An Overview of Restoration Efforts for the Eastern Oyster, *Crassostrea virginica*: Some Successes and a Lot of Lessons Learned

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http://www.coastal.edu/marine/sgoyster

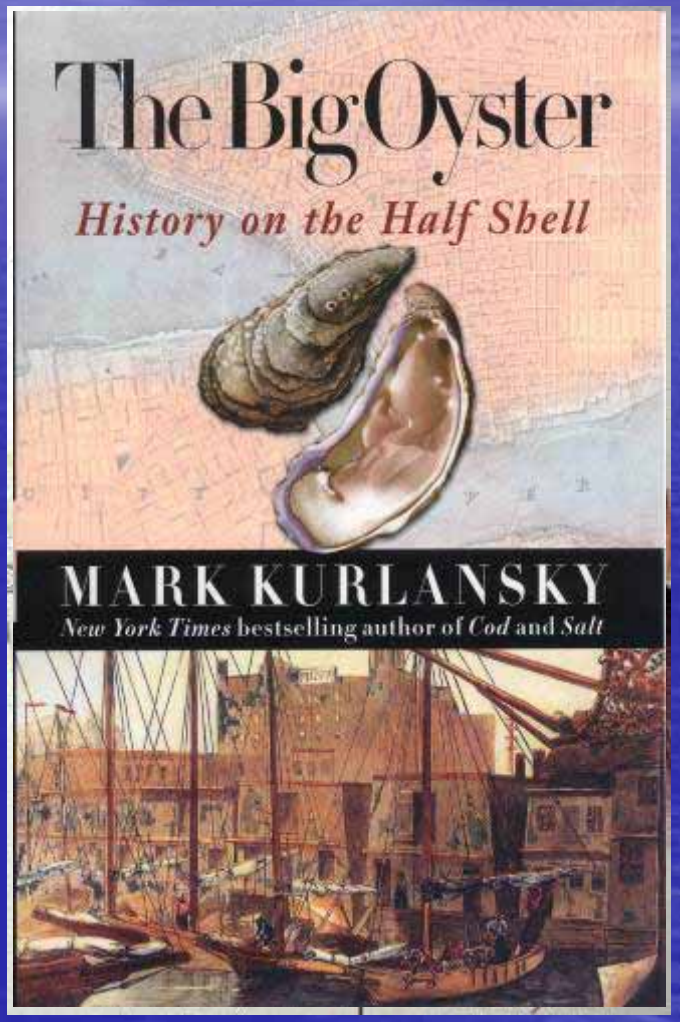
Overview of Talk

- U.S. fishery
  - East Coast vs. Gulf of Mexico
- Intertidal oysters in the southeastern U.S., elsewhere
- Why invest in restoration? Numerous "ecosystem services", intertidal erosion
- Lessons (19 total)
- 2004 Workshop
  - Assessing ecological function, sustainability & reef success, 'monitoring'
  - Goal(s), reef 'siting' characteristics
  - Natural & constructed reefs metrics, their monitoring for success
  - Novel approaches/methods

The good old days...

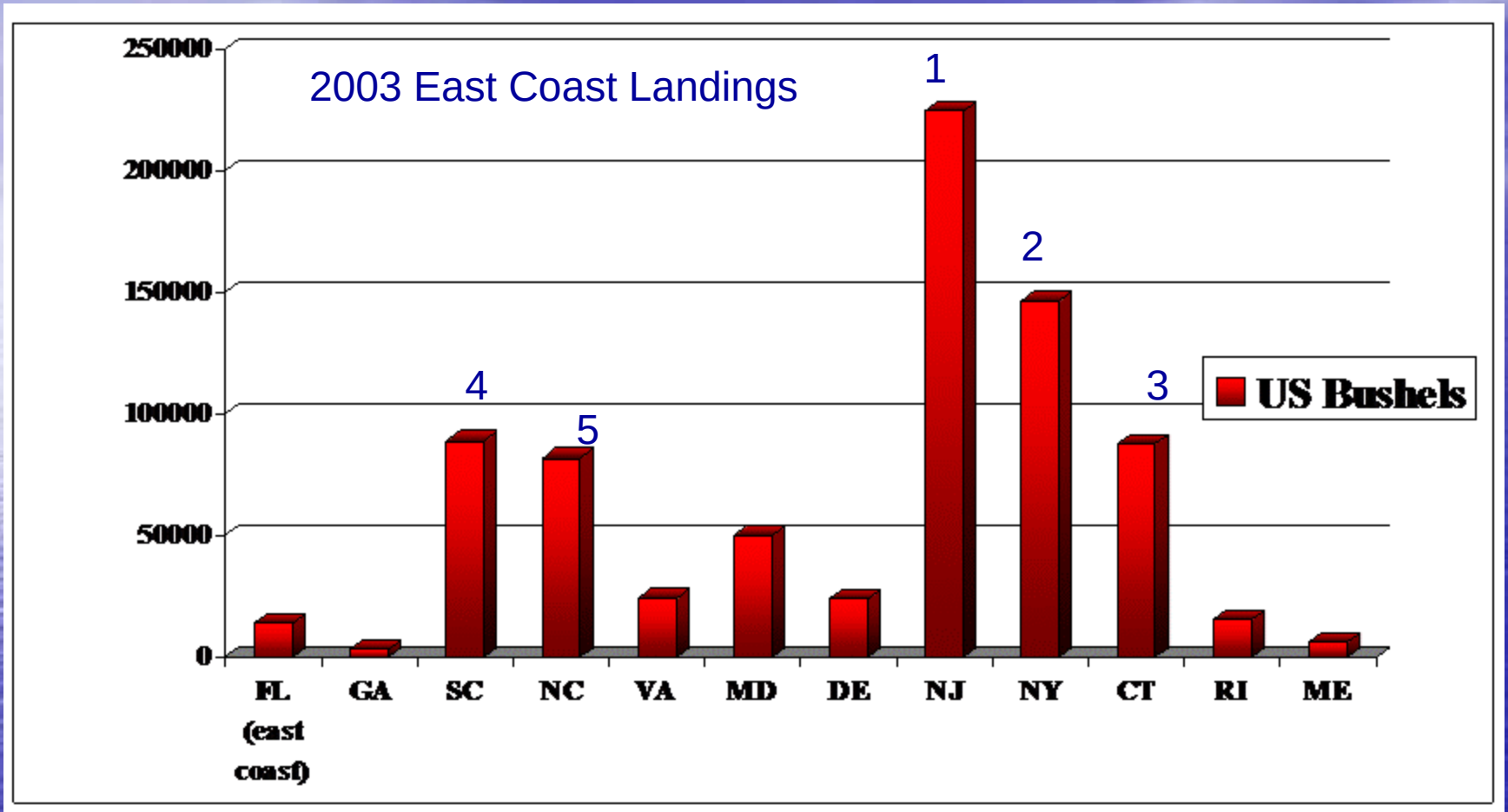
"The abundance of oysters is incredible. There are whole banks of them so that the ships must avoid them.... They surpass those in England by far in size...they are four times as large. I often cut them in two, before I could put them in my mouth."

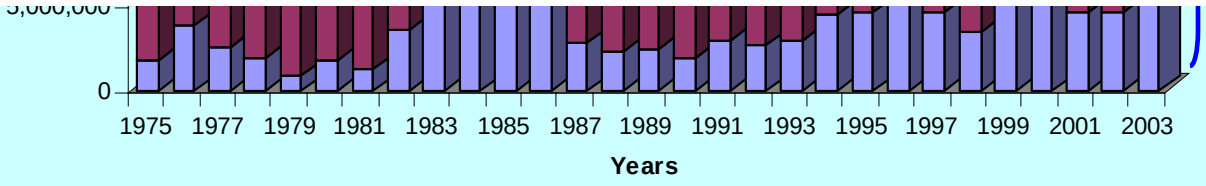
From: J. Wharton, 1957. *The Bounty of the Chesapeake: Fishing in Colonial Virginia.* University Press of Virginia, Charlottesville, VA.



Is their return possible?

