Hypotheses-based restoration study for mitigation of a S.E. Florida U.S.A. coral reef damaged by the grounding of a nuclear submarine.

Introduction:

The *United States Submarine* Memphis ran aground in approximately 10 meter depth on a coral reef off southeast Florida February 25, 1993. Extensive physical damage to the reef substrate and injury to the coral community were attributed to the initial grounding and subsequent attempts to free the submarine from the impacted reef.

U.S.S. Memphis

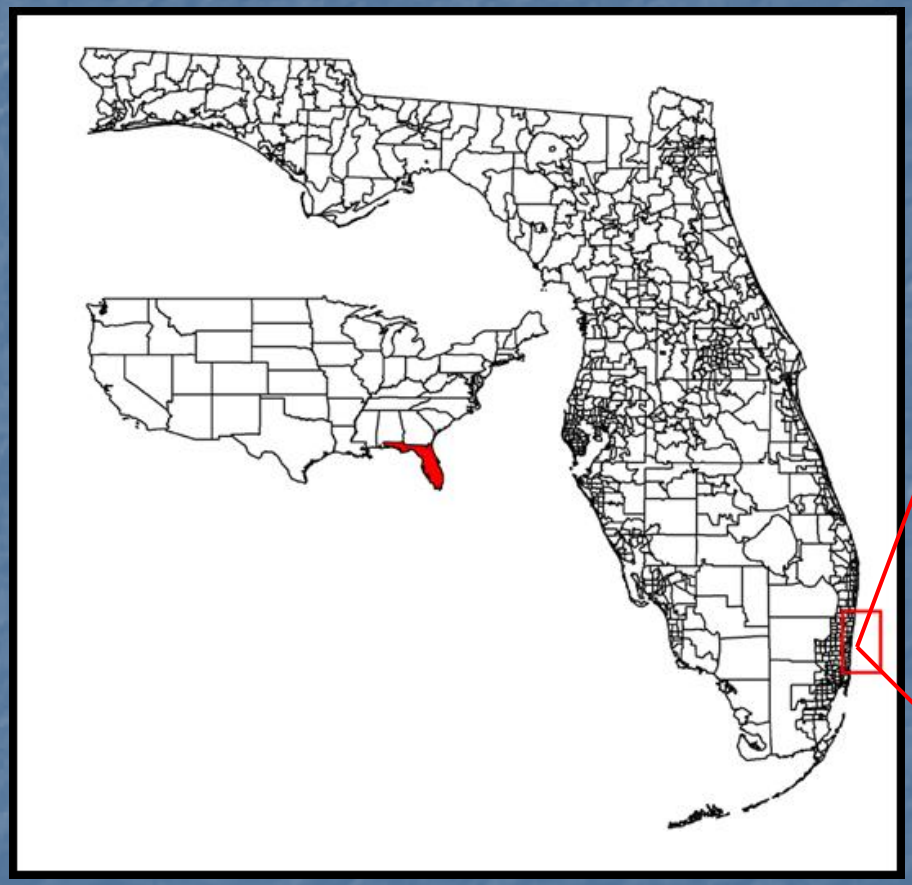
As part of the damage mitigation, we examined the potential of differing substrates to increase coral recruitment to, and survival on, artificial reefs and the interaction between fish assemblages and the coral recruitment dynamic.

