables

5 yrs post-deployment

- stony corals – 18 spp, high recruitment and density
- fishes – 150 spp observed

# Reef Impacts from Cable Drag

Sheared sponges and octocorals

Mitigated with limestone boulders

# Segment III Beach Nourishment Mitigation

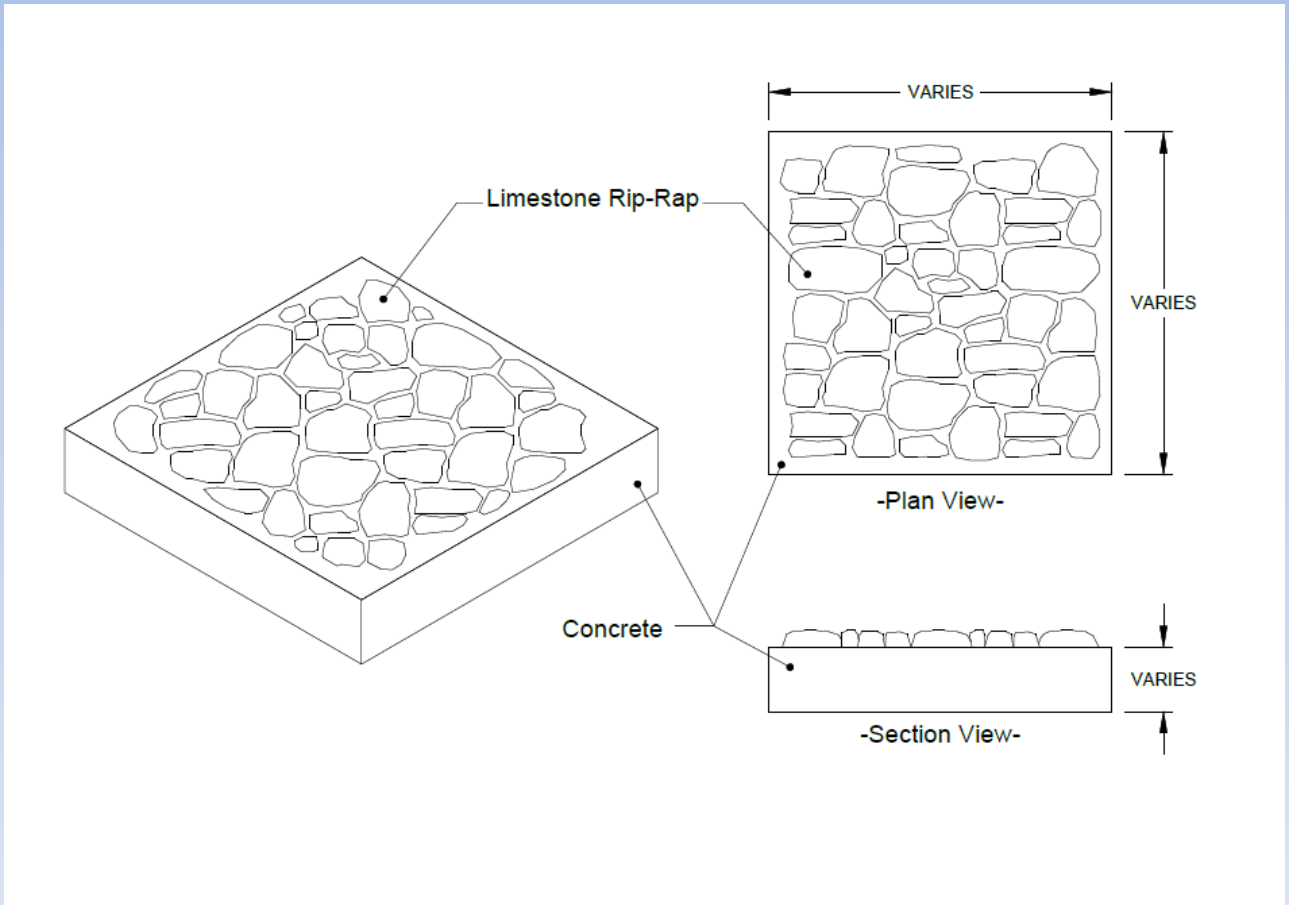
8.9 acres of limestone boulders deployed