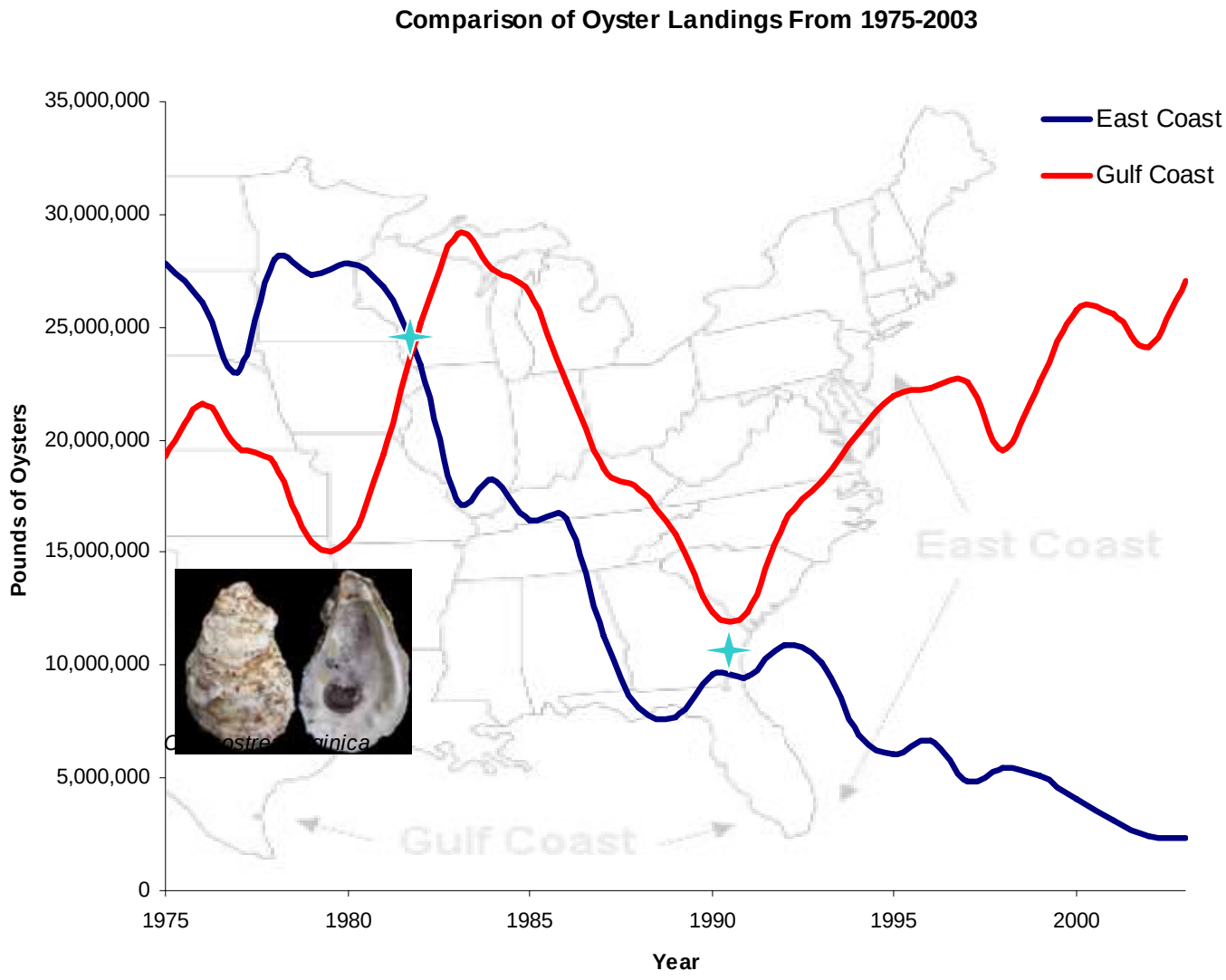
All U.S. States (Atlantic, Gulf of Mexico)





SR

Gulf of Mexico versus East Coast (41-92%)



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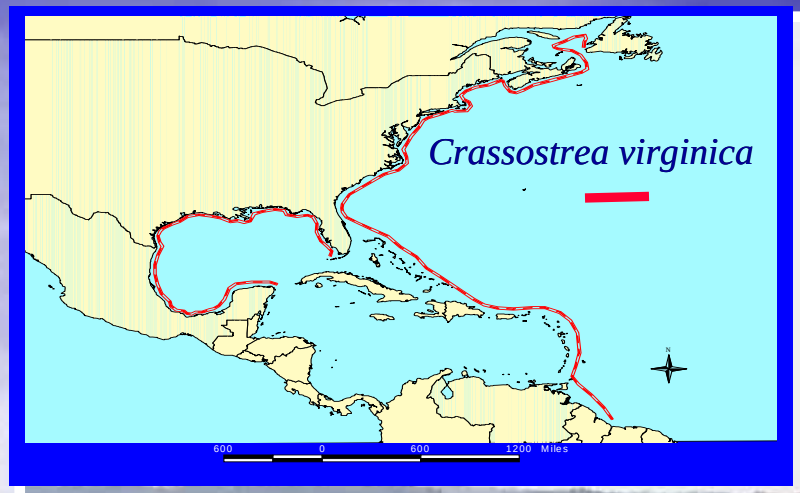
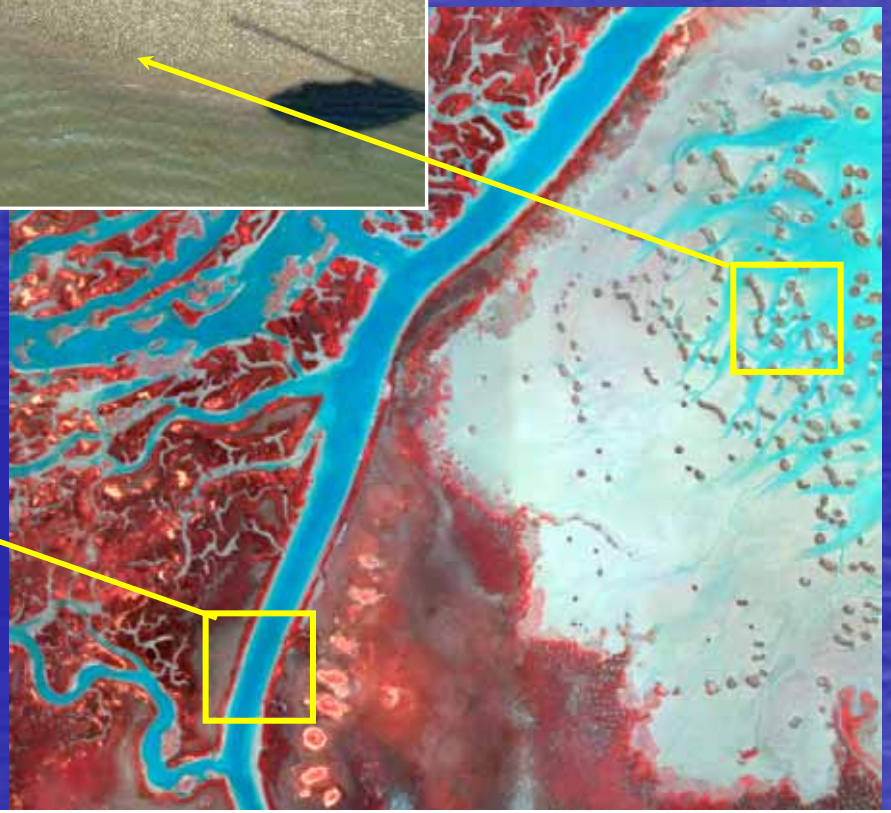


95% of SC are intertidal (above MLW)
Paralleled in southern portion of NC, GA, FL, seaside of VA

Southeastern U.S., Intertidal Oysters: 'Flats' & 'Fringing Reefs'



Intact Intertidal Reefs Form Natural Breakwaters

- Protect fringing salt-marsh
- Reduce bank erosion
- Bind/trap sediments
- Dissipate energy from tidal/ wind/boat wake impacts
- Generate a unique habitat “landscape”

We have found it impacts restoration efforts significantly!!

Some Lessons Learned or Lost and Related Observations

1. Minimize user conflicts on the front-end. Don't pit ecological vs. fishery restoration. This requires planning for coexistence; be aware of legislation threatening stakeholders. Include fishery & aquaculture stakeholders, as well as environmental/ecological service proponents. Also deal with permitting issues early;

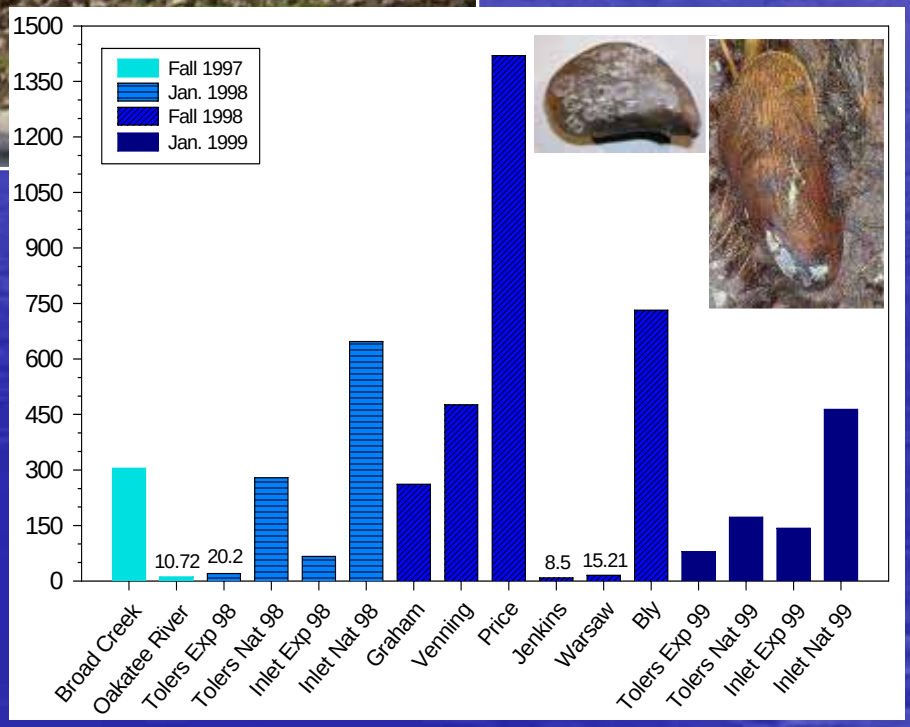
2. Understand your restoration partners, their 'constituencies' and constraints. Each group is responding to: a) different constituencies; b) different monetary constraints; c) expectations; and d) different timeframes. Each often interprets the same results differently. For large-scale restoration efforts (adding shell or broodstock, relaying oysters, spat on shell) most conducted by state fisheries managers, ACOE or large NGOs.

