



Assessing the environmental impacts of beach nourishment:

Universal lessons about the need for rigorous design and effective process to assess projects of all kinds

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Increasing rates of shoreline retreat



Increasing rates of shoreline retreat



Increasing coastal development

Beach Nourishment



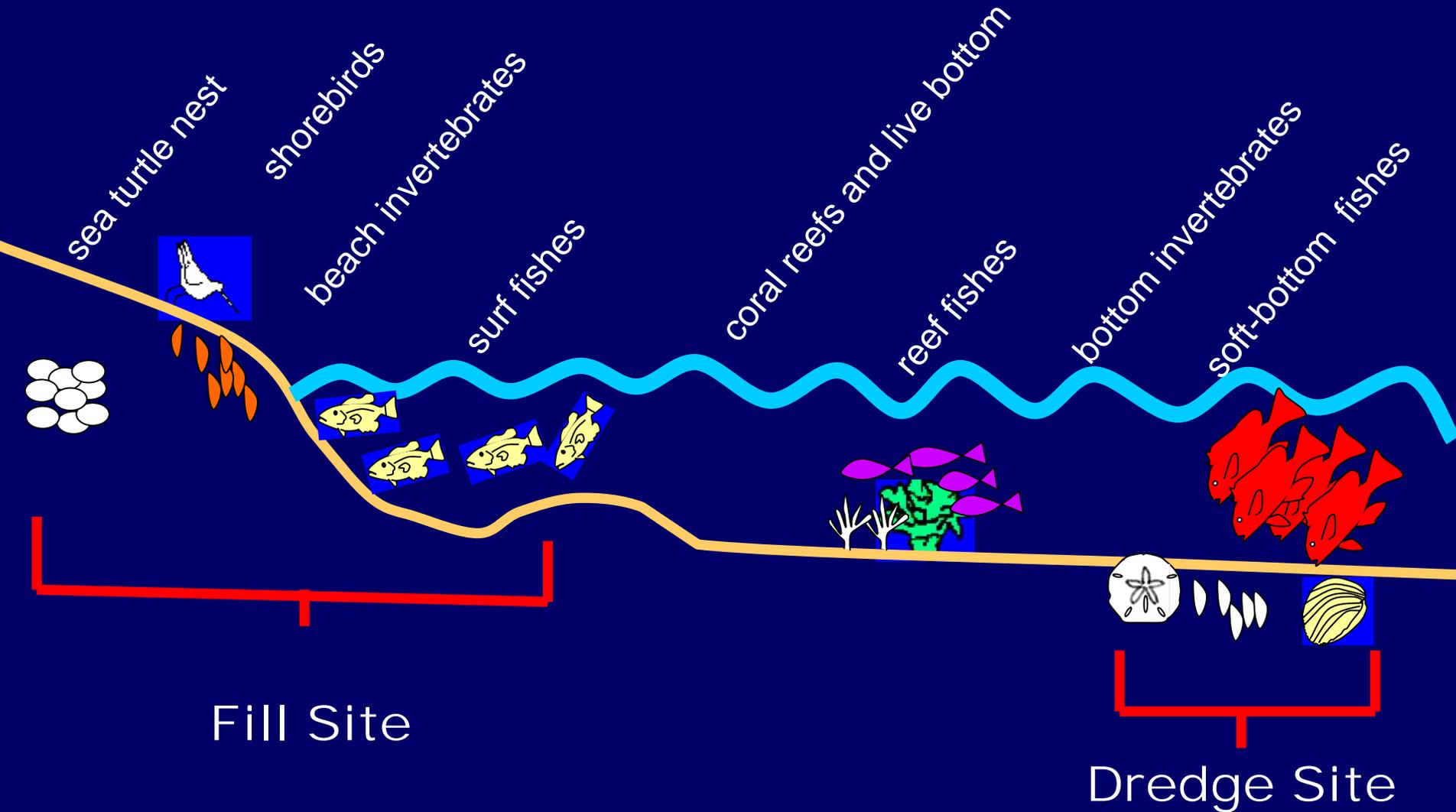
Dredge



Fill

Beach

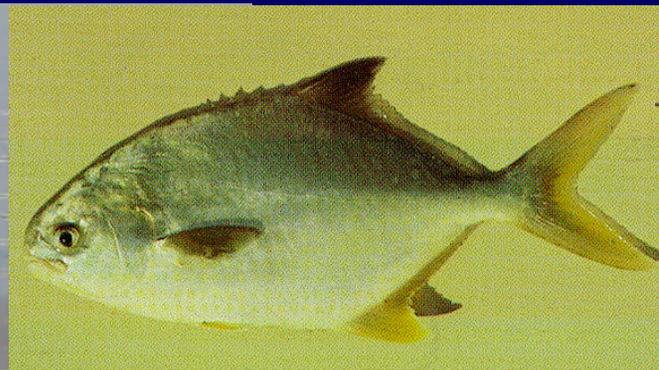
Coastal Ocean



Paradox

