

*Panel 2: Lessons Learned and Recommendations for
Oyster Restoration/Enhancement Project Directions,
Designs, and Downfalls*



Loren D. Coen, HBOI, FAU

NC Oyster Reef Workshop

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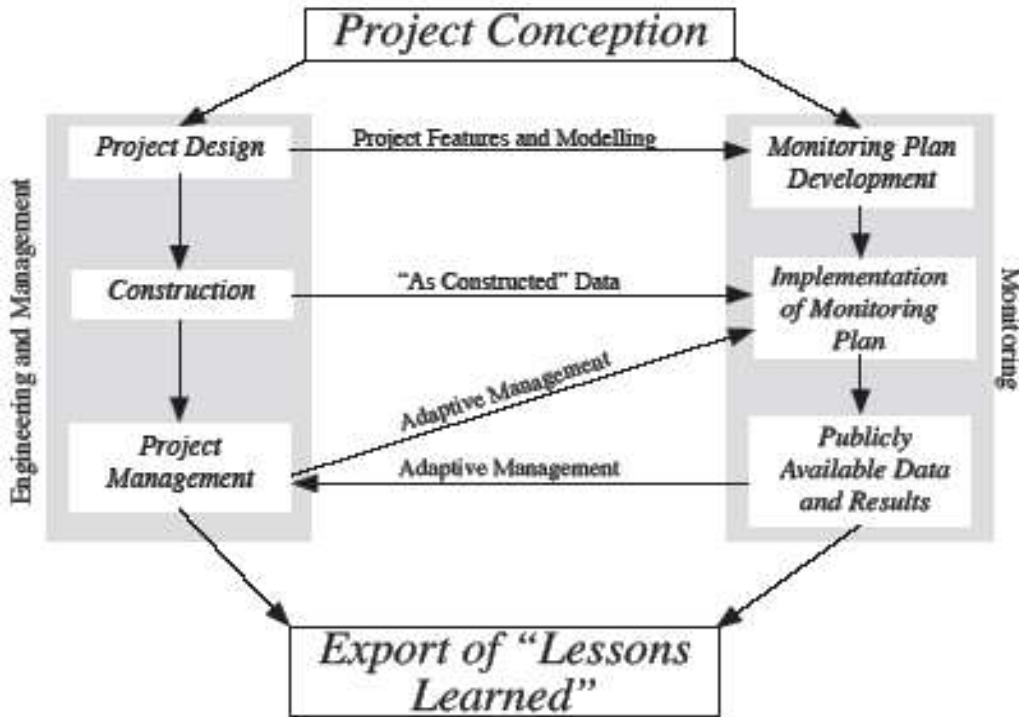
Stock Enhancement & 'Restoration'

- For oyster populations valid fisheries management objective, but at odds with most other restoration services for oyster habitats.
- Limiting restoration to “reestablishment of a species or habitat to replace lost ecosystem function” eliminates any inclusion of many fishery enhancement activities as ‘restoration’.



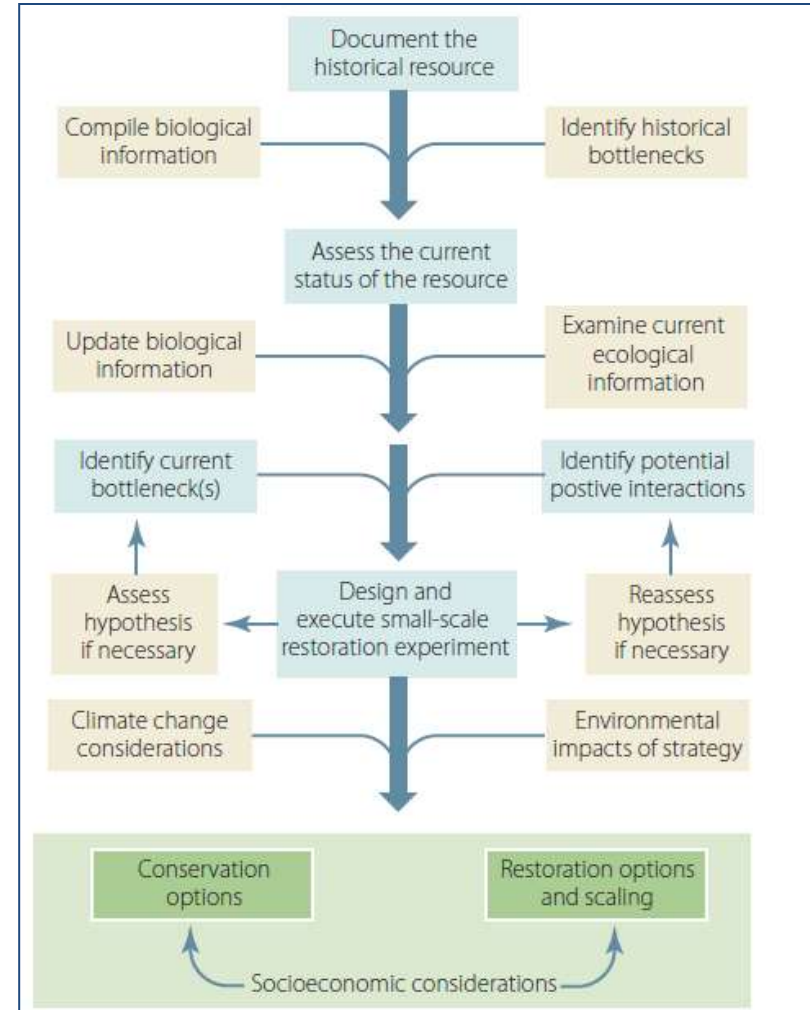
*From: Powers and Boyer, 2014. Marine Restoration Ecology. Bertness, et al., Eds.,
Marine Community Ecology and Conservation.*