3. Invest in solid science by developing rigorous datasets (e.g., teams of collaborators): a) use identical methods; b) clear goals; c) use reference sites for comparison; and d) appropriate metrics to better understand success. Have focused workshops early and often!

Unanticipated ‘Players’: Birds and Mussels

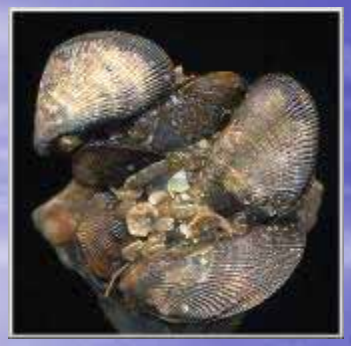
For mussels, we have a lot of population data for three spp.; for wading birds, little or no information.

However, in 2007 will start a new two year effort.



Mussel densities can exceed 1,000s/m^2

Other Filter-Feeders/Parasites/Sediment Processors



Brachidontes exustus, scorched mussel, <1.5”

Ischadium recurvum, hooked mussel , <2”

Ilyanassa obsoleta, Eastern mudsnail, <0.5”

Geukensia demissa, ribbed or marsh mussel , >4”

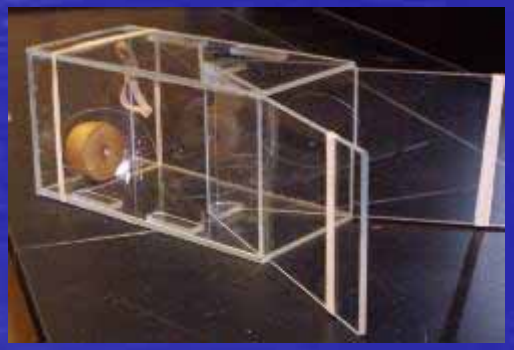
Boonea impressa (Pyramidelidae), <6 mm

Ostreola equestris, crested oyster, <2”

Some Lessons Learned or Lost and Related Observations cont.

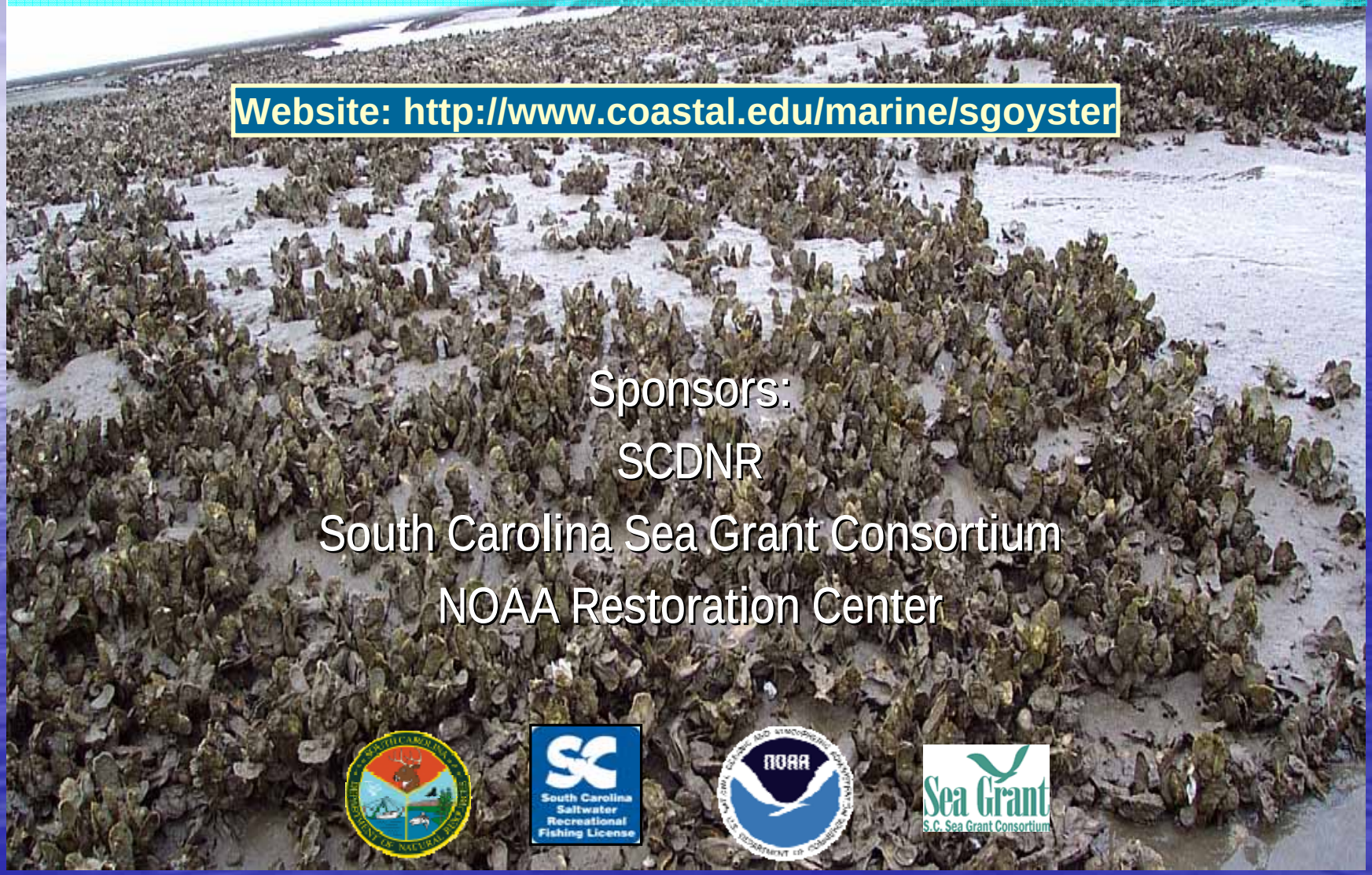
4. Take the time to develop clear, realistic goals for restoration at all levels (be it project, bay-wide, state-wide or at a regional scale). Identify the most likely areas for success and tackle them first. If 'success' is achieved (requires many years), then and only then expand to other areas (employ Adaptive Mgmt.);

5. Develop relevant and agreed upon (cost-effective) metrics to evaluate your goals. Also, don't oversell the 'Services' (e.g., water quality benefits, habitat) see Pomeroy et al. 2006.



Enhanced Biodiversity/Filtering Stressed

2004 WORKSHOP ON OYSTER RESTORATION METRICS FOR ASSESSING ECOLOGICAL FUNCTION, SUSTAINABILITY AND SUCCESS



Website: http://www.coastal.edu/marine/sgoyster

Sponsors:

SCDNR

South Carolina Sea Grant Consortium

NOAA Restoration Center

Group Proposed Six Goals

http://www.coastal.edu/marine/sgoyster

Metrics Most Relevant to Goals

RESTORATION GOAL

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 (s)		X	X	X	X
Chlorophyll *a*			X			
Turbidity/TSS			X			X
Temperature	X		X		X	

1. Restore/Enhance Over-Harvested Resources

Recruit- vs. Substrate-limited Oyster Populations

Recruit-Limited

- Broodstock insufficient
- Spat settlement low
- Reduced effective population sizes
- Still need shell &/or seed
- Subtidally, competition often with other sessile organisms
- Generally, situation subtidal

Substrate-Limited

- Recruitment high, but insufficient clean, hard substrate
- Many of these are in areas with primarily in areas with intertidal oysters (e.g., southern NC, SC, GA, parts of FL)

"Field of Dreams Approach"

Two not mutually exclusive or as clearly differentiated

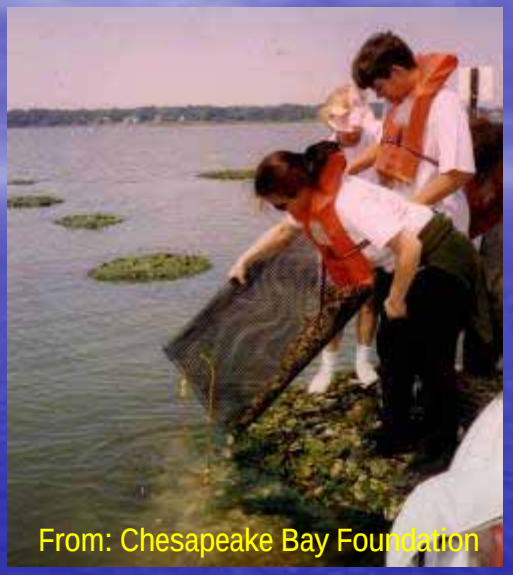
***No clear guidelines/data for evaluating sites

Assessing Reef Progress Over Time:
Oyster Populations

2. Broodstock Enhancement (Jump-starting Reefs)

Can often go hand in hand with cultch planting

From: Chesapeake Bay Foundation


From: Chesapeake Bay Foundation

- Large or small-scale
- Often employ disease-resistant strains (DEBY, CROSBreeds)
- Most often used to jump-start subtidal reefs
- Spat/seed sizes vary from mm-cm
- Community efforts often involved (‘gardening’)


From: Ed Gatling, Kiwanis Club of Suburban Norfolk, 6 mo. old oysters

3. Filtration Effects (B-P Coupling)

- Do oyster reefs remove ‘particulates’ and chlorophyll *a* as predicted?

  See Ray’s talk!