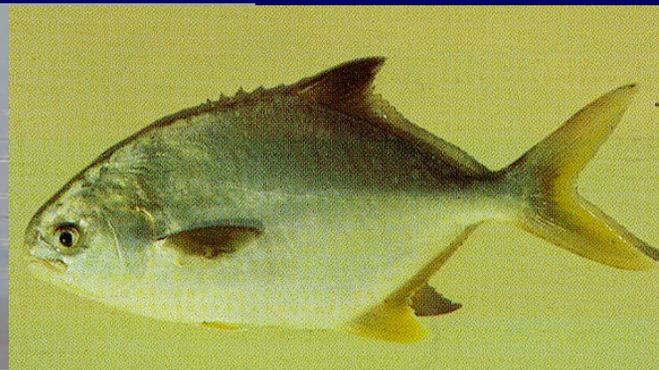
- 1922-1987: 400 miles of US shoreline nourished
- permits for beach nourishment typically require ecological monitoring \Rightarrow scores of monitoring studies

Why is there great uncertainty regarding ecological impacts of nourishment?



Resolution of paradox

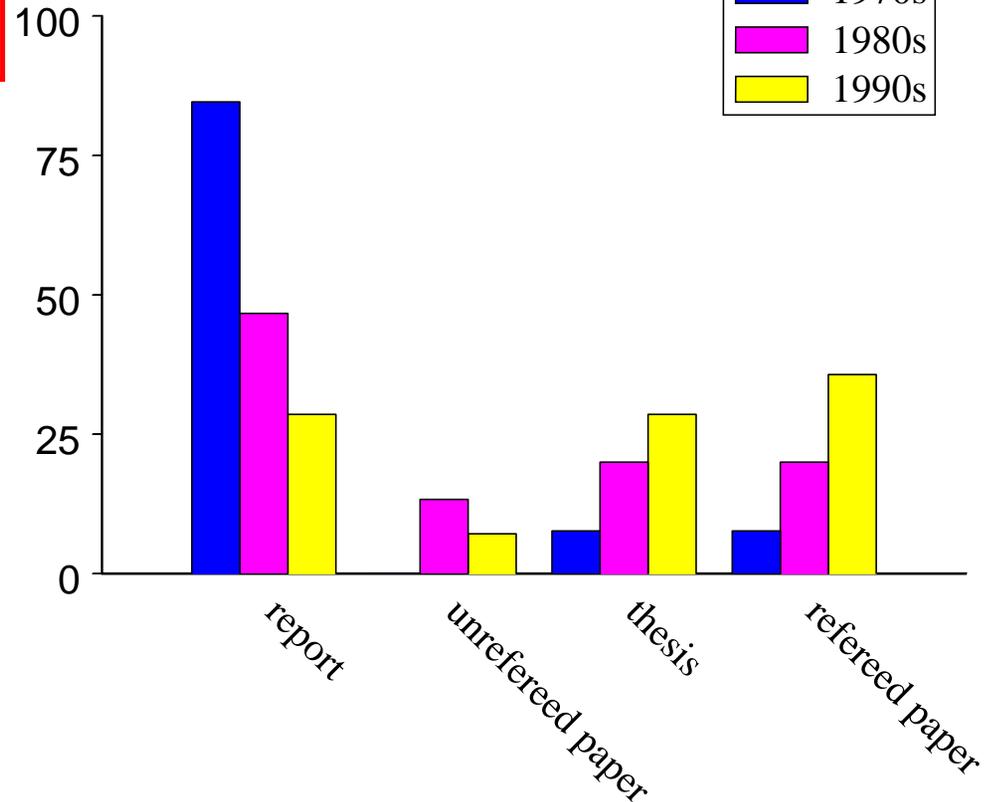
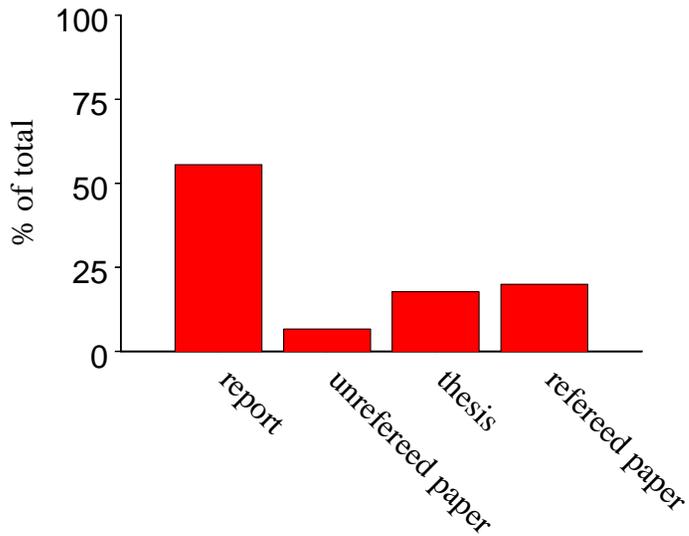
- Synthesis of designs of previous monitoring studies
- Review agency process of permitting beach nourishment