Specific Monitoring and Data Inventory Protocols Now for Funded



Thayer et al., 2003. Vol. 1,
Restoration Monitoring, NOAA

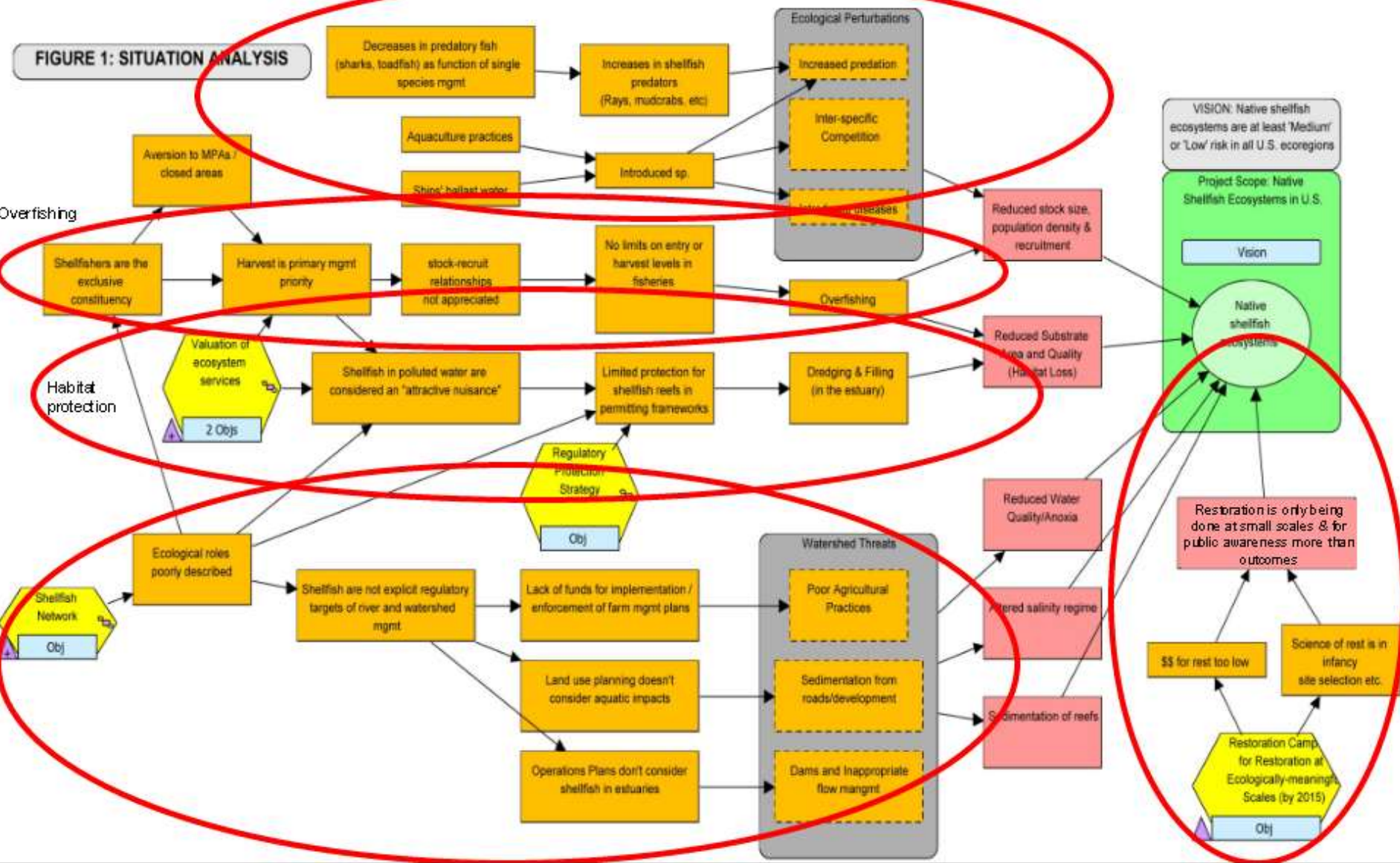
Stages for the Development and Assessment of a Restoration Plan



From: Powers and Boyer, 2014. Also M. Palmer et al.
2005, 2006, etc.