Cressman et al. 2003; Nelson et al. 2004

4. Reefs as 'Habitat'

- Faunal colonization/utilization of constructed vs. natural (='reference') reefs (100s of spp. documented)
- Use oyster populations as 'surrogates' to explain observed resident/transient faunas

Meyer and Townsend 2000

Collecting Reef-Associated "Transients"

Block Nets, SC

Trawling, VA

Lift Nets, SC

Video Recording
MD

Drop Cylinders, TX

Seining, VA

5. Shoreline Stabilization

After 16 months, constructed reef's presence enhances marsh regrowth

After 34 months

6. Public Education/Community Oyster Restoration Projects

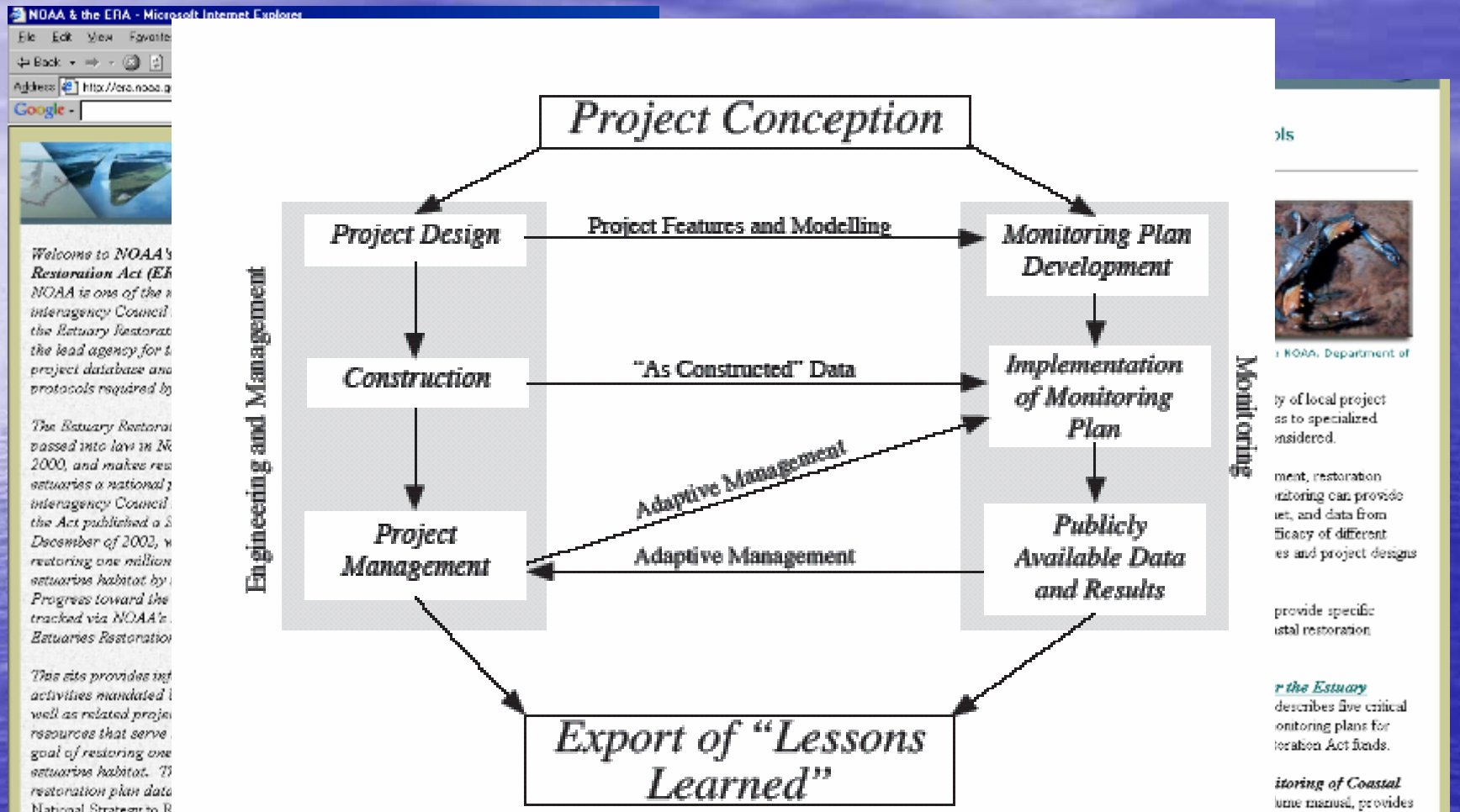
Aswani & Tolley (FGCU)

Grabowski & Powers (UNC CH)

Some Lessons Learned or Lost and Related Observations cont.

6. Start educating grant agencies immediately that monitoring is a critical phase for restoration efforts and that these efforts often require monitoring for periods >3-5 years (beyond the life of a normal grant cycle, discussed in Coen and Luckenbach 2000, Thayer et al. 2003, 2005; Luckenbach and Coen 2005, ASMFC 2007);

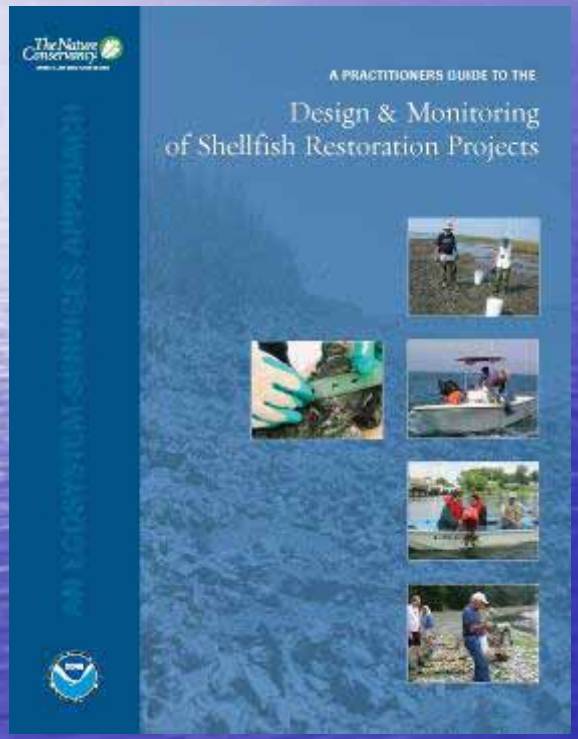
Specific Monitoring and Data Inventory Protocols Now for Funded NOAA Projects



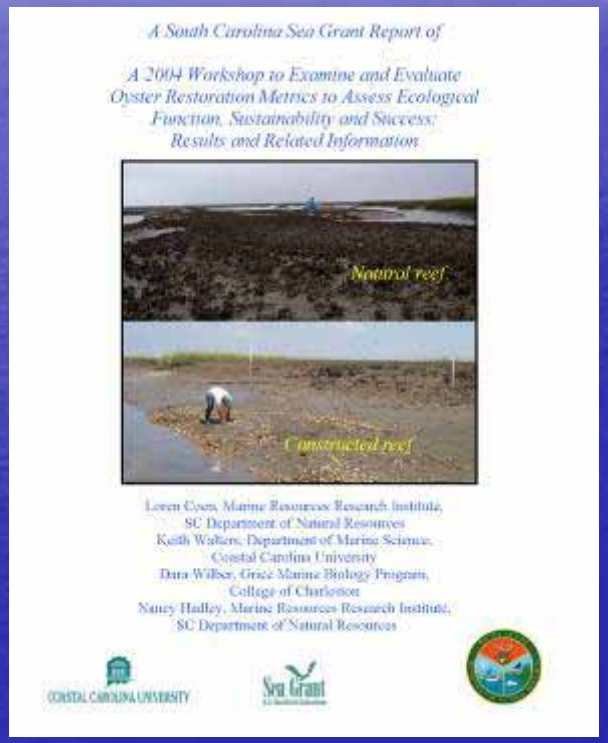
Thayer, G.W. et al. 2003

Develop Design and Monitoring Manuals, Working Groups, Websites, 'Wikis'

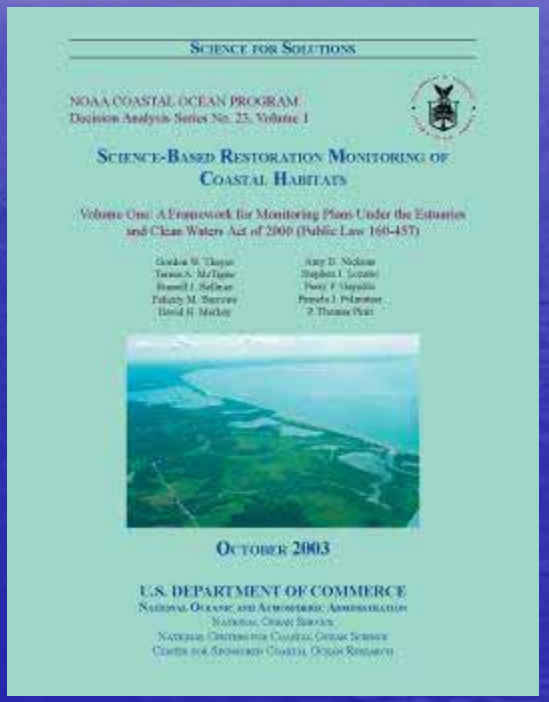
Oyster Restoration Working Group
http://www.coastal.edu/marine/sgoyster



Brumbaugh, Beck, Coen, Craig and Hicks, 2006. TNC, 28pp.



Coen, Walters, Wilber, Hadley, 2007. SC Sea Grant Publ.