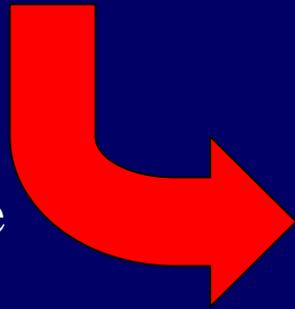
Assessment of study designs

- All available (45) US studies evaluating ecological impacts of beach nourishment
- 2 independent reviews of each (some published in multiple forms)
 - type of study
 - biological and physical variables measured
 - sampling design
 - statistical analyses
 - interpretation of data
 - scholarship

Presentation of monitoring studies



Majority have never been subjected to peer review



Subject of monitoring studies

Of the 45 studies:

- 11 – impacts of dredging only
- 23 – impacts of filling only
- 11 – impacts of dredging AND filling
- 1 – included manipulative experiments;
- 0 – included modeling

Most studied – impacts of filling on macroinvertebrates
(53% of studies)

% of studies (by taxon) examining impacts of DREDGING that measure important environmental variables

	macroinvertebrates		fish
	soft bottom	hard bottom	
	(<i>n</i> = 16)	(<i>n</i> = 8)	(<i>n</i> = 7)
turbidity	13	25	29
sedimentation	13	50	0
mean grain size	56	13	14
sediment grain size distribution	56	38	29
sediment mineralogy	25	0	14
organic content of sediment	44	13	29
sediment compaction	0	0	0
topography	0	0	0
direct physical contact	0	25	0
no environmental variables measured	25	38	57