$6,000,000

Fish spp richness & abundance greater on mitigation

Benthic assemblage significantly different

# Segment II Beach Nourishment Mitigation (proposed)




6.8 acres

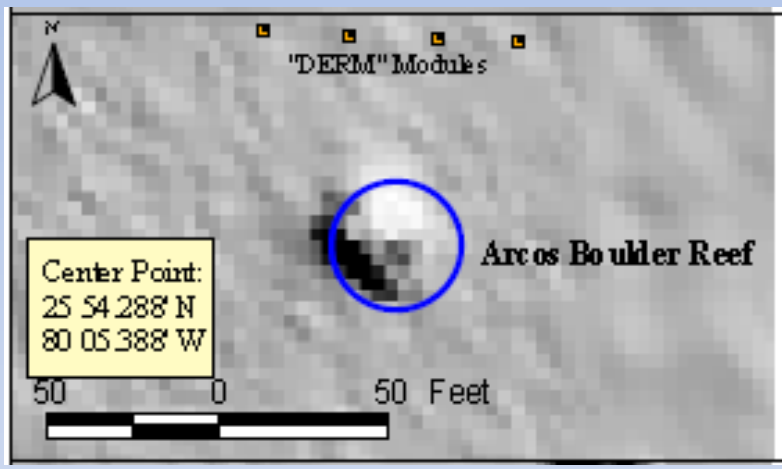
4,000-6,000 units

~ 60 sq. ft/module

$5.5-6.5 million

# Reef Mitigation in Miami-Dade County

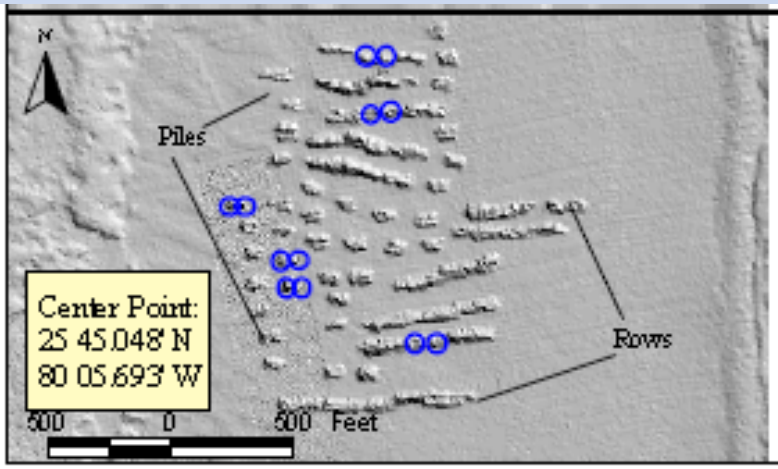
Beach nourishment mitigation




**Arcos Boulder Reef**

| | |
|---|---|
| Artifcial Reef Site: | Sunny Isles |
| Deployment Date: | August 2001 |
| Age During Survey: | 5.5 years |
| Total Tonnage: | 270 tons |
| Footprint: | 105 m2 |
| Depth: | 68 ft. |
| Relief: | 6 ft. |