Burrows et al. 2005. Ch. 4, Vol. 2, Restoration Monitoring of Oyster Reefs, NOAA

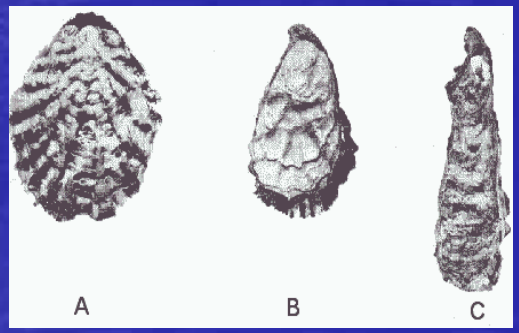
Some Lessons Learned or Lost and Related Observations cont.

7. Design the monitoring (=research) program, along with the restoration program, so that the two are seamless and robust;

   a. Consider for baseline: bottom types, sediment deposition rates, local hydrodynamics, water quality, intertidally-boat wakes and fetch, HABs, introduced species, predators, competitors, diseases, etc. Follow changes in 'reef architecture/complexity' over time. Oyster morphology also can tell you a lot (see Kent 1992);

   b. Look at resident and transient faunas, develop/utilize novel methods. However, for this effort, level of effort vigorously debate at our 2004 workshop, due in large part to the cost/expertise (P/A vs. enumeration);

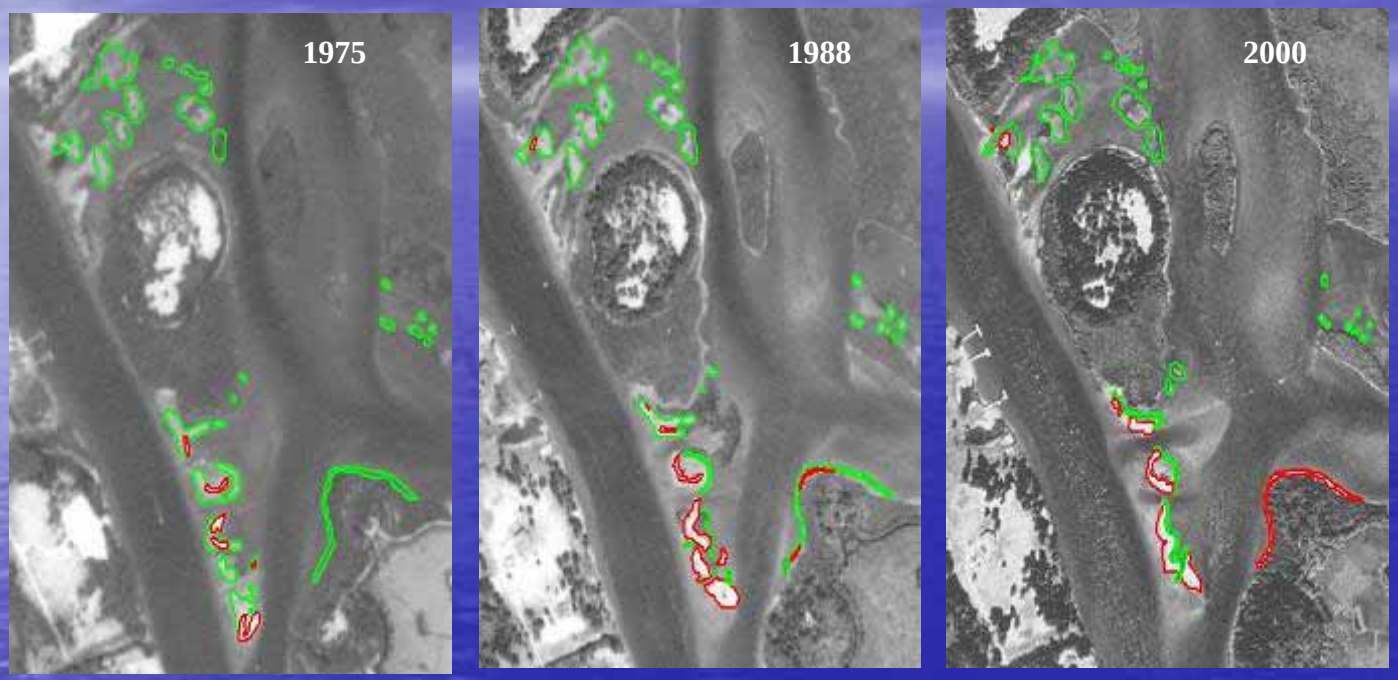
8. Justify monitoring for adaptive management or as a means to provide an understanding of why a particular effort worked or failed--this is critical;



Kent, B.W., 1992. Making dead oysters talk : techniques for analyzing oysters from archaeological sites. MD Historical Trust

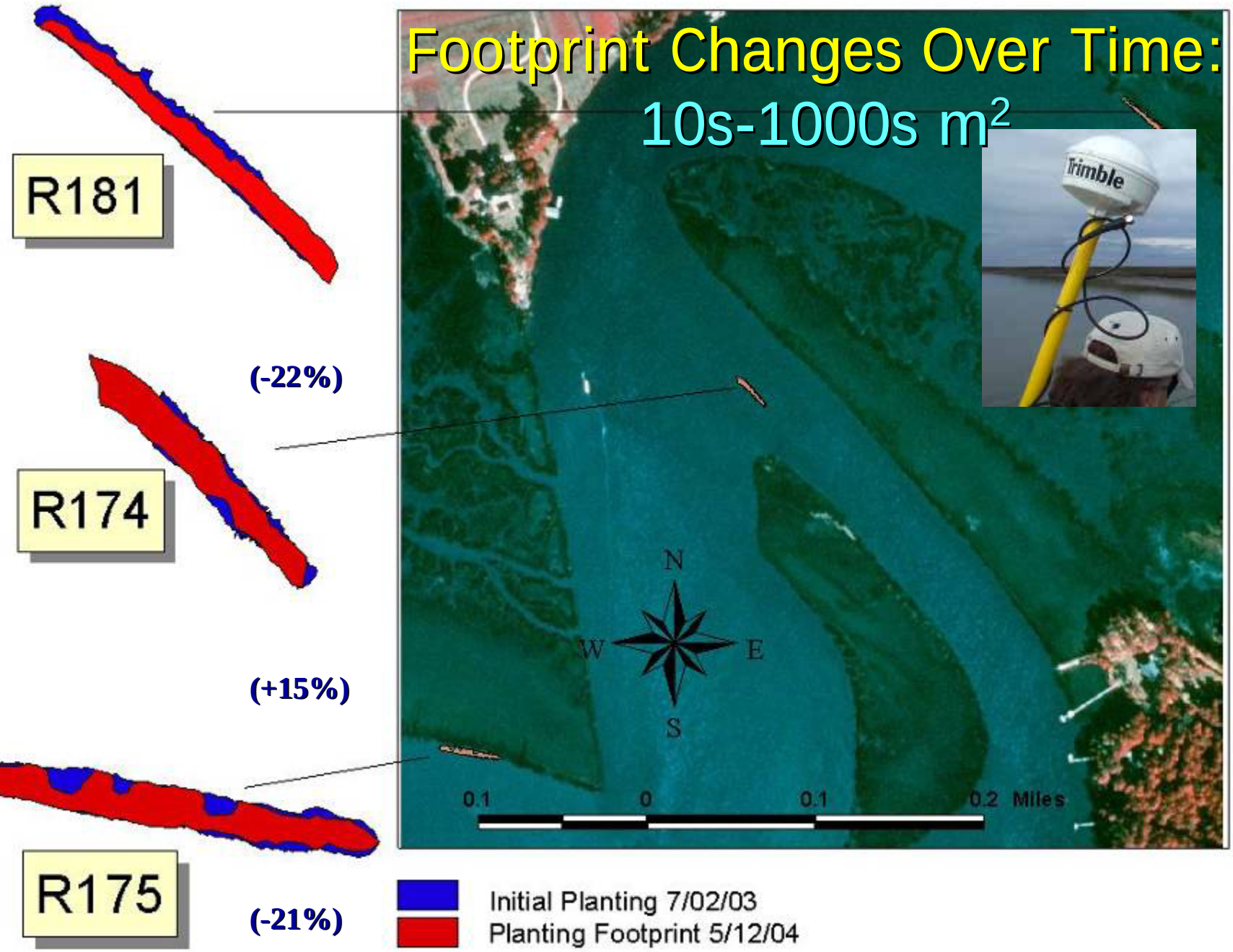
Scale of SC Intertidal Assessments: 100s Km Statewide Program

Temporal Intertidal Reef Changes over Km



Intertidal oyster reefs (Canaveral National Seashore, CANA) Florida. Aerial imagery over 25 years shows increased dead reef areas (red) compared to living (green), assumed most probably caused by increased boating activities along AICW (see Grizzle et al. 2002).