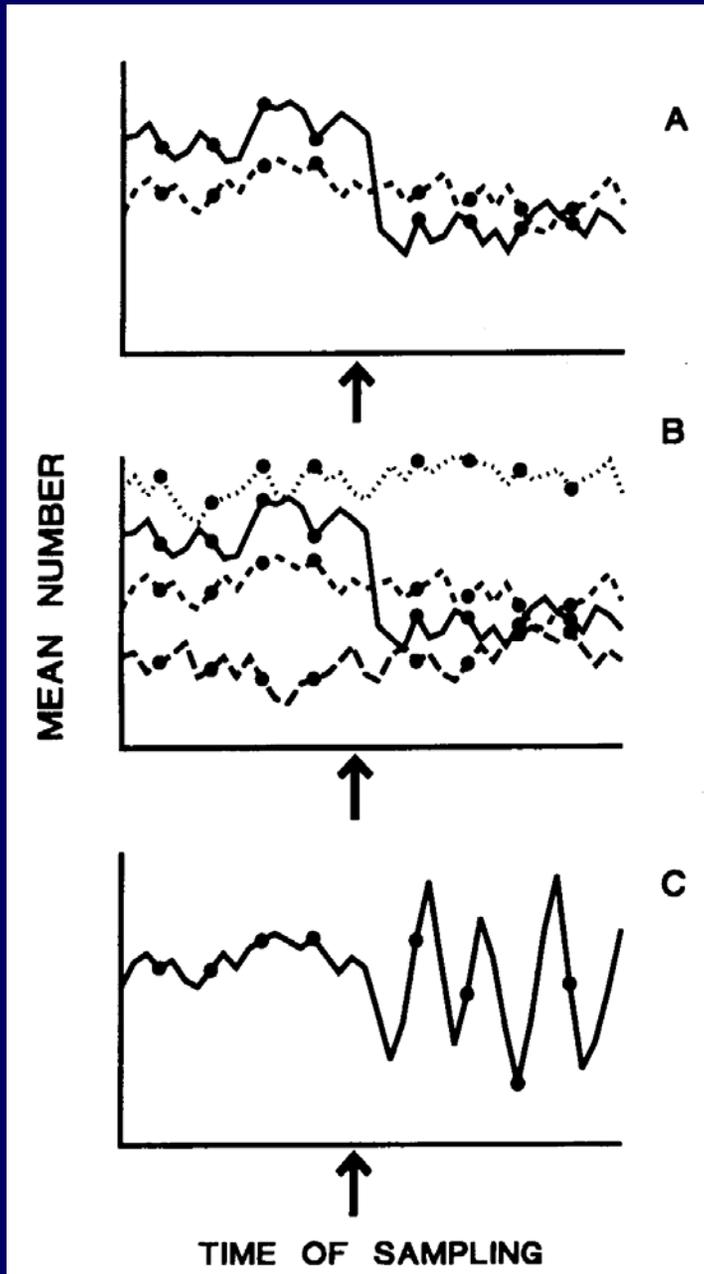
Analyses testing for relationships between biological and physical variables
only included 4% of the time

% of studies (by taxon) examining impacts of FILLING that measure important environmental variables

	macroinvertebrates		fish	sea turtles
	soft bottom	hard bottom		
	(<i>n</i> = 26)	(<i>n</i> = 5)	(<i>n</i> = 10)	(<i>n</i> = 5)
turbidity	27	0	50	0
sedimentation	4	20	0	0
mean grain size	62	20	20	20
sediment grain size distribution	58	20	20	40
shell cover	4	0	20	0
sediment mineralogy	27	0	0	0
organic content of sediment	31	0	0	0
sediment compaction	4	0	0	80
slope of swash zone	31	0	20	0
topography (other)	27	0	30	0
no environmental variables measured	15	80	10	0

Analyses testing for relationships between biological and physical variables only included 11% of the time