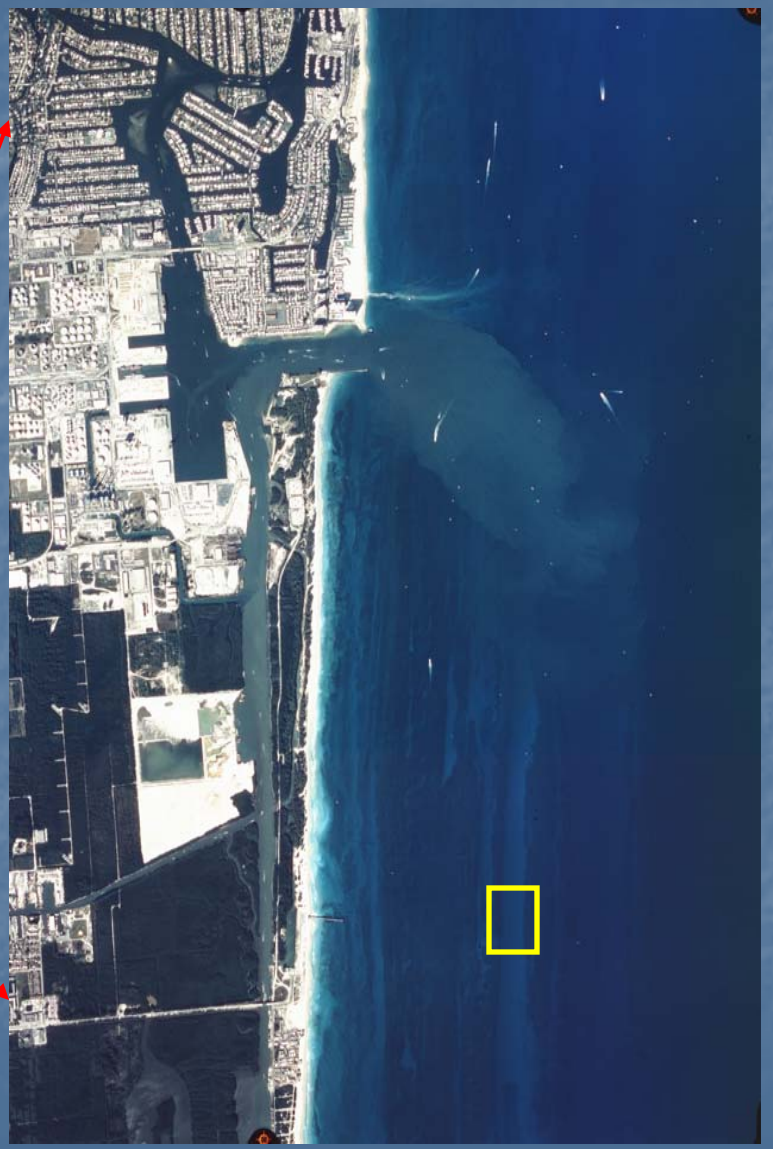
Thus, with an eye to restoration, we are looking at multiple components of the ecosystem (structure, substrate, fishes and corals)

Experimental Design

- 160 Reef Balls™ were organized into 40, 4-module reef units
- 4 treatments: iron, limestone, coral transplants or plain concrete
- 4 treatments of structural complexity (empty, small, mixed, large)

Study site: 2nd reef tract off Broward County, FL, USA.





Artificial reef construction

Mould preparation prior to the day's concrete pour.

Pouring 'mud'.

Breaking down moulds the following morning.

A day’s work ready to be moved.

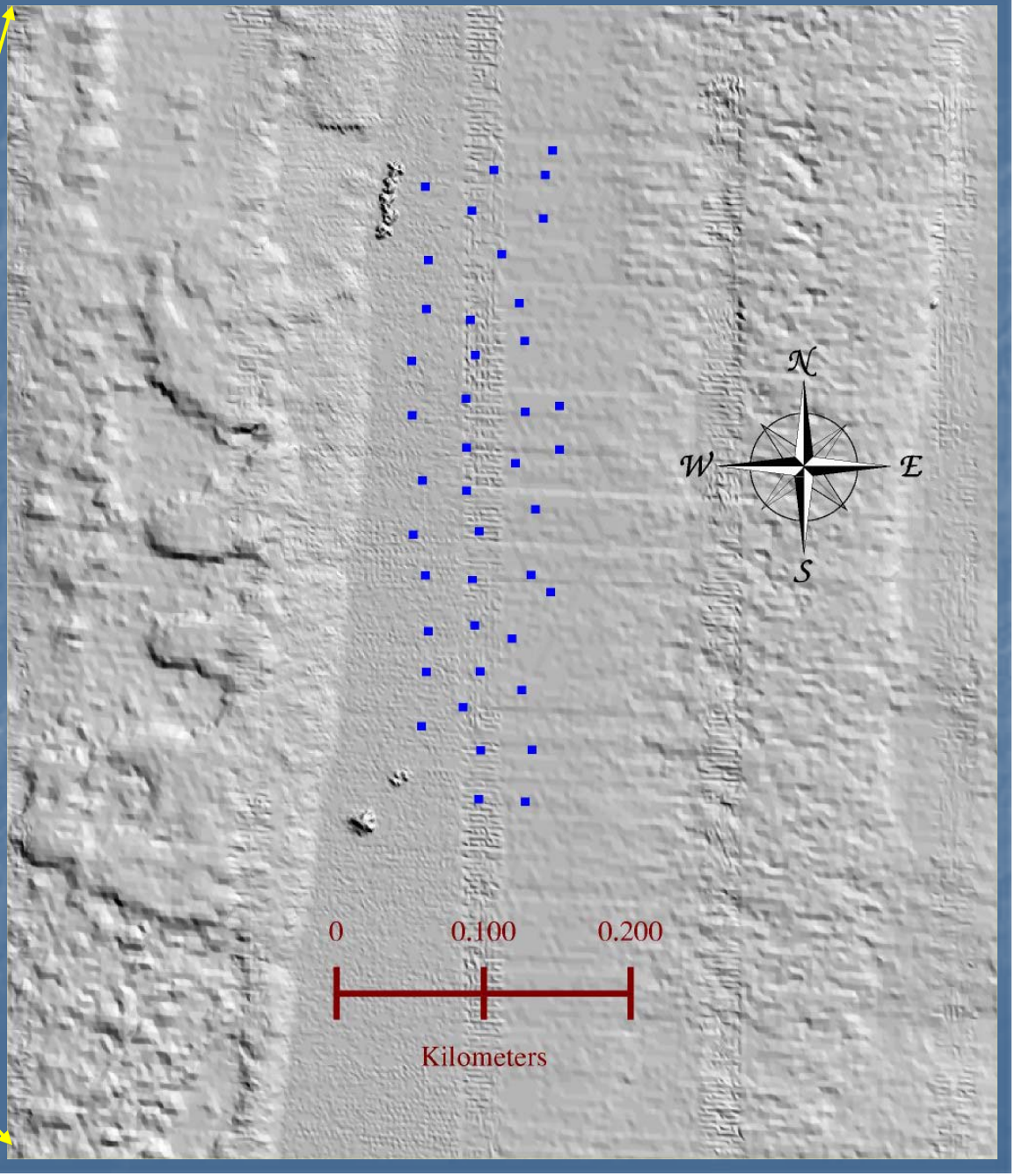
One hundred sixty Reef Balls at NSUOC.