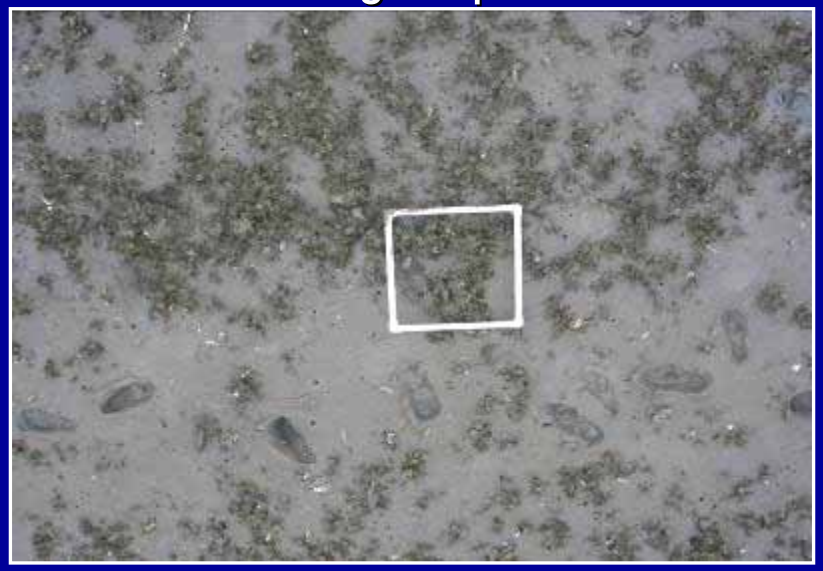
Footprint Changes Over Time: 10s-1000s m^2



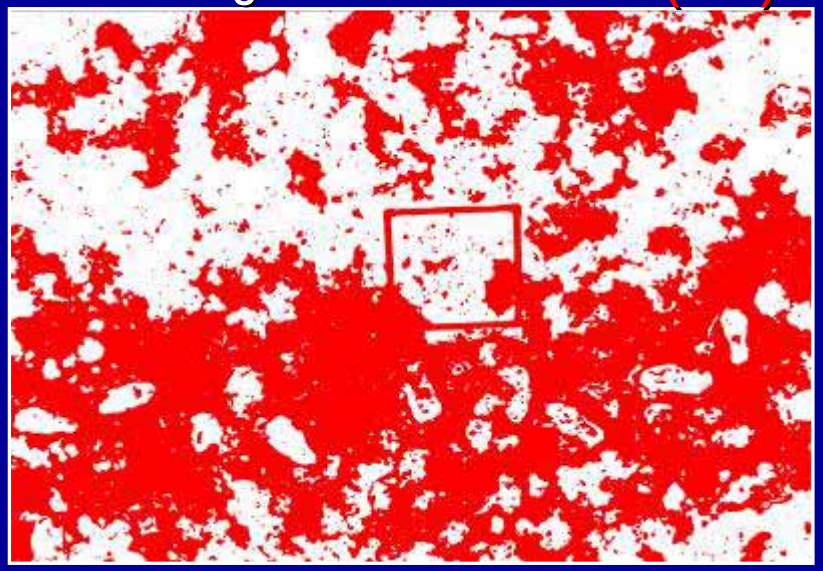
Footprint 5/12/04 – 252.2 m^2

Intertidal Overhead Digital Photography

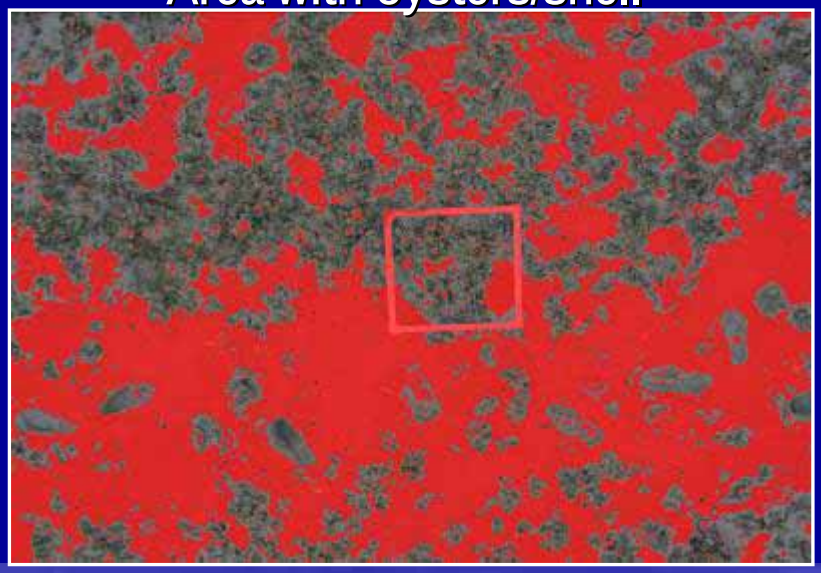
Original photo



Digitized mud areas (red)



Area with oysters/shell



52% Oyster Coverage
48% Mud

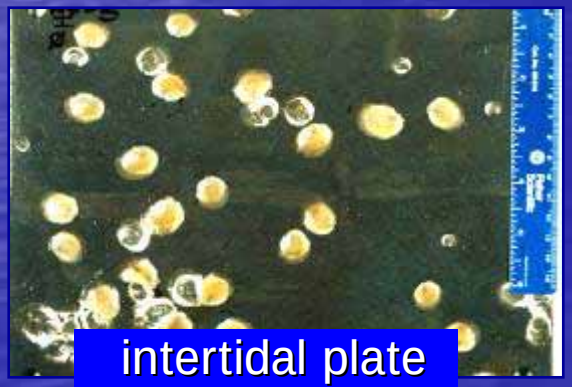
Some Lessons Learned or Lost and Related Observations cont.

9. Early on, put significant effort into assessing appropriate site selection criteria (e.g., flow and/or sediment type, etc.) when identifying candidate sites for restoration;

10. Work to translate the science-based 'lessons learned' (e.g., low DO, rays), as they are often difficult to interpret into public policy (see #2), as missions of agencies/organizations vary;

11. Don't succumb to early failures, or simplistic cost-benefit analyses that 'demonstrate' that restoration efforts are a losing strategy. Plan to invest in long-term, valuation of 'Services', as this is still in its infancy, so estimates are probably undervalued (Powers et al.'s "The Myth of Failure", in review);

    a. Don't underestimate the resiliency of natural oyster populations. This gets back to the issue of metrics, and giving things time to show results;


intertidal plate


subtidal plate

Landings as Success Measures: Unrealistic Expectations/Inappropriate Success Criteria?

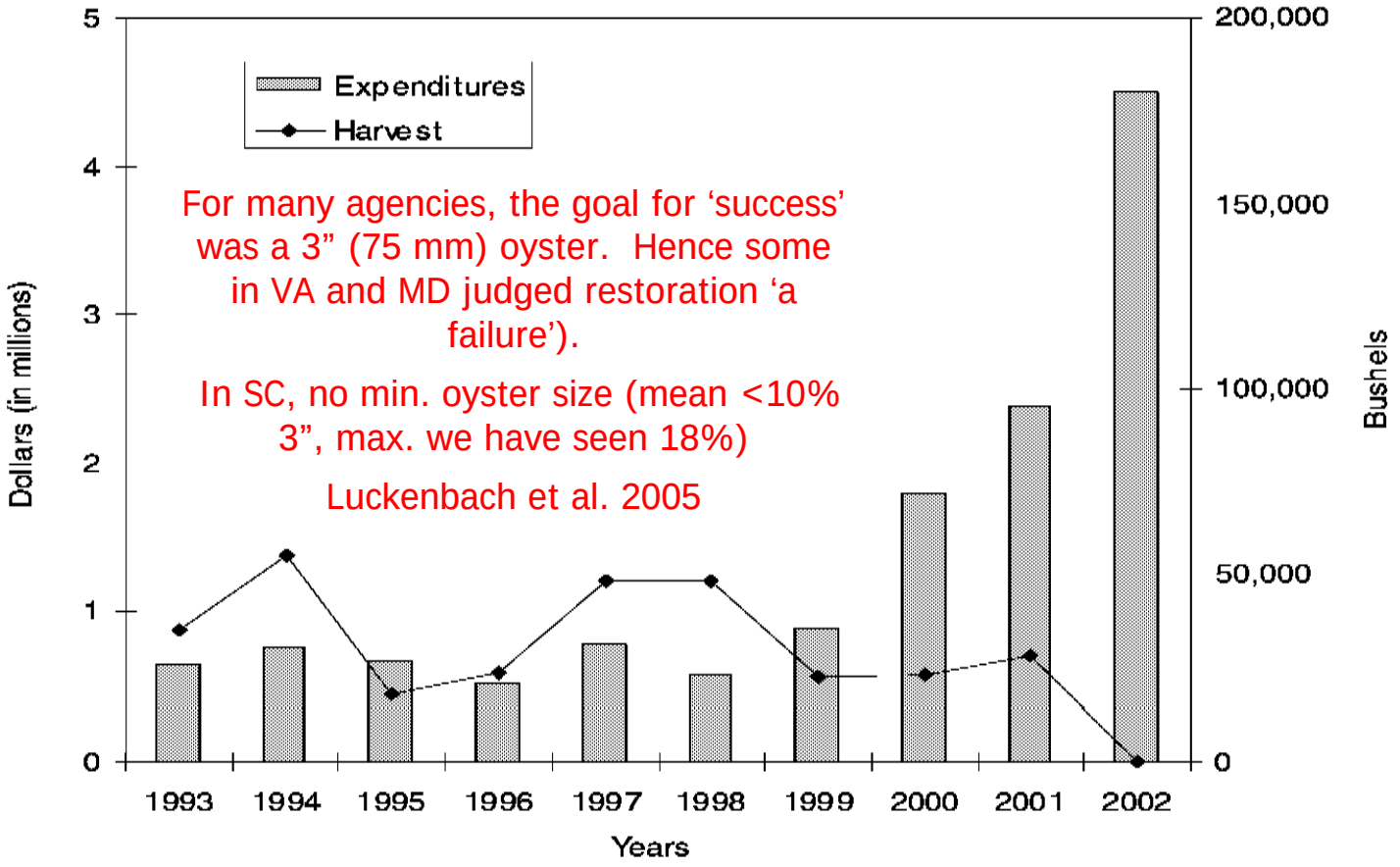


FIGURE 6.1 Virginia expenditures on oyster restoration and oyster landings. SOURCE: Data from J. Wesson, VMRC, Newport News, personal communication, 2003.