Experimental design

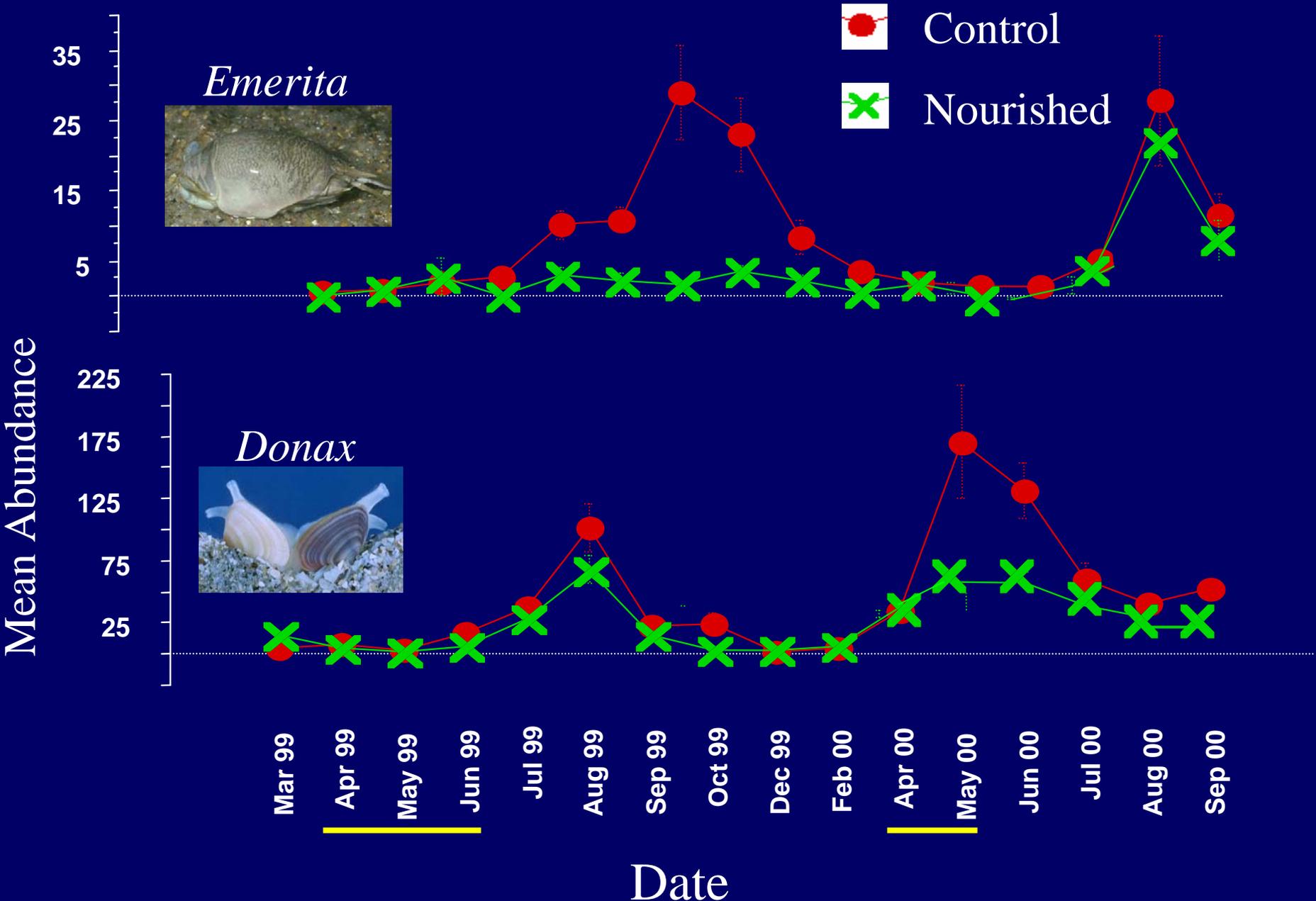


49% of studies fail to include both spatial AND temporal components in their design

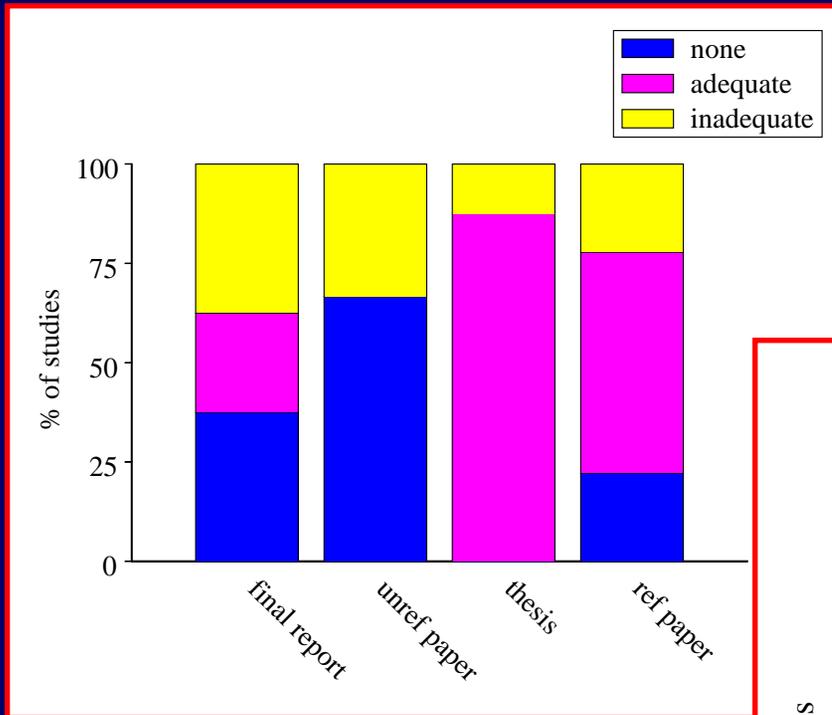
Only 37% of studies include multiple controls (usually not interspersed).
17% contain NO controls.

Of the 51% of studies that do include spatial and temporal components, only 8 % test for an impact using a BACI analysis.