Situation Analysis – National Shellfish Strategy

FIGURE 1: SITUATION ANALYSIS



Regional Paradigms

Oyster Sentinel in GOM

Subtidal oyster distributions used to:

- Evaluate the salinities for oysters, control parasites and predators
- Model the impact of freshwater (salinity) alterations
- Select sites for reef restoration
- Estimate sustainable harvests

Assumptions: Optimum salinities for subtidal oysters 10-20 psu. Higher salinities (>15 psu) are optimum for *Perkinsus* and reduce the oysters ability to resist Dermo

http://gbic.tamug.edu/partner_pif.ASP?pif=TAMUG-24
<http://www.oystersentinel.org/>

Restoration Suitability Index

This Restoration Suitability Index (RSI) is designed to assist in the selection of sites for reef restoration and cultch planting based on historical salinity records. The user can eliminate sites with low RSI values and further consider sites with high RSI. Minimum salinity requirements of the model are monthly means for the previous ten years. From monthly means the mean salinity during the spawning season, and annual mean salinity are calculated. Mean interval (years) between killing floods is determined from the historical salinity record. With a record of monthly mean salinities, a killing flood could be defined as one in which the monthly mean salinity is ≤ 2 .

MEAN SALINITY DURING THE SPAWNING SEASON

HISTORIC MEAN SALINITY

MEAN INTERVAL BETWEEN KILLING FLOODS

Habitat Suitability Index

This Habitat Suitability Index (HSI) evaluates the impact of salinity alterations on oyster habitat. The user defines the area of interest and determines the percent of bottom covered with suitable cultch. Minimum salinity requirements of the model are monthly means for a year. From monthly means the mean salinity during the spawning season, and annual mean salinity are calculated. Minimum annual salinity is the lowest mean monthly salinity in the annual record. This HSI is thus an evaluation of a single site (area) for a single year, without reference to historical trends. An application of the model is to compare HSIs for a site within a year calculated with and without salinity alterations.

PERCENT OF BOTTOM COVERED WITH SUITABLE CULTCH

MEAN SALINITY DURING THE SPAWNING SEASON

MINIMUM ANNUAL SALINITY

ANNUAL MEAN SALINITY

Shell Budget Demo

Welcome to the shell budget model demonstration. This model applies to the northern Gulf of Mexico only.

In this demo, you will be able to input **oyster counts** and **cultch density** (clean oyster shell weight) of an oyster reef.

Then, you'll be able to input a **fishing rate**, **growth rate** and **mortality rate** as variables of the simulation. From that, you will be able to determine if reef cultch is lost or gained.

Inputs: reef size, cultch density, fished or closed, oysters removed (by size/mo), growth, etc.

