# Chesapeake Bay Oysters 201:
## Restoration, Wild fishery, Aquaculture & Water Quality

Mark W. Luckenbach

Chesapeake Bay Commission
November 10, 2016

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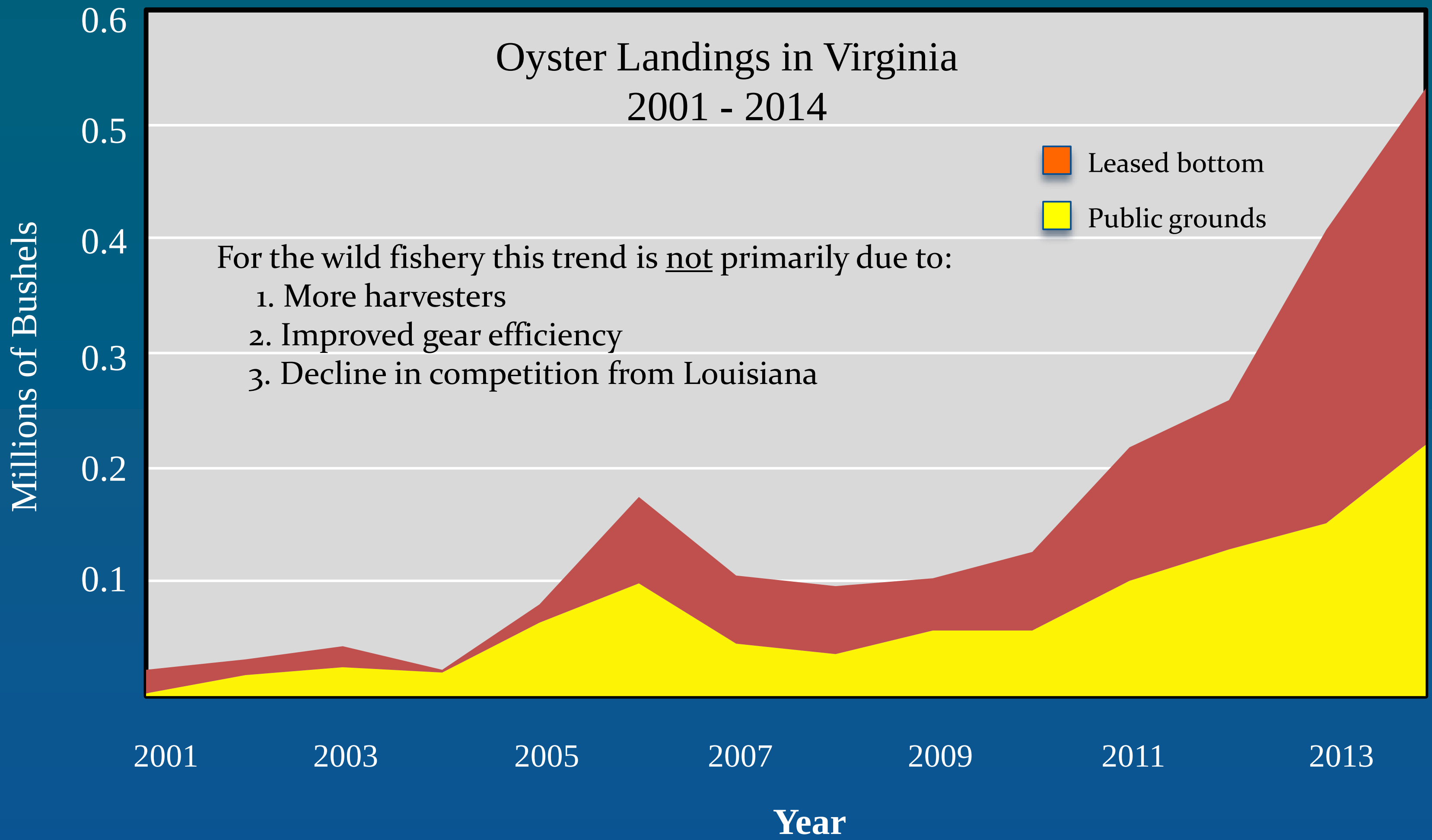