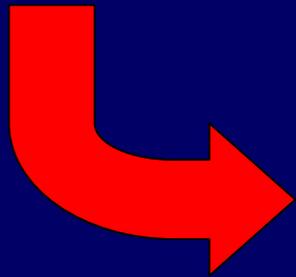
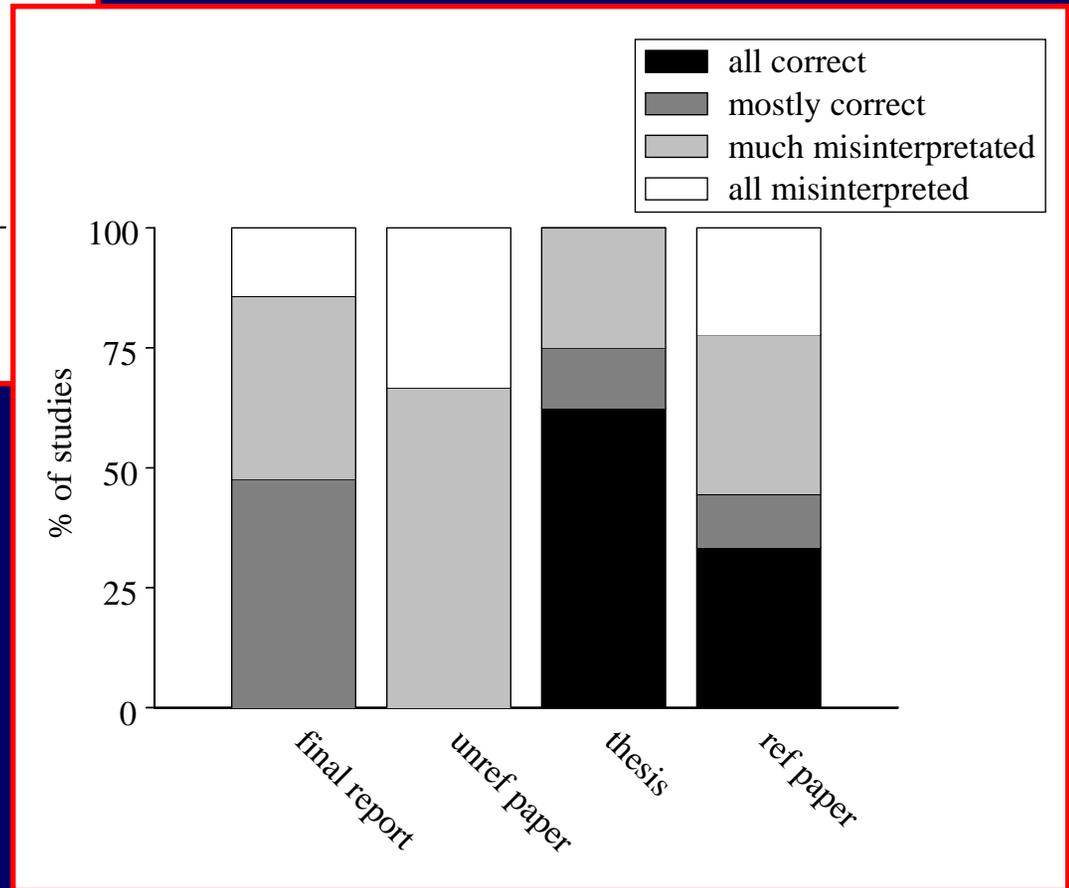
39 % of studies do not control for seasonal variability