Observed Local Paradigms

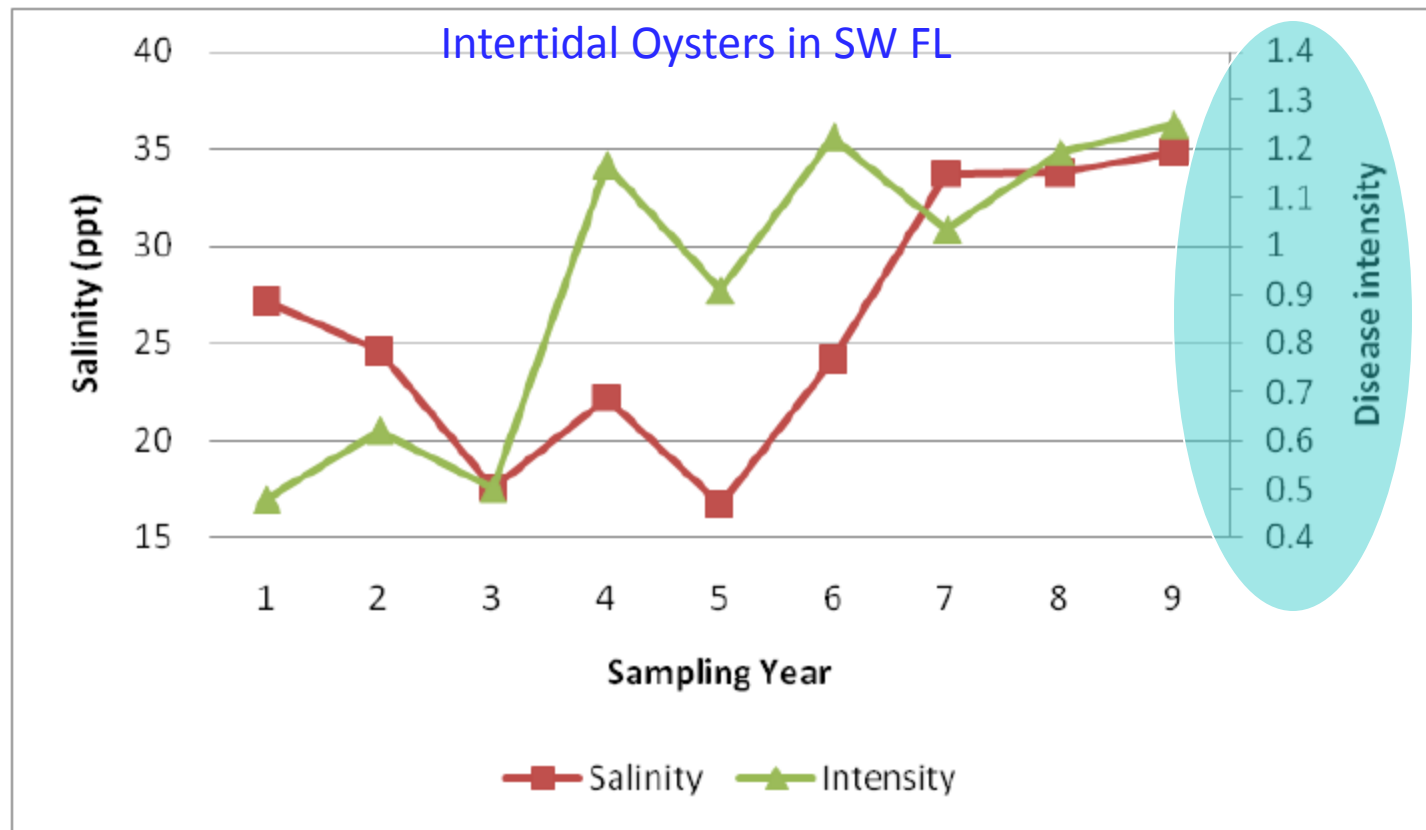


Figure 6: Mean *Perkinsus marinus* intensity (on a scale of 0-5) and salinity averaged across all the sampling locations in the Caloosahatchee Estuary during the sampling period. Sampling years 1-9 are 2001-2009, respectively.

(1-9) are from upstream to downstream within the estuary.

SC Workshop

Goals & Most Relevant Metrics

RESTORATION GOAL(S)

METRIC	Habitat	Shoreline	WQ	Harvesting	Broodstock	Education
Reef Size	X	X	X	X	X	
Reef Condition						
Density	X	X	X	X	X	X
Size Frequency	X	X	X	X	X	?
Associated Fauna	X					X
Reef Architecture	X	X	?	X		X
Reef Fragmentation	X	X	?	X	X	
Salinity	X		X	X	X	X
DO	X (sub)		X	X	X	X
Chlorophyll <i>a</i>			X			
Turbidity/TSS			X			X
Temperature	X (Int.)		X		X	

Top Ten Ranked Site Selection Criteria Based on Responses from *C. virginica* Restoration Practitioners

SUBTIDAL		INTERTIDAL
Reef depth	1	Primary substrate
Harvest status	2	Boat traffic/wakes
Primary substrate	3	Average salinity
<i>Substrate firmness</i>	4	<i>Substrate firmness</i>
Water quality	5	Siltation/sedimentation
Average salinity	6	Harvest status
Elevation off bottom	7	Politics/jurisdiction/permitting
Disease	8	Height relative to MLW
Siltation/sedimentation	9	Typical recruitment
Ownership issues/permitting	10	Water quality

Broodstock Enhancement or Remote Setting to Jump-Start Reefs

Often goes hand in hand with shell (“cultch”) planting

From: Ray Grizzle, UNH



Few million larvae
But---\$2000



Spat



SOS



From: CBF

- Large or small-scale efforts
- Requires larvae (\$\$) to “remote” set larvae (then ‘spat’) onto substrates (SOS) for later deployment
- Test hatchery “lines” that have disease-resistant, fast growth (2n or 3n), etc.
- Jump-start reefs or use where recruitment is very limiting)
- Vary size of “seed” oysters (mm-cm but cost rises!!)



NYC: SOS



SOS

From: CBF

6 mo. old seed oysters



From: E. Gatling, Kiwanis Club of Suburban Norfolk



Novel Approaches for Field Sets



Steppe, et al., 2010. *In situ* setting of hatchery reared eyed larvae on a restored *Crassostrea virginica* bar. ICSR. Charleston, Nov. 2010. <http://www.scseagrant.org/content/?cid=468>.

Fredriksson, et al. 2010. Aquacult. Engineering 42:57-69.