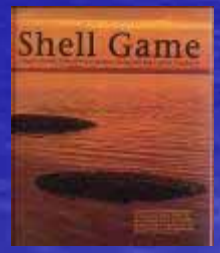
Figure, National Research Council Publ., 2004

Some Lessons Learned or Lost and Related Observations cont.

12. Choose stocks carefully. Don't assume that stocks selectively bred for aquaculture are the most appropriate for *C. virginica* restoration this has generally been ignored (especially in the mid-Atlantic). In contrast, new west coast *O. conchaphila* work appears to place more value on population genetic structure;

    a. We may be deliberately obliterating natural genetic structure/variation, in favor of "terraforming" our systems with domesticated stocks (DEBYs, CROSBreeds)-at our peril (see http://www.ifremer.fr/icsr05/communications/room1/Wed%20am/icsr05-reece-et-al.pdf-http://www.ifremer.fr/icsr05/communications/room1/Wed%20am/icsr05-gaffney.pdf);

13. Be open to trying new ideas (e.g., alternative substrates, shell planting methods, different reef architectures, shell capping, underutilized labor resources); think 'outside the box'; and learn from failures (share them with your colleagues and publish them). Oysters on non-traditional substrates or 'Closed' areas can be significant in urbanized areas (='sanctuaries');



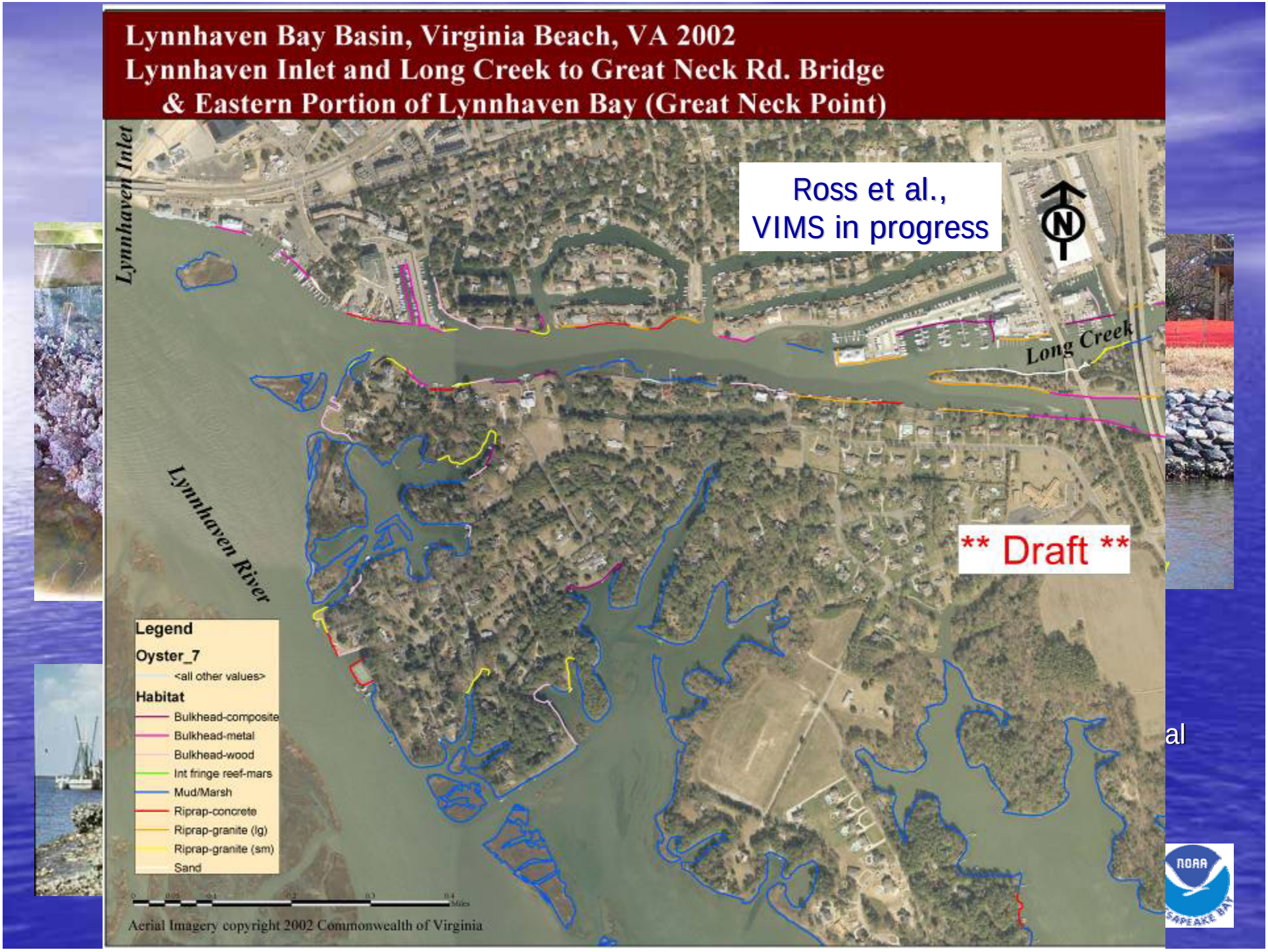
Try Alternative Substrates

Observed as much as 2.5 bushels of oysters/ghost crab trap

Shell bag in FL after one year! Volety et al.

Marl vs. shell recruitment cages in VA, R. Brumbaugh

A. McCall, 2005 NC marl in remote set shell bags


Lynnhaven Bay Basin, Virginia Beach, VA 2002
Lynnhaven Inlet and Long Creek to Great Neck Rd. Bridge
& Eastern Portion of Lynnhaven Bay (Great Neck Point)
Lynnhaven Inlet
Long Creek
Lynnhaven River
Ross et al.,
VIMS in progress
** Draft **
Legend
Oyster_7
<all other values>
Habitat
Bulkhead-composite
Bulkhead-metal
Bulkhead-wood
Int fringe reef-mars
Mud/Marsh
Riprap-concrete
Riprap-granite (lg)
Riprap-granite (sm)
Sand
Aerial Imagery copyright 2002 Commonwealth of Virginia

Enhanced Substrate on a Limited Scale

Deploy cement-coated stakes of various materials, also hardware cloth
Both require reasonable natural recruitment

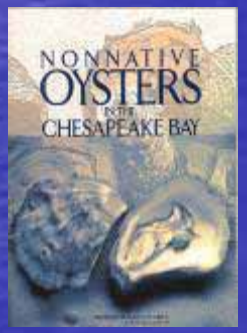
Large Clam Pens In SC: Substrate, Habitat?

Pens each ~4.68 m^2. Located on mudflats exposed at low tide, >2 m at high tide. At peak operation > 7,000 pens on mudflats, with over 70 million clams planted. Today, approximately 4,000 still remaining in field, many covered with oysters, do we leave as habitat (legalities)?

Some Lessons Learned or Lost and Related Observations cont.

14. Start looking for potential native or introduced diseases (R. Carnegie, pers. comm.). Recent *Bonamia* spp. effects on potential introductions of *C. ariakensis* in NC suggest a lot more to learn!

15. Natural disease resistance. For *C. virginica*, reefs with intense MSX and Dermo challenges, seeing natural resistance to MSX and growing tolerance of Dermo, the latter demonstrated by: a) oysters in waters where *Perkinsus* is most intense, and (b) a remarkable number of large, disease-free, fecund oysters. Look for natural selection/local adaptation to diseases. Does one need to invest in directed breeding programs (e.g., DEBYs, CROSBreeds)?



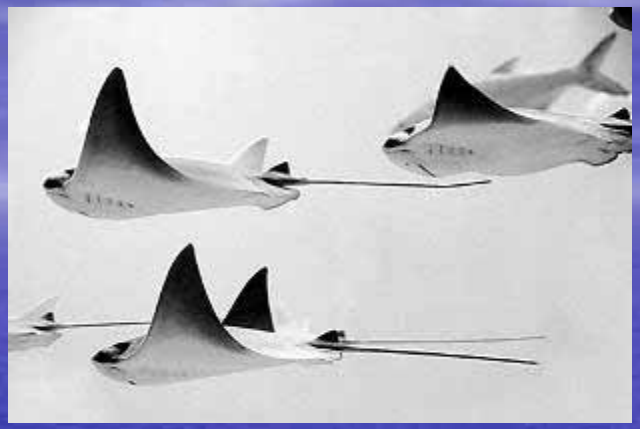
Some Lessons Learned or Lost and Related Observations cont.

16. Be mindful of the manifold threats/factors that can influence a project's success or failure (Note: that regardless of oyster spp., predators and low DO would have had the same result);

    a. increased ray predation, exotic introductions (often a long time frame for observed impacts), timing can be critical;

    b. Minor differences in materials and timing of substrate(s) planting can determine what colonizes and ultimately dominates the reef community

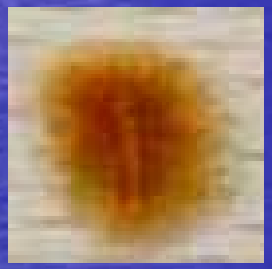
People aren't the only oyster predators...



Hungry rays thwart effort to restore oysters in Piankatank

By Associated Press

Cow-nosed rays gobbled up most of the 775,000 oysters in days after they were planted in the Piankatank River. The rays ate about 90% of the young oysters planted by CBF/TNC.



Stylochus ellipticus
<5 mm^2

Eupleura, Urosalpinx

http://www.fisheries.vims.edu/

http://www.mobilebaynep.com/OysterGardening/

Exotics/Non-Native Molluscs

From J. Fajans, Keys Marine Lab

← *Perna viridis* overgrowing *C. virginica* intertidal reefs in FL, now in GA, SC

Rapana venosa & Stramonita sp. in VA, but are they a threat?

http://www.jaxshells.org/stram7.jpg

← *C. ariakensis* (Suminoe Oyster) Chesapeake Bay, NC (an escapee)

C. gigas (Pacific oyster) covering rocky shores in Puget Sound, >80 yrs. →

From D. Padilla, SUNY SB

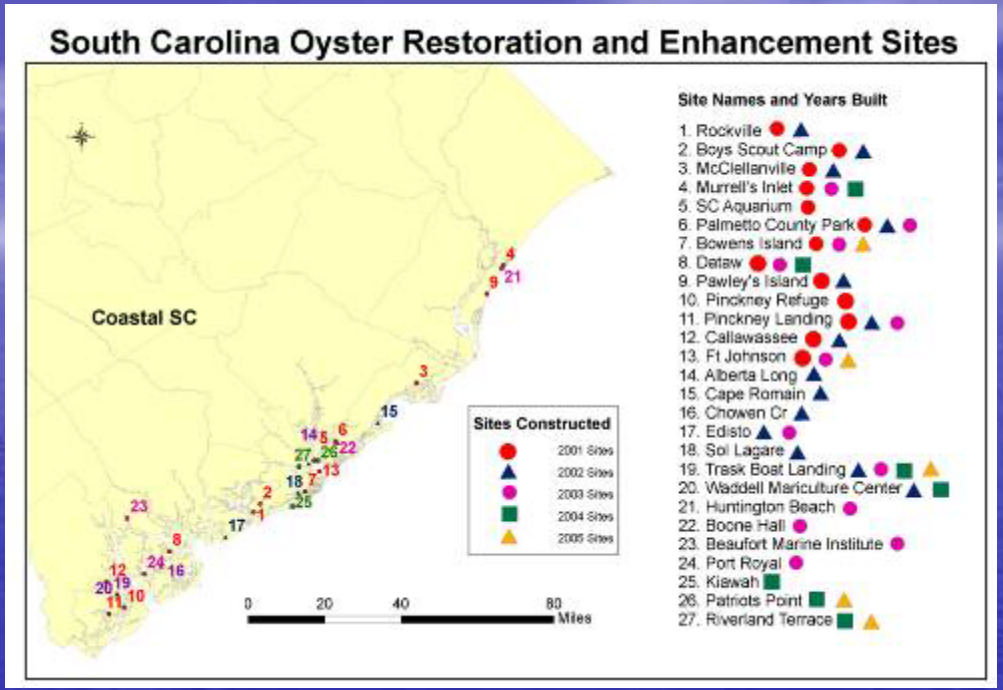
Lessons cont.

17. Capture and use the community's interest for restoration and larger issues (e.g., water pollution, land-use/land conservation of coastal watersheds, fisheries management, erosion, etc.) to build constituencies. NGOs can be especially helpful and effective at fulfilling these tasks (e.g., TNC's new Shellfish Initiative). Early on, too few state's involved public 'by-in' for all types of restoration (non-resource Services);

18. Employ novel strategies such as 'oyster gardening' or shell recycling to involve the public (but quarantine shell before putting overboard, see Bushek et al. 2004, JSR) and finally;

19. Don't be afraid to use 'Administrative Closures' (Prohibited or Restricted classifications) as enforced sanctuaries, these can be invaluable (not all closures bad, see #13, 'outside the box').

SCORE Community Restoration Sites Built Since 2001



105 reefs at 28 sites in just 5 years
275 tons (>13,300 bags) of shell planted!

NOAA

South Carolina Department of Natural Resources

The Hilton Head Island Foundation

South Carolina Marine Recreational Fisheries Stamp Program

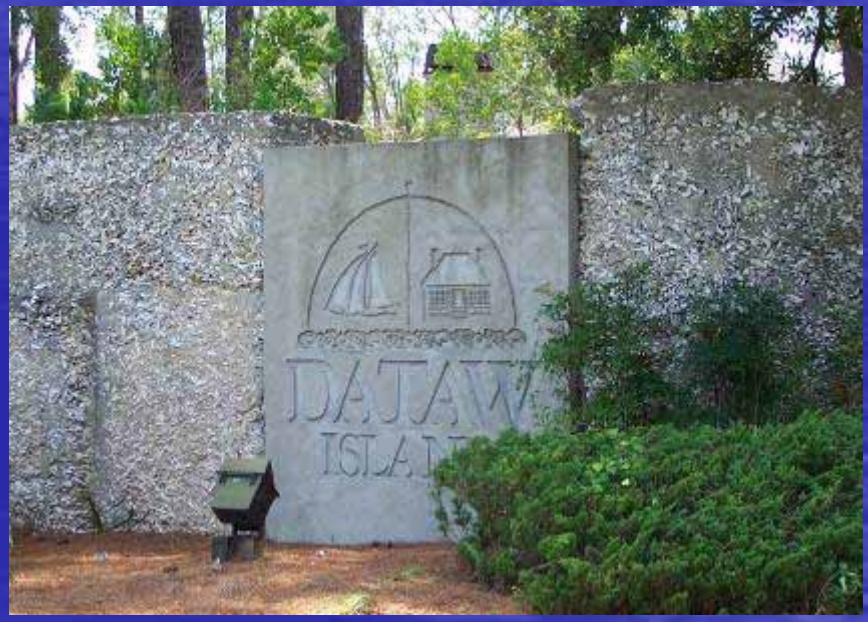
Sea Grant S.C. Sea Grant Consortium

Fish America Foundation

U.S. Fish & Wildlife Service

South Carolina Saltwater Recreational Fishing License

Capture Oyster Shell



Recycle Shell

Initiated in Fall 2001 with SCORE, over 16 regional drop-off sites, more than 15,000 bushels recycled last year

South Carolina Saltwater Recreational Fishing License

http://saltwaterfishing.sc.gov/oyster.html

Recycle Oyster Shell

Overview/Summary

- We are still too hung-up in many states on ‘resource restoration’ alone
- In most areas, oyster reefs generate additional ‘services’
- Few *C. virginica* datasets have statistically-comparable methodologies for meta-analyses, nor do we have good data on natural reefs prior to their decline (i.e. ‘reference’ sites) for nearly any area, subtidal or intertidal
- Develop sampling methods early and use across projects/programs for ease of data interpretation and comparison

Overview/Summary cont.

(Coen, FL Workshop 3/07)

Lessons Learned or Potentially Lost include:

1) Minimize user conflicts on the front-end.
2) Understand your restoration partners, their 'constituencies' and constraints (e.g., missions, monetary, expectations, time-frames). Be careful how the media/public are fed information and related misperceptions
3) Invest in solid science and develop rigorous data to assess related success/failure. Focus on a few sites, collaborate and if successful, scale-up. Have workshops early-on and often and communicate both positive and negative results
4) Develop clear goals and relevant metrics. Get the biology right early-on (unsuspecting players)
5) Develop relevant and accepted (cost-effective) metrics to evaluate your goals. Also, don't oversell the 'Services'
6) Educate grant agencies that monitoring is a critical phase for restoration, often requiring periods >3-5 years.
7) Design monitoring, along with your restoration research programs so that the two are seamless and rigorous. Be open to new ideas and learn from failures.
8) Justify monitoring for adaptive management or as a means to provide an understanding of why a particular effort worked or failed.

Overview/Summary cont.

(Coen, FL Workshop 3/07)

Lessons Learned or Potentially Lost include cont.:

9) Early on put significant effort into assessing appropriate site selection criteria.

10) Work on translating the science-based 'lessons learned' into public policy because of #2, as missions of agencies/organizations vary.

11) Don't succumb to early failures, or simplistic cost-benefit analyses.

12) Choose stocks carefully.

13) Be open to new ideas, think 'outside the box', and learn from failures.

14) Start looking for potential native or introduced diseases (e.g., Bonamia).

15) Take advantage of natural disease resistance.

16) Be mindful of the manifold threats/factors that can influence a project's success or failure.

17) Capture and use the community's interest for restoration and to address larger issues.

18) Employ novel strategies such as 'oyster gardening' or shell recycling to involve the public.

19) Don't be afraid to use 'Administrative Closures' , enforced sanctuaries.

Acknowledgements

Special thanks for generous input

David Bushek (Rutgers), Rob Brumbaugh & Mike Beck (TNC), Keith Walters (CCU), Mark Luckenbach, P.G. Ross & Ryan Carnegie (VIMS), Ray Grizzle (UNH), Denise Breitburg (SI-SERC), Pete Peterson (UNC-CH), Sean Powers (DISL-USA), Mark Camara (ARS-OR), Martin Posey & Troy Alphin (UNCW), David Meyer (NOAA)

Thank Organizers for Invitation & Support

ASMFC, 2007. The importance of habitat created by shellfish and shell beds along the Atlantic coast of the U.S., prepared by Coen, L.D., and R. Grizzle, with contributions by J. Lowery and K.T. Paynter, Jr., 106pp.

http://www.coastal.edu/marine/sgoyster

ANY QUESTIONS/COMMENTS??

Jefferson: Charismatic Megafauna?