Data source: Jim Wesson, VMRC

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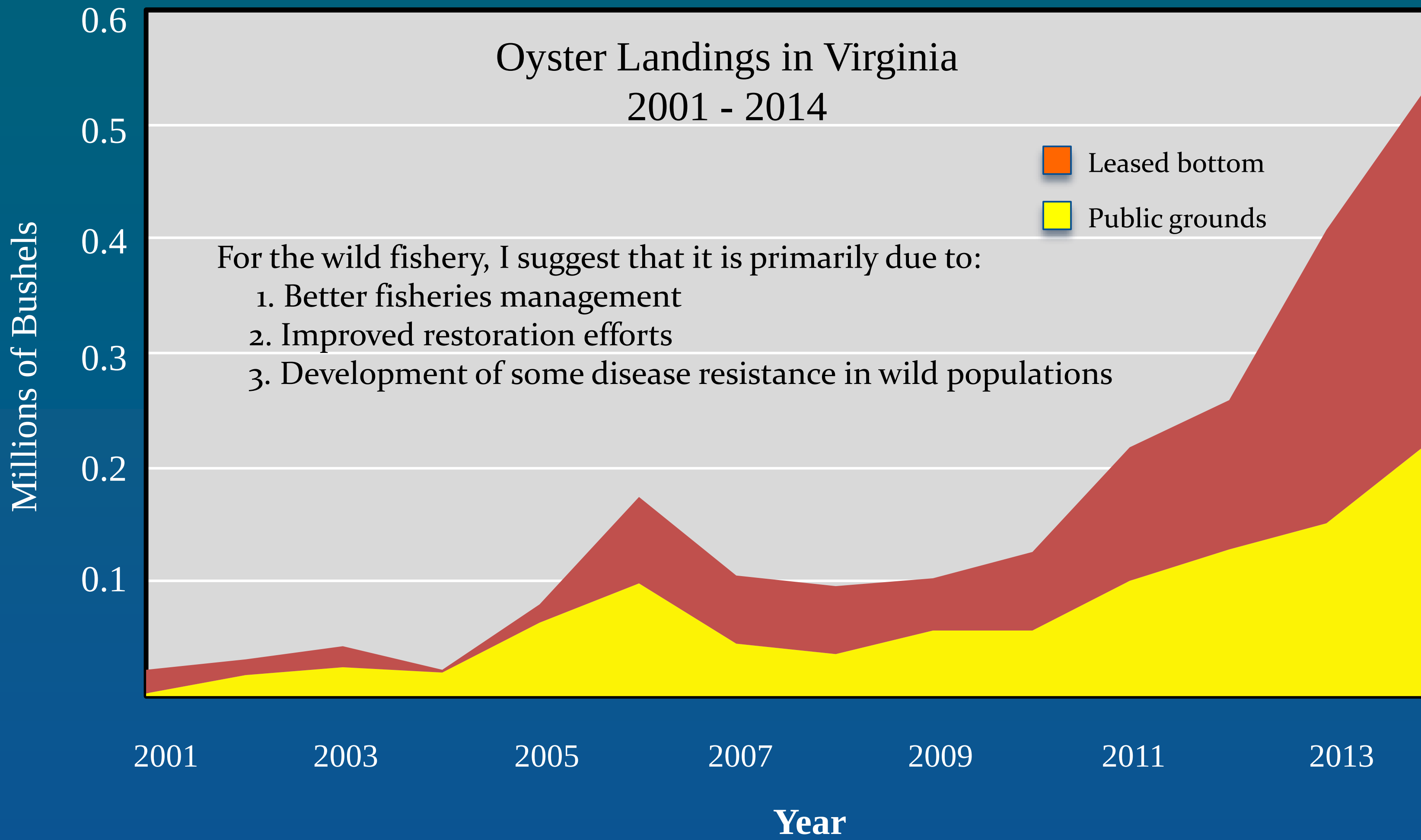
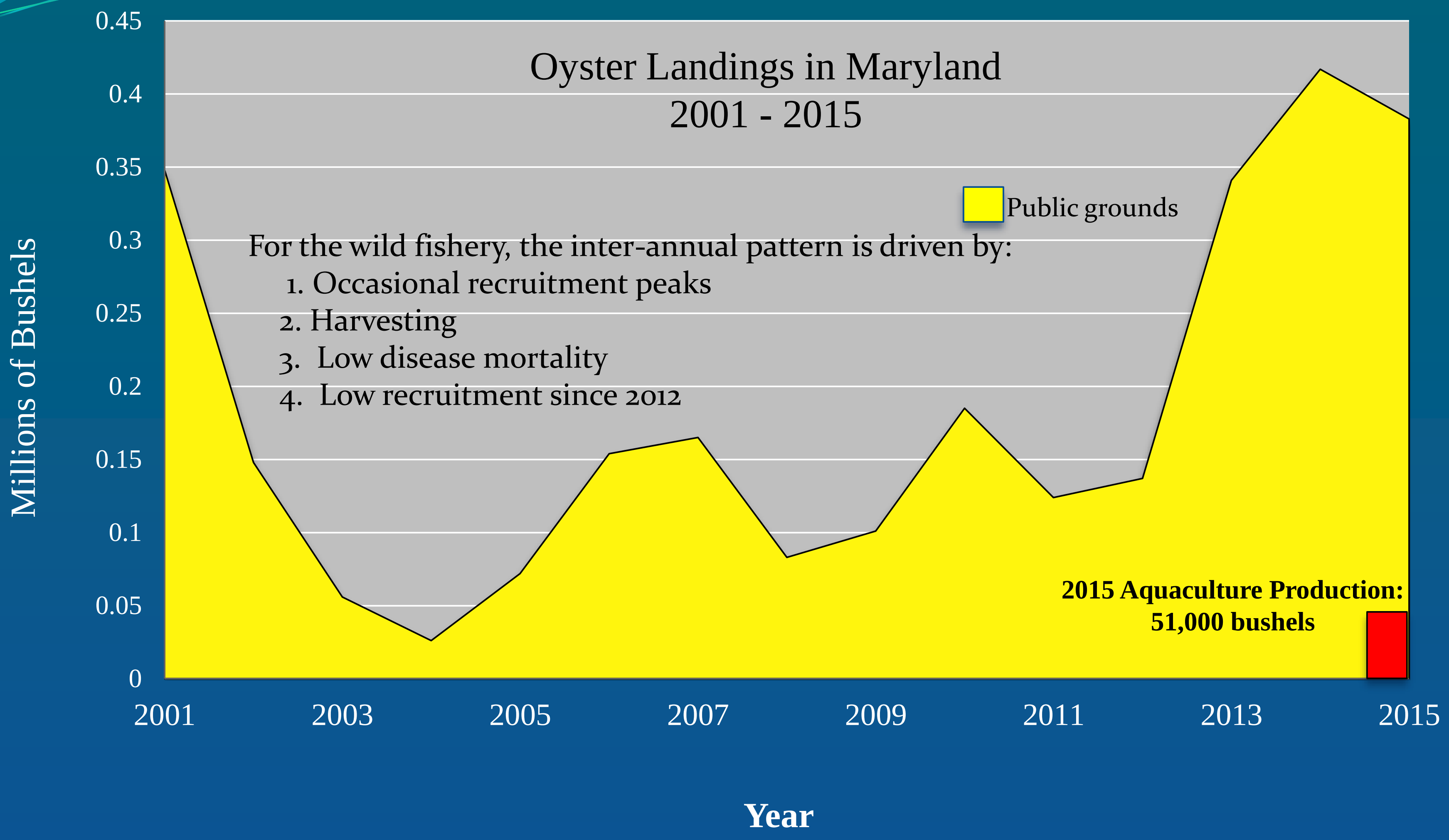