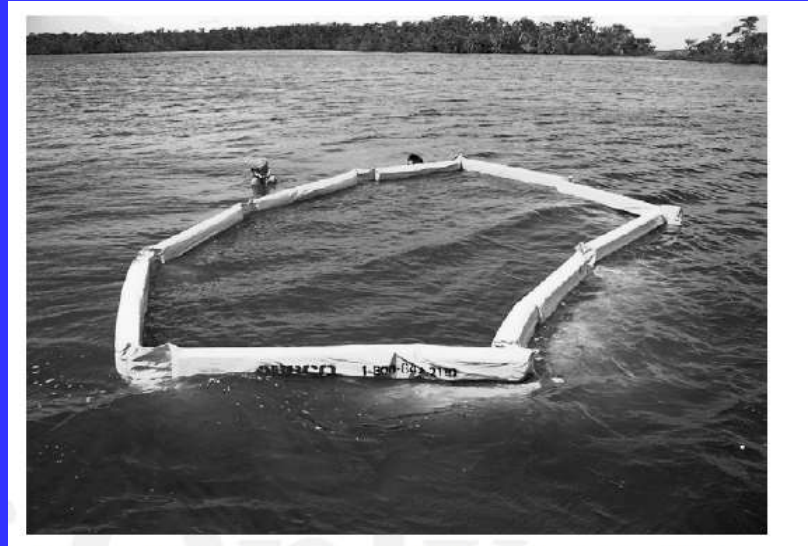


Figure 1. Completed sediment curtain deployment forming a larval release enclosure.

Leverone, et al., 2010. Increase in bay scallop (*Argopecten irradians*) populations following release of competent larvae in two west Florida estuaries. J. Shellfish Res. 29 395-406.

Assessing Oyster Recruitment, Growth, and Habitat Quality Across Sites



State-Wide Oyster Assessments

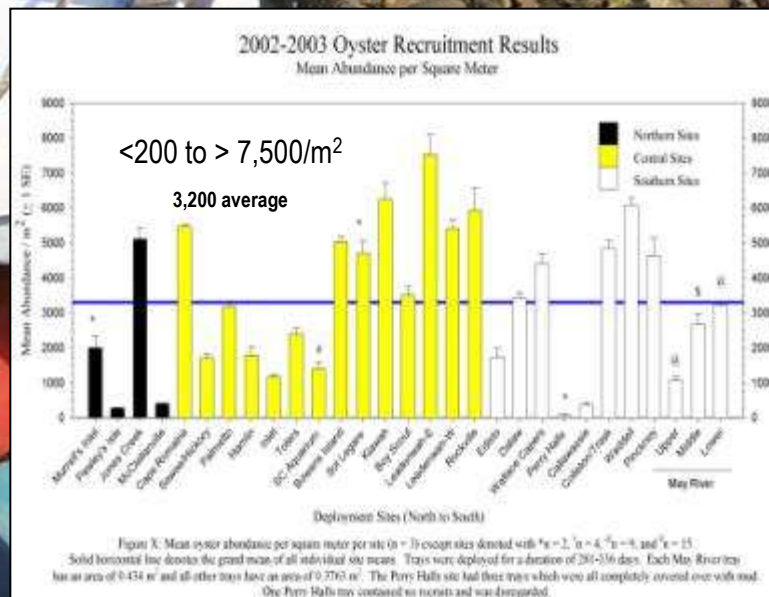
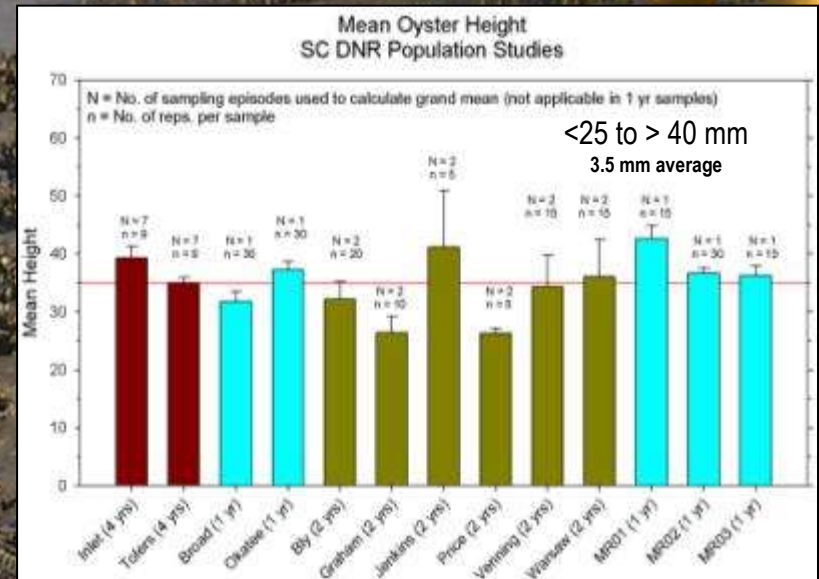
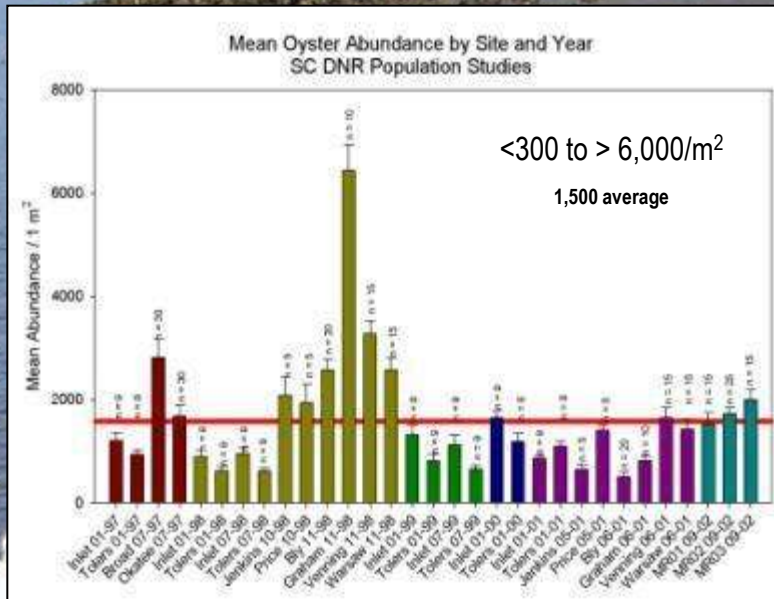