0.02 acres

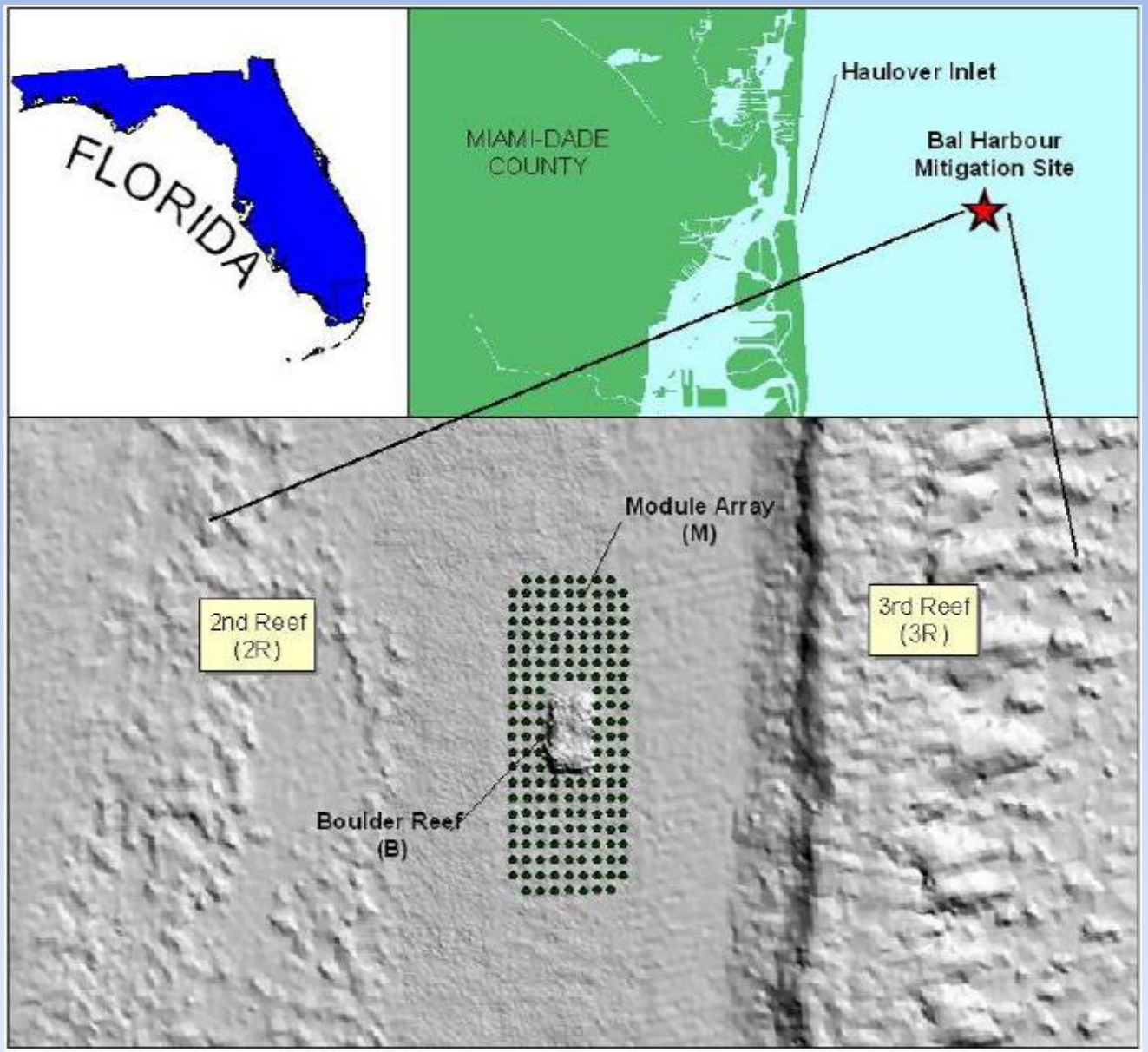



**Port of Miami Boulder Reefs**

| | |
|---|---|
| Artifcial Reef Site: | POM Site B |
| Deployment Date: | September 1996 |
| Age During Survey: | 10.5 years |
| Total Tonnage: | 120,000 tons |
| Footprint: | 36,320 m2 (Rows) & 20,070 m2 (Piles) |
| Depth: | 45 ft. |
| Relief: | 10 ft. |

14 acres

# Bal Harbor Mitigation Site




10 yrs monitoring vs natural reef

Benthic community approaching similarity

Fish assemblages remain distinct

# Summary

- Costs ranged from $400,000 to $2,000,000/acre.
- Materials included materials of opportunity, boulders, commercial modules, designed modules.
- Few mitigation projects included comparison with the natural reef.
- Often mitigation was not designed to mimic the natural conditions of the habitat impacted.
- Beach nourishment projects may be moving more toward mimic-ification of the impacted hardbottom.
- Mitigation techniques have ‘evolved’ over the years, but don’t seem to be quite there yet.

# Summary

The approach to mitigating reef impacts should involve five steps:

1) assess physical and biological impacts,
2) *project design,
3) secure funding ($700,000+/acre),
4) Construct/deploy mitigation,
5) and monitor recovery of damage and mitigation results compared to natural habitat

*emphasis on “project design” function

# Bal Harbor
# school ‘o grunts