Data source: Jim Wesson, VMRC




Data source: Mitch Tarnowski, MD-DNR

# What has worked and what has not?

**In most, but not necessarily all, locations planting a thin veneer of shells has not been sufficient to promote the development of a sustainable reef.**

Recruitment + New shell growth < Shell loss rate

# What has worked and what has not?

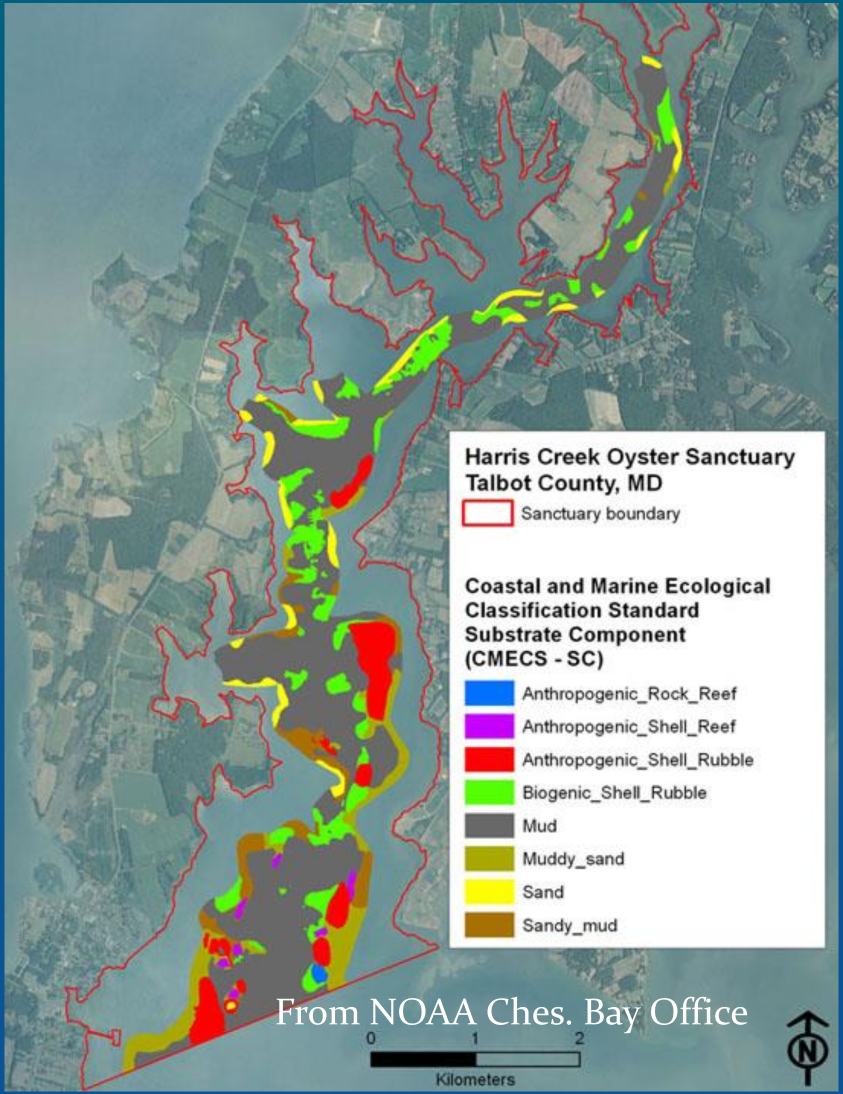
**Greater attention to habitat architecture**