Figure X. Mean oyster abundance per square meter per site (n = 3) except sites denoted with *n = 2, n = 4, n = 8, and n = 15. Solid horizontal line denotes the grand mean of all individual site means. Trays were deployed for a duration of 281-336 days. Each May River tray has an area of 0.434 m² and all other trays have an area of 0.2767 m². The Perry Hills site had three trays which were all completely covered over with mud. One Perry Hills tray contained no recruits and was discarded.

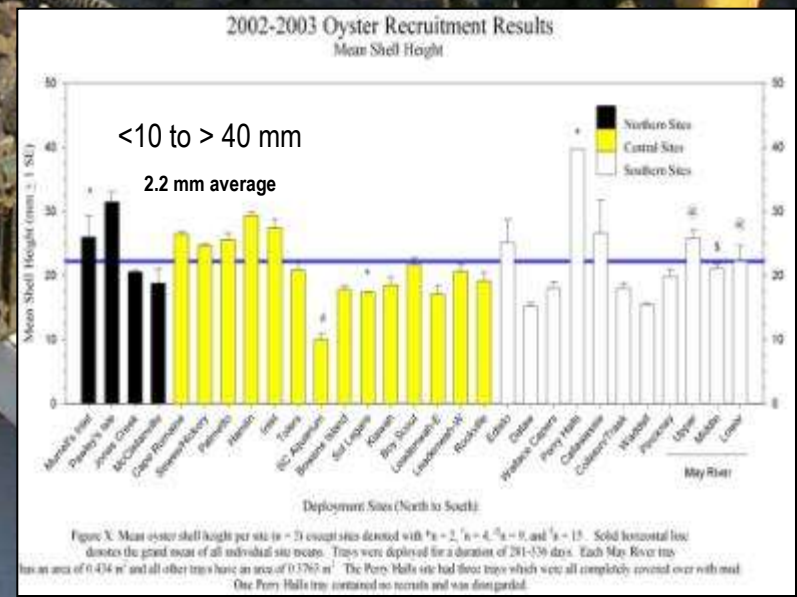


Figure X. Mean oyster shell height per site (n = 3) except sites denoted with *n = 2, n = 4, n = 8, and n = 15. Solid horizontal line denotes the grand mean of all individual site means. Trays were deployed for a duration of 281-336 days. Each May River tray has an area of 0.434 m² and all other trays have an area of 0.2767 m². The Perry Hills site had three trays which were all completely covered over with mud. One Perry Hills tray contained no recruits and was discarded.