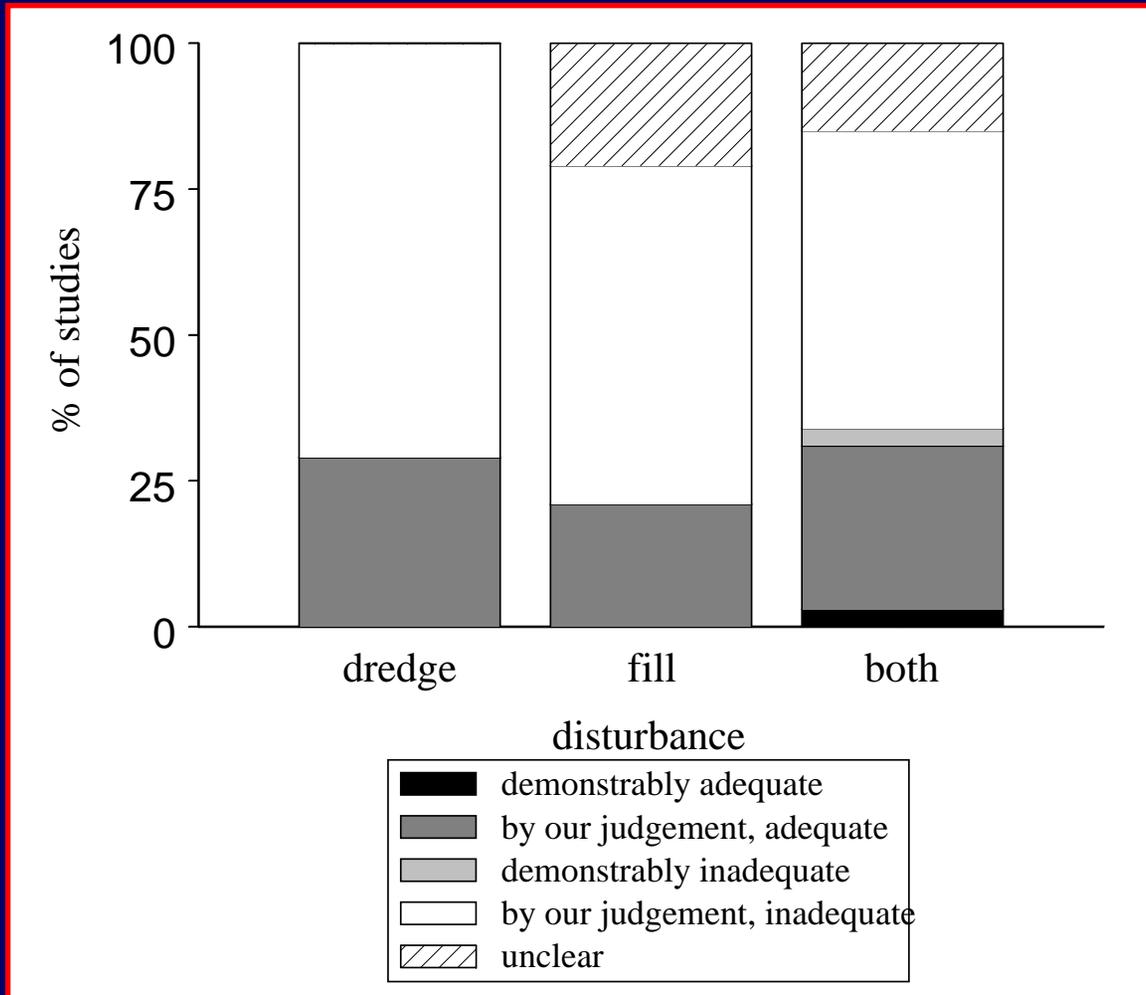
Statistical analysis of data



Interpretation



Statistical Power



- Only 1 study included an appropriate *a priori* power analysis
- 1 study included an appropriate *a posteriori* power analysis

Scholarship

- 7% of studies did not review literature; 42% included a review below publication (MEPS) standard
- 21% of studies did not discuss results with respect to potential mechanisms
- 54% of studies drew conclusions not supported by results and analyses

Most critical shortcomings

1. Uniform absence of experimental manipulations and modeling
2. Widespread omission of tests of relationships between biological and physical variables
3. Failure to employ the required BACI design to test for impact
4. Lack of consideration of statistical power
5. Failure to reach conclusions of publication standard
6. High proportion reaching conclusions that are not supported by data

Who pays for this?

Federal Contribution

Protection of public shore: 50-65%

Recreational purposes: 50%

Protection of private private property: 0%

**Where federal funds involved, responsibility of
US Army Corps of Engineers**



Why is quality so poor?

- Neither state nor federal permitting agencies employ anonymous process of peer review of sampling designs or final reports
- Failure to incorporate manipulative experiments and modeling into monitoring projects
- Lack of explicit goals
 - [1. Address unanswered questions about environmental impacts
 - 2. Identify injury to public trust so as to allow compensatory mitigation]

Not for lack of funding...

“because inter-annual variation of surf zone fish community dynamics is considerable, it is unlikely that anything other than catastrophic impacts on surf zone fishes would be evident.”



USACE \$8.6 million dollar monitoring project, NJ

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