**Sufficient 3-D structure to:**

- **Enhance growth and survival**
- **Provide persistence of shell substrate**

# What has worked and what has not?

## Tributary-scale restoration plans that include:



From NOAA Ches. Bay Office

**Detailed bottom mapping**

**Understanding connections between reefs**

**Pre- and post restoration monitoring**

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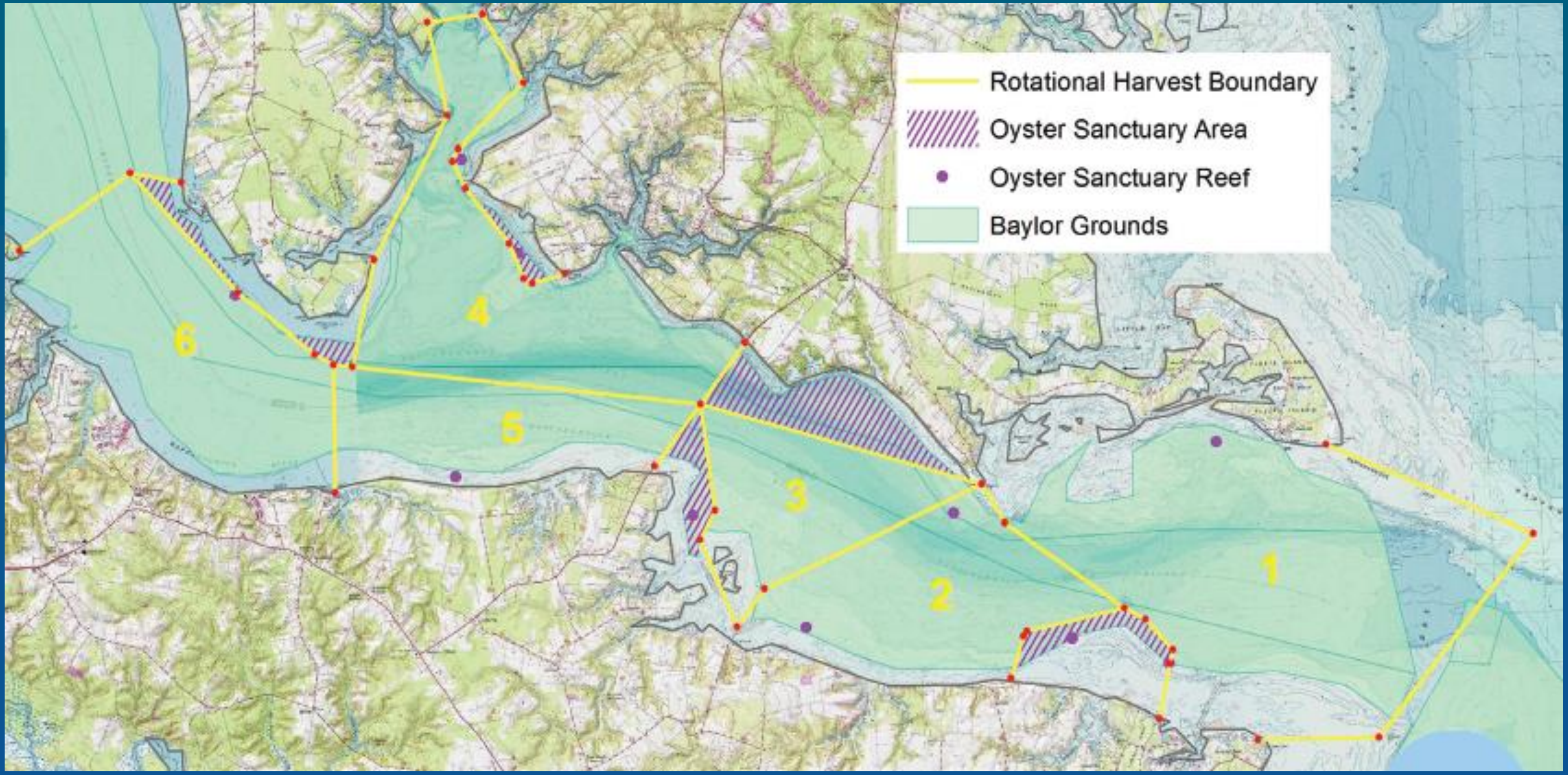
# What has worked and what has not?

**Fisheries management: Holistic approach which includes, harvest targets based on recent surveys, rotational harvest, and sanctuary reefs.**




**Rappahannock River, Virginia**

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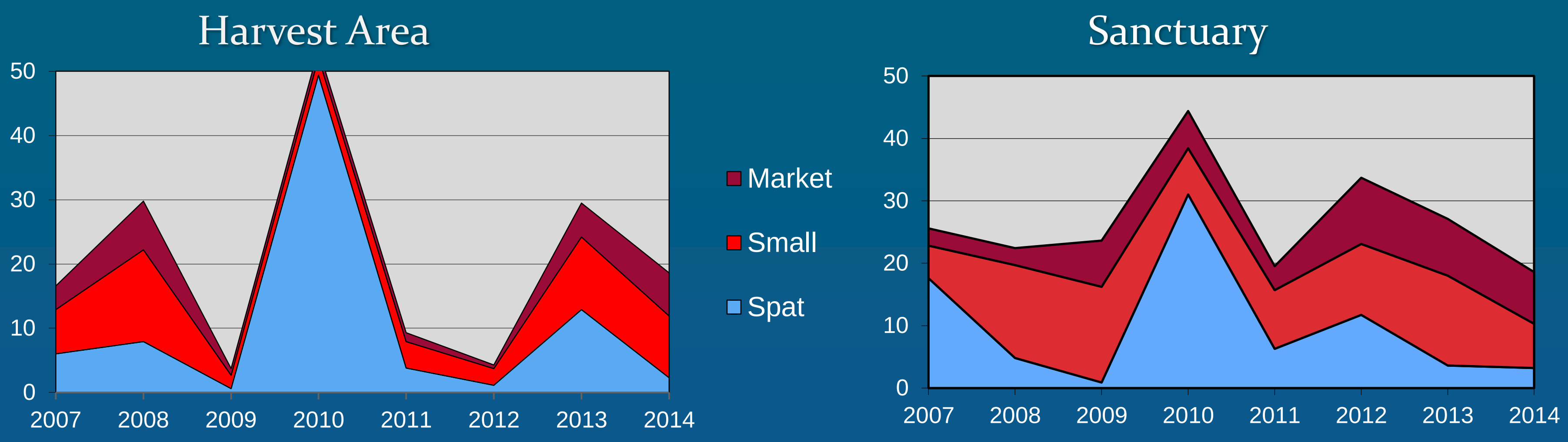
# What has worked and what has not?

**Sanctuary reefs preserve broodstock and DO NOT reduce spatfall**




**Throw away the notion that the reefs "have to be worked to be productive."**

Data from Jim Wesson, VMRC

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# What has worked and what has not?

## Sanctuary reefs and improved fisheries management support the evolution of disease tolerance

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FEATURE ARTICLE:

**Declining impact of an introduced pathogen: *Haplosporidium nelsoni* in the oyster *Crassostrea virginica* in Chesapeake Bay**

Ryan B. Carnegie*, Eugene M. Burreson

Virginia Institute of Marine Science, College of William & Mary, Gloucester Point, Virginia 23062, USA

ABSTRACT: Disease caused by the parasite *Haplosporidium nelsoni* has devastated *Crassostrea virginica* in Chesapeake Bay, exacerbating effects of overharvesting and adversely impacting the ecology of the bay. *H. nelsoni* is thought to persist as an impediment to oyster restoration because strong reproductive contributions from oysters in low-salinity refugia from parasitism have prevented development of disease resistance. On the contrary, long-term data indicate that while infection pressure on naïve sentinels has grown, *H. nelsoni* levels in wild oysters have fallen, with prevalence typically below 20% and advanced infections uncommon. A transplant experiment comparing naïve sentinels with oysters from disease-enzootic populations indicated that these observations represent true disease resistance, and its geographical distribution was revealed by annual fall surveys, and by intensive sampling in 2007 and 2008. Resistance is best de-


*Haplosporidium nelsoni* spores (S) and plasmodia (P) in a rare heavy infection of an oyster, *Crassostrea virginica*, from lower Chesapeake Bay

*Image: Ryan Carnegie*

### In Virginia

- Strong evidence for MSX resistance
- Evidence for Dermo resistance

### In Maryland

- Low disease mortality
- Salinity related

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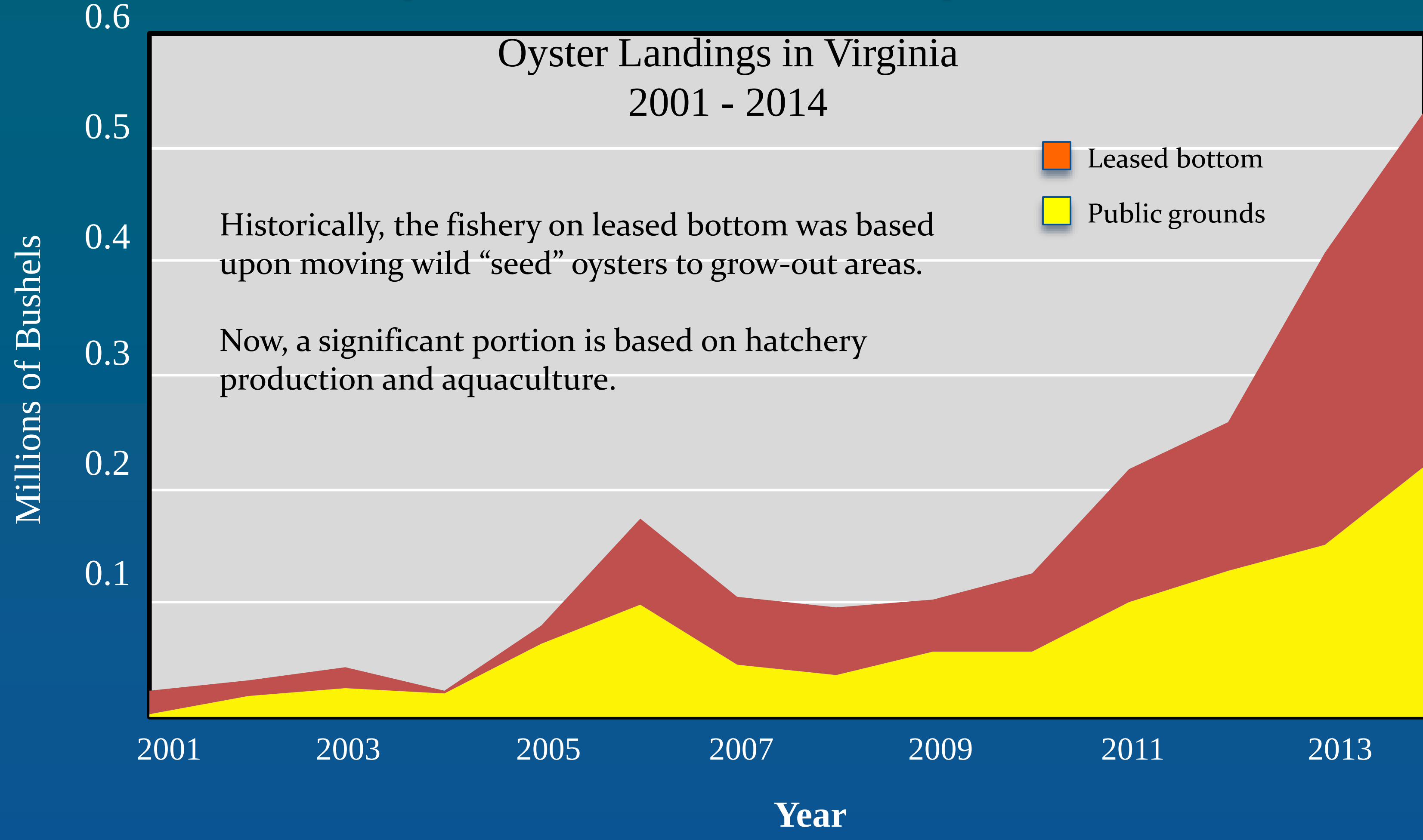
# Aquaculture Development




From Jim Wesson, VMRC

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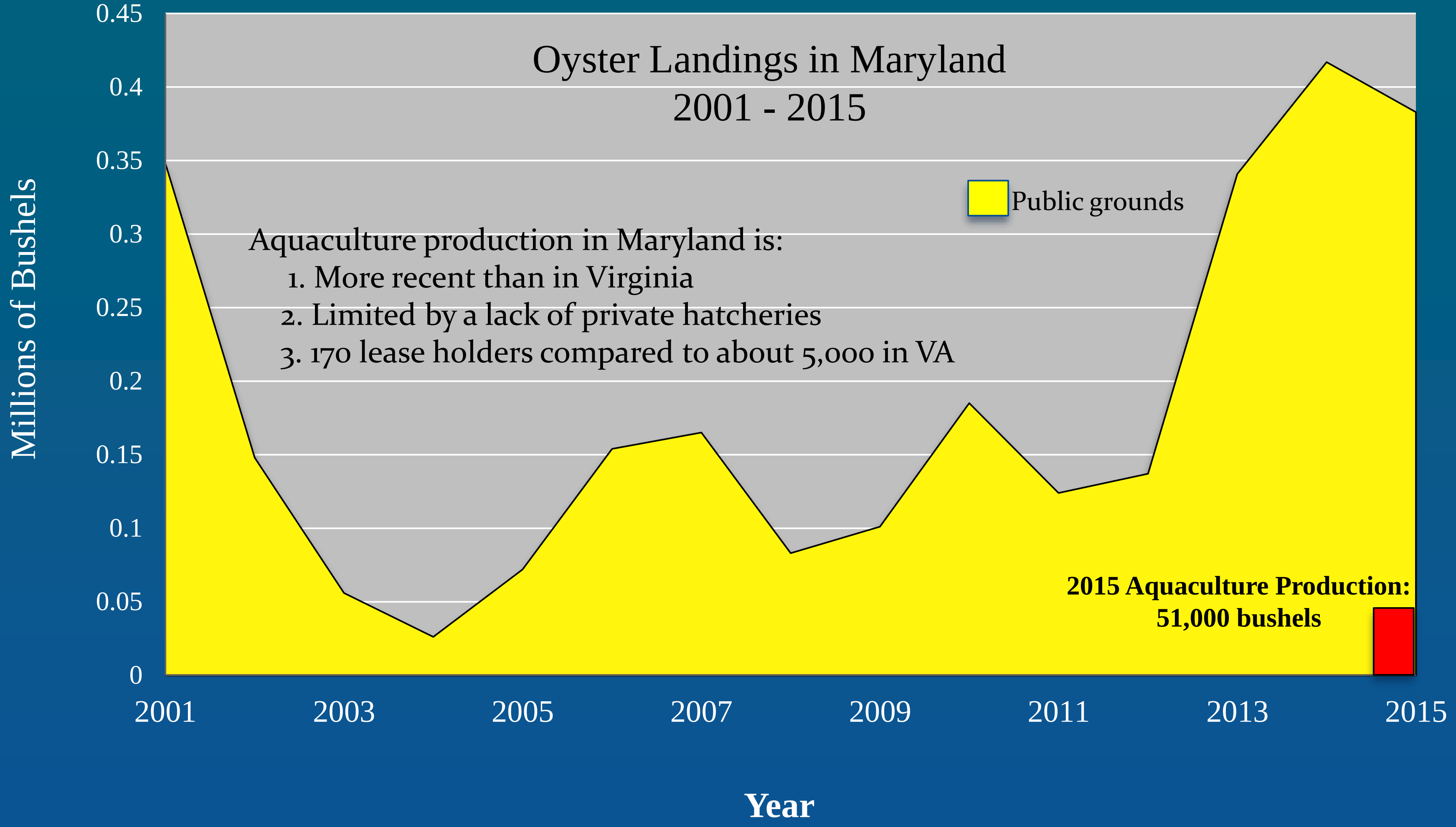
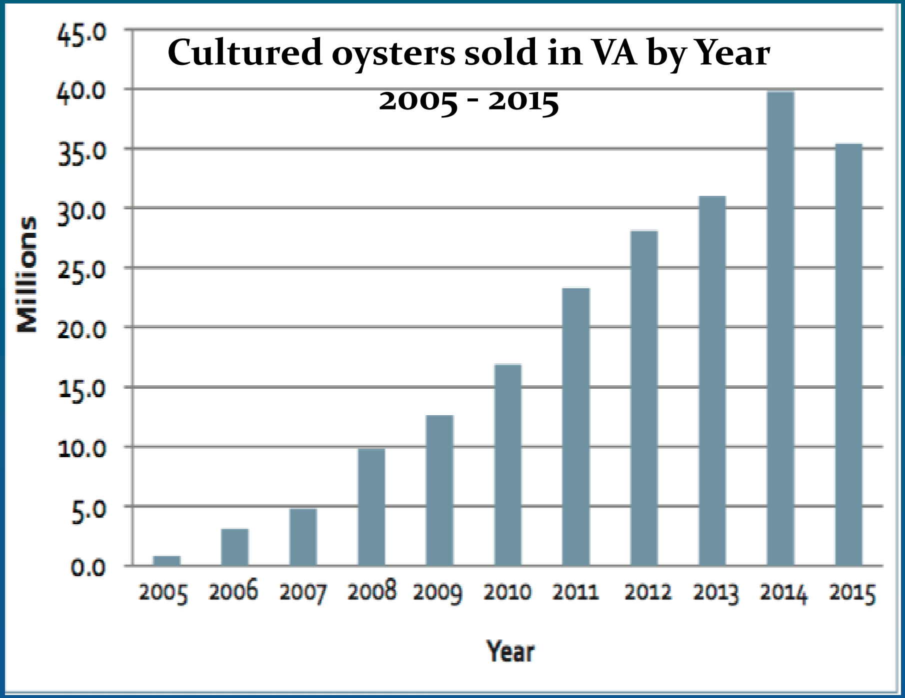
# Aquaculture Development



# Aquaculture Development




From Hudson and Murray 2016

In 2015:

135.6 M single oyster seed planted

35.4 M aquacultured oysters sold

$14.5 M farm gate value

U.S. East Coast leader in oyster aquaculture production

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# Aquaculture Development

<u>This development has been enabled by</u>:

- Favorable leasing laws in VA and recent changes in MD
- Selective breeding for disease resistance and rapid growth
- Triploid development and production
- Formal and informal training programs
- Private investment and innovation
- Strong supporting science—breeding, genetics, disease diagnostics, water quality monitoring

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# Policy Issues – Fisheries & Aquaculture

Restoration efforts and sanctuaries are critical to the success of the wild oyster fishery. Creating sanctuaries in the "last best places" is more cost effective than restoration in poor locations.

- This is not ecology vs. the fishery
- It is the current fishery vs. the future fishery

Leasing laws (in VA) need clarification and effective enforcement tools.

Managing use conflicts, both within the Bay and with adjacent upland uses, will be crucial to the expansion of the oyster aquaculture industry.

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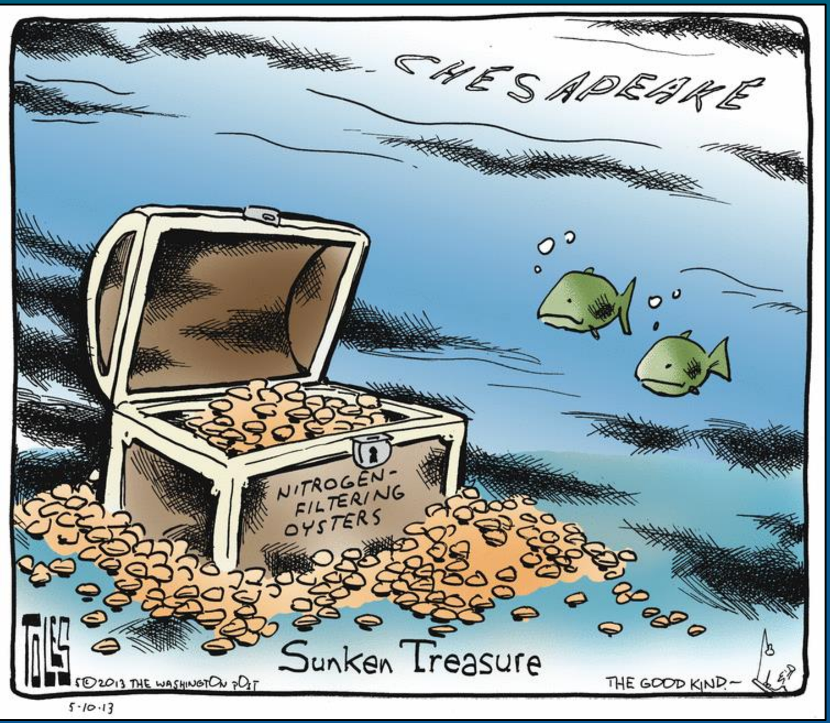
# Oysters and Water Quality

www.dnr.sc.gov

Oysters are filter-feeders. They filter *stuff* out of the water.

The *stuff* that most TMDLs seek to reduce is nitrogen (N).

# Oysters and Water Quality




Oysters are filter-feeders. They filter *stuff* out of the water.

The *stuff* that most TMDLs seek to reduce is nitrogen (N).

Oysters don't filter N, they filter phytoplankton that contain N (and P).

So, what happens to the N when they filter phytoplankton?

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