Collecting Reef-Associated “Transients”

Block Nets, SC



From D. Allen, USC-Baruch Lab

Trawling, Encircling Nets, VA



From M. Luckenbach, Nestlerode

Lift Nets, SC



From L. Coen

Video Recording, MD



Drop Cylinders, TX

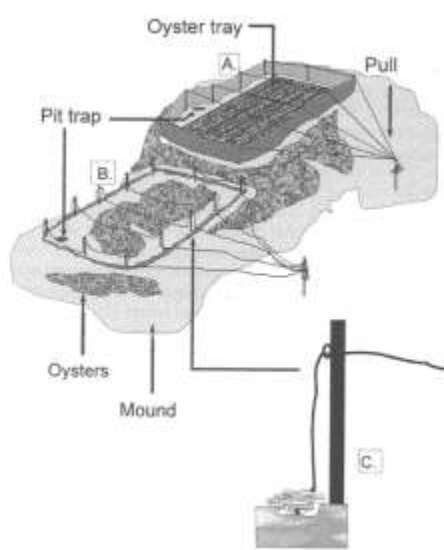


From T. Minello, NMFS

Seining, VA



From M. Luckenbach, VIMS



See Wenner et al. 1996; Coen et al. 1999, ASMFC 2007

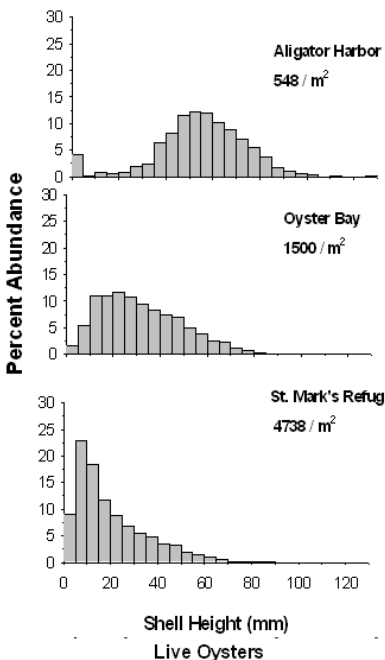


Summary of Intertidal Habitat Collections (n = 5): All Dates (Sept./May), Individuals and Biomass (Ranking)

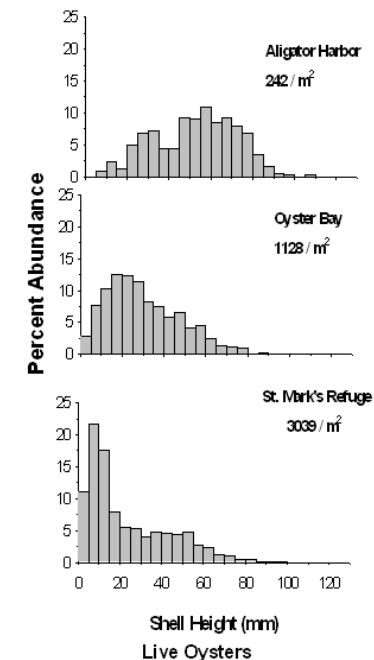
Totals	Oyster Reef	Fringing Marsh	Mudflat
Abundance	3,988 (2)	9,021 (1)	1,550 (3)
Biomass (g/360 m ²)	14,264 (1)	15,169 (1)	3,968 (3)



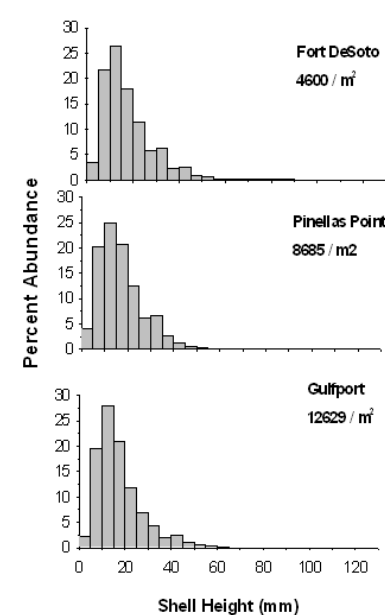
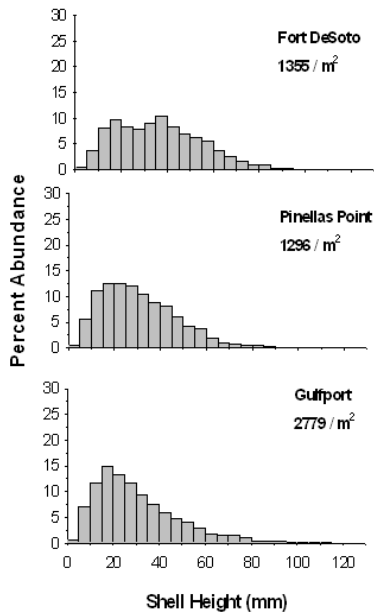
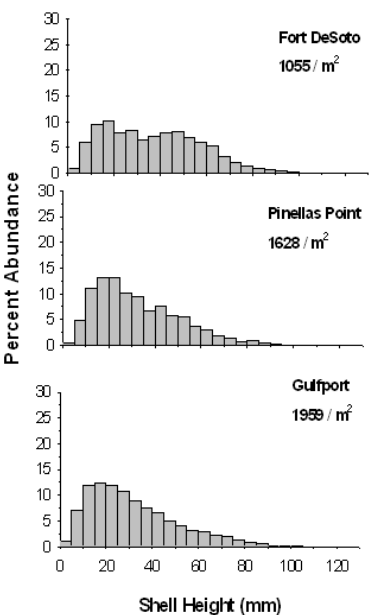
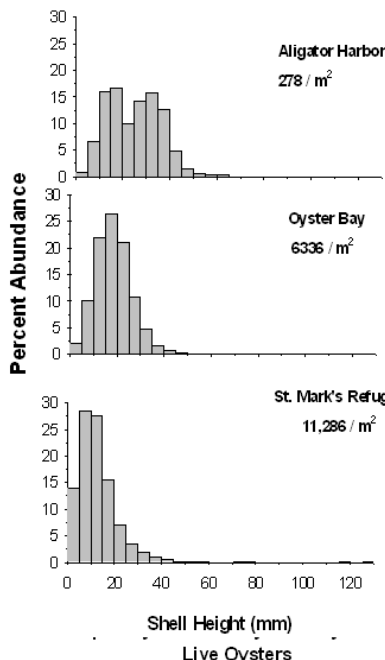
Florida Panhandle Dec 2010 Oyster Survey Live Oysters