Artificial Reef Deployment

Reef Balls were placed in sets of 4 termed a ‘quad’...

a square configuration with 3-m sides.

Quad array



Small fill:

Plastic cage material with 1.9 cm square mesh.

Plastic mesh cones were cable-tied into the reefs...

to provide small refuge fill.

Large fill:

Two hundred cinder blocks were used...

to provide large refuge fill.

Four types of quad fill complexity:

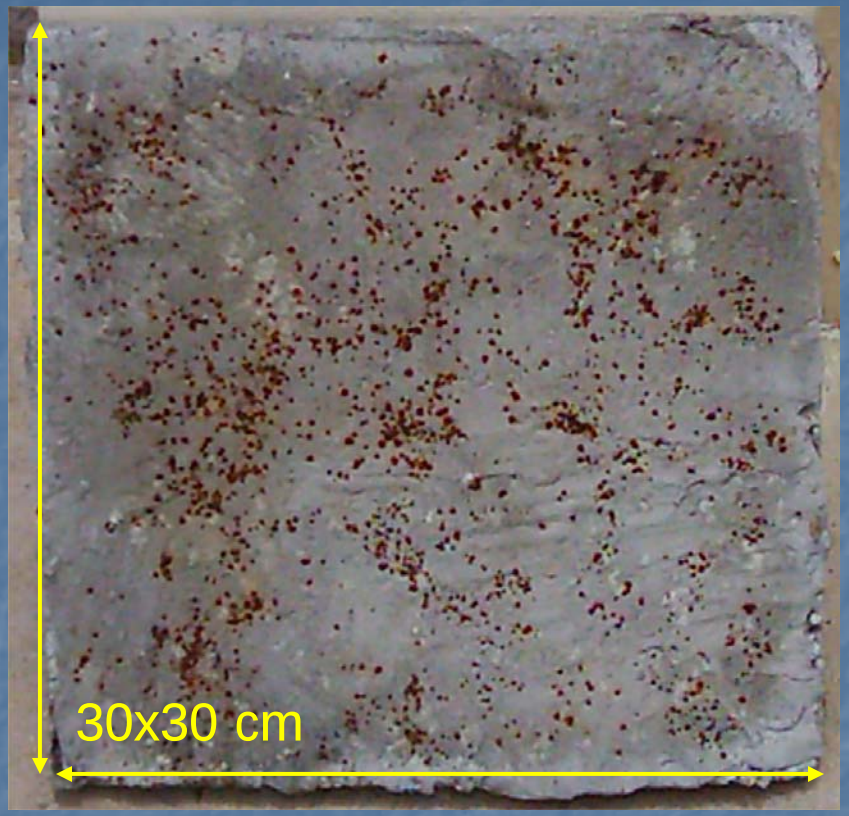
1) Empty - no fill
2) Small - cage in each RB
3) Mixed - 1 empty RB, two cage, one block
4) Large - 4 block in each RB

Ten quads (randomly chosen)
received each type of complexity.

Settlement plate construction:

Three hundred twenty settlement plates were constructed at the same time as the artificial reefs.

Settlement plate treatments:



Settlement plate with iron treatment

Settlement plate with $CaCO_3$ treatment

Settlement plate attachment:

Attachment sites were brushed clean of biota

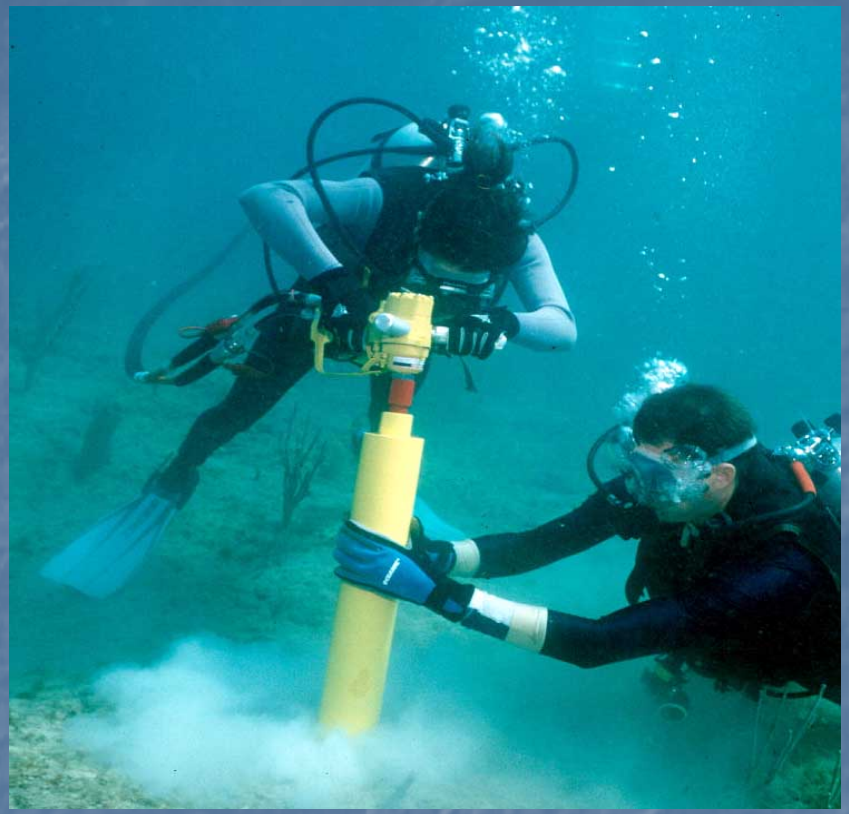
Concrete mixture:
2 parts Type II cement
2 parts molding plaster
1 part sand

Settlement plate attachment:

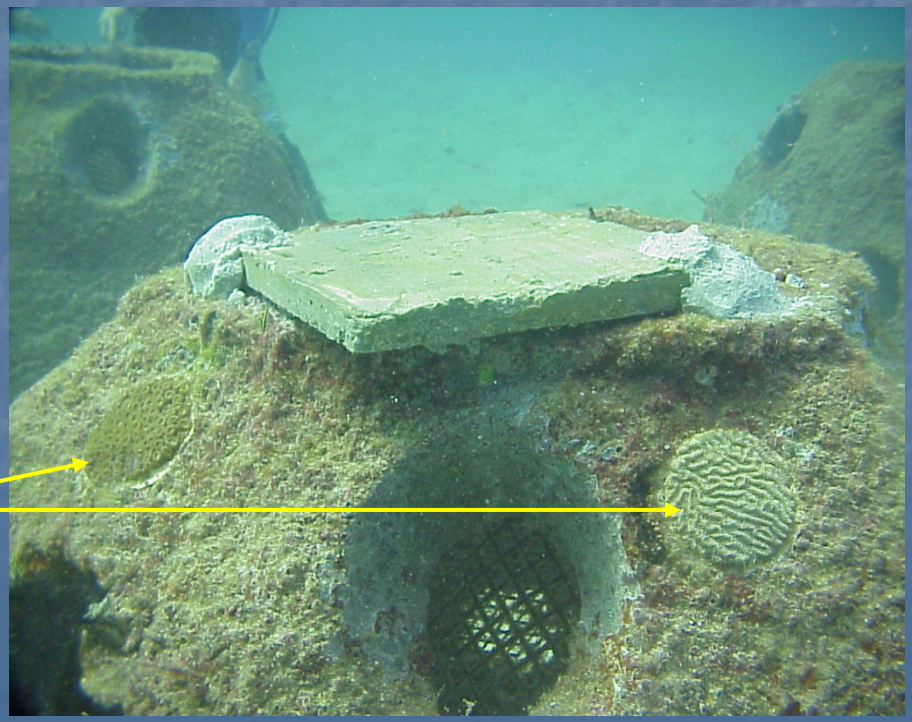
Each Reef Ball received two plates of the same treatment

Transplant RB with both plates attached

Coral transplants:



Collecting corals for transplantation using 4 inch core barrel



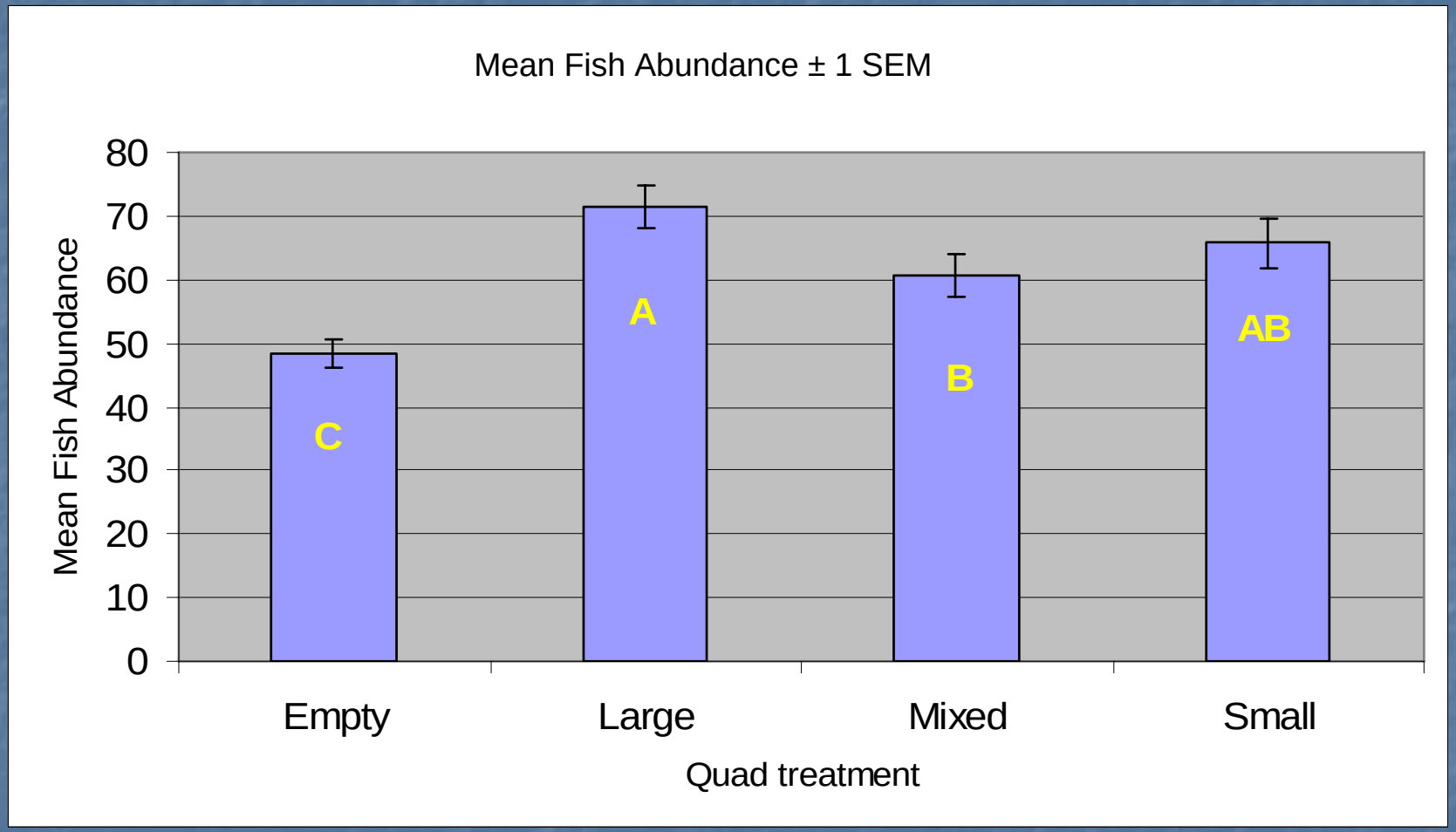
Transplants epoxyed into transplant ball

Coral transplant species:

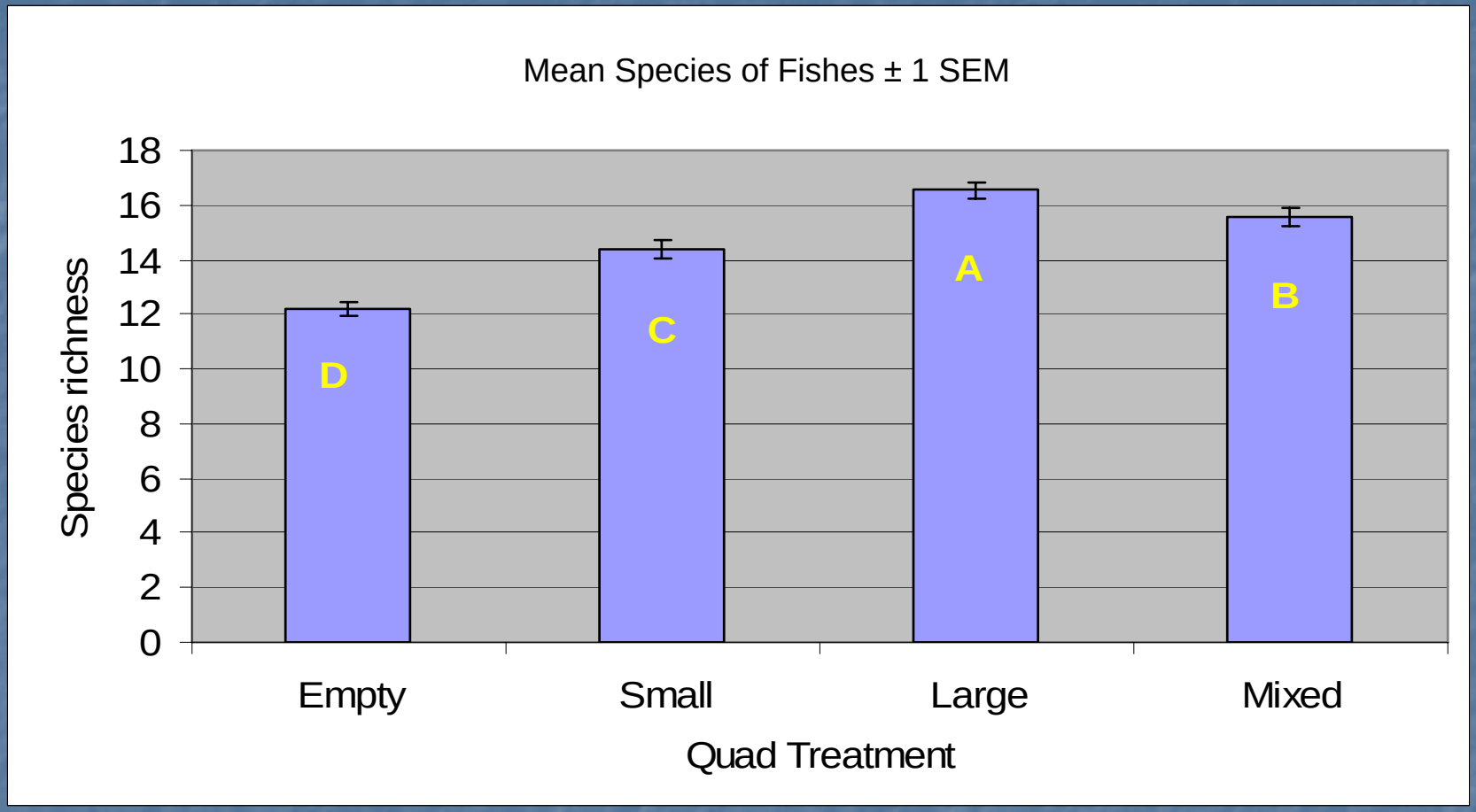
Montastraea cavernosa transplant

Meandrina meandrites transplant

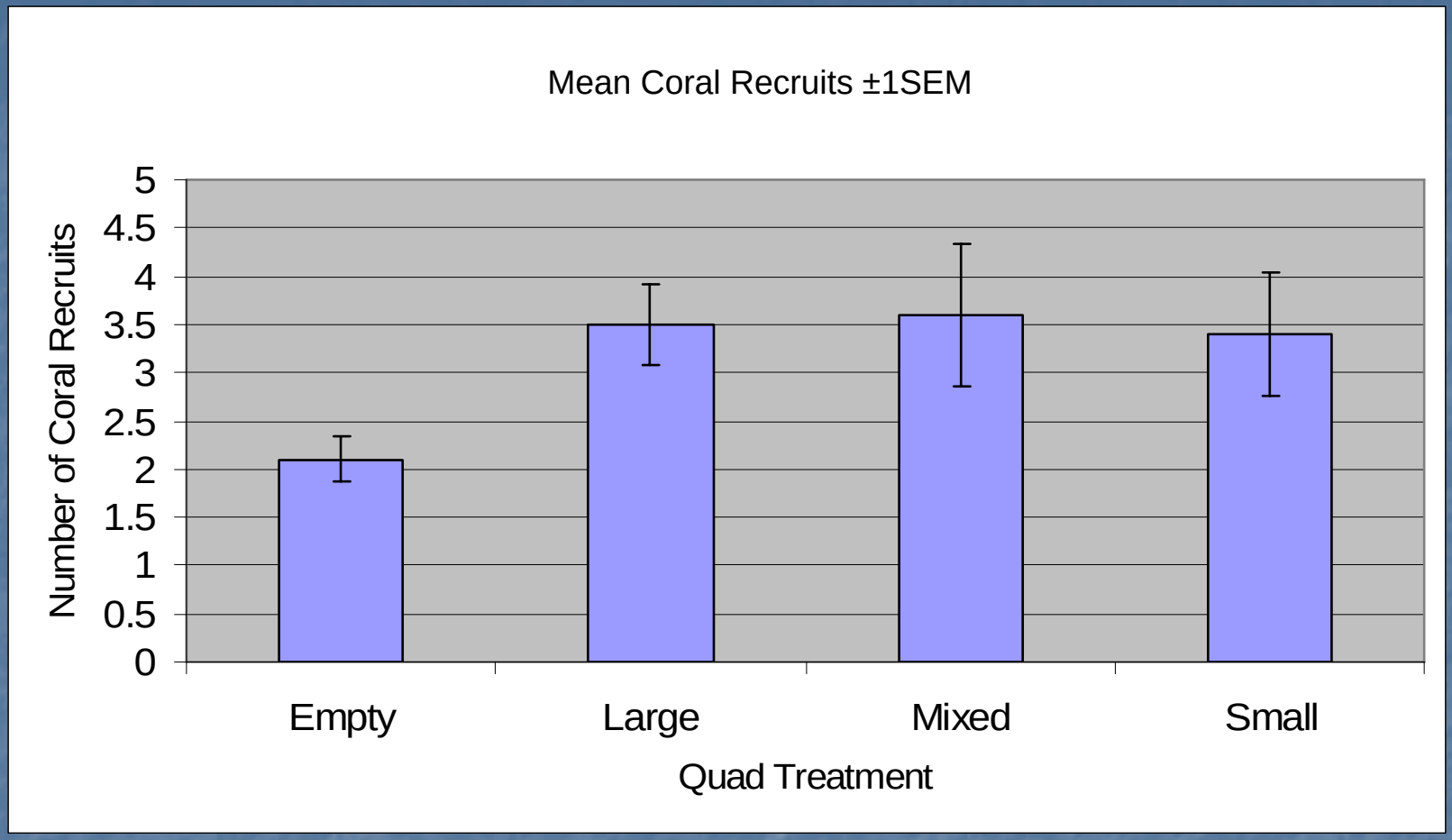
Fish Abundance



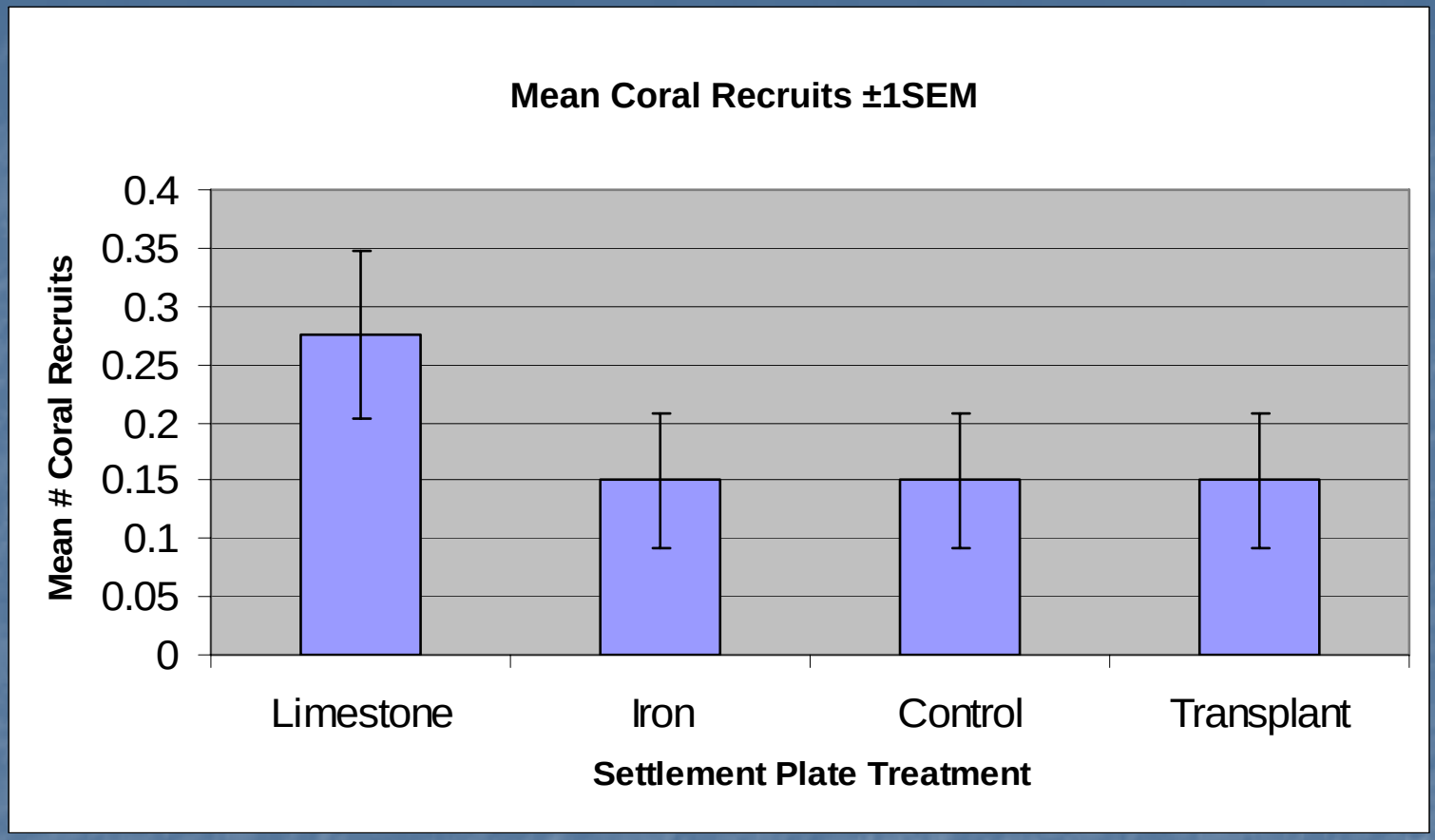
Fish Richness



Coral Recruitment



Although no significant difference is found between quad treatments for coral recruits, when Empty is compared to Filled, the difference is significant (P=0.03).



Mean coral recruits associated with settlement plate treatments ($p \approx 0.08$, ANOVA).

Preliminary Conclusions

The following factors need to be taken into account in the design of artificial substrate for coral reef restoration

- Differing reef complexity yields differing fish assemblages
- Differing reef complexity yields differing numbers of corals
- Limestone may be superior to iron or concrete for coral recruitment/survivability
- There are species-specific differences in transplant mortality

An additional 12 months of funding have been requested from FWC

New Project

We are continuing this line of ecosystem-restoration research.

In May, we will deploy 32 modules with differing structural complexity and with, or without, invertebrate-attracting artificial substrate. We will examine the effects of the these structures, and the resulting biota, on fishes, corals and non-coral invertebrates.