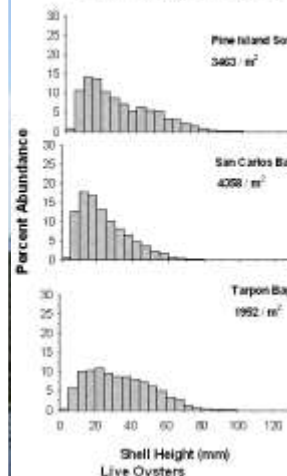
Florida Panhandle Dec 2011 Oyster Survey Live Oysters



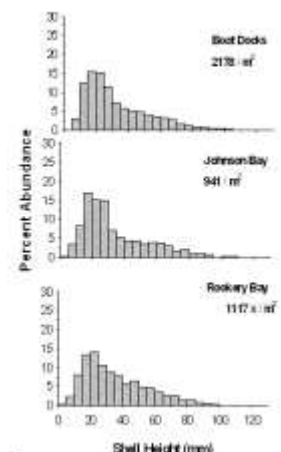
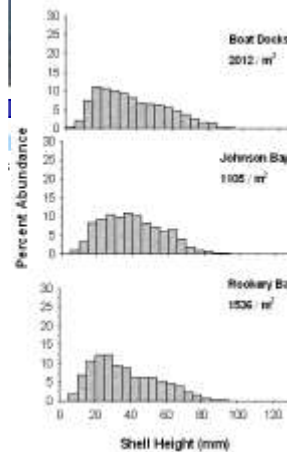
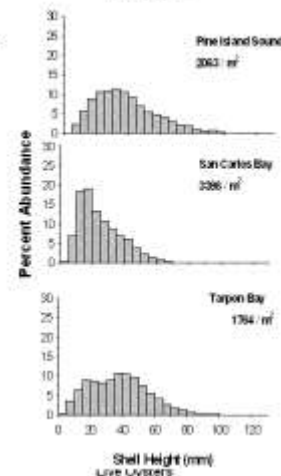
Florida Panhandle Oct 2011 Oyster Trays Live Oysters



Pine Island Sound - Jan-Feb 2011 Oyster Survey - Live Oysters

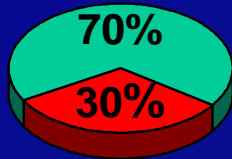


Pine Island Sound Dec 2011 Oyster survey Live Oysters



Oyster Habitat in “Closed Areas” & Non-Traditional Substrates

SC Shellfish Approved Harvesting Waters



Polluted Waters

- All of the natural ‘Ecosystem Services’
- Administrative closures = ‘Reserves’
- Enhancing genetic diversity of available populations.



Oyster Habitats in an Urban Landscape: Lynnhaven, VA



Value of Other Settlement Substrates

40% of live oysters found in “non-traditional” habitats that typically would NOT be sampled in a typical ‘fishery-only based’ assessment (Ross, Luckenbach, Birch and Coen, NSA 2006)

Enhancement of Adjacent Habitats (Regulating)

Protect and/or enhance shoreward vegetated habitats through wave attenuation and forming more “resilient” shorelines

- Can include *Living Shorelines (LS)*
- Reduced erosion via enhancement of natural plant survival through regrowth or novel plantings
- Often a “landscape” of two or more adjacent habitats

Causes

- Loss from boat wakes (anthropogenic causes)
- Tidal and wind driven flows (natural)
- Impacts from native and non-native plant herbivores, burrowers, etc.



Shoreline Stabilization Pilot Efforts



After 16 months, constructed intertidal reef's presence enhanced marsh regrowth



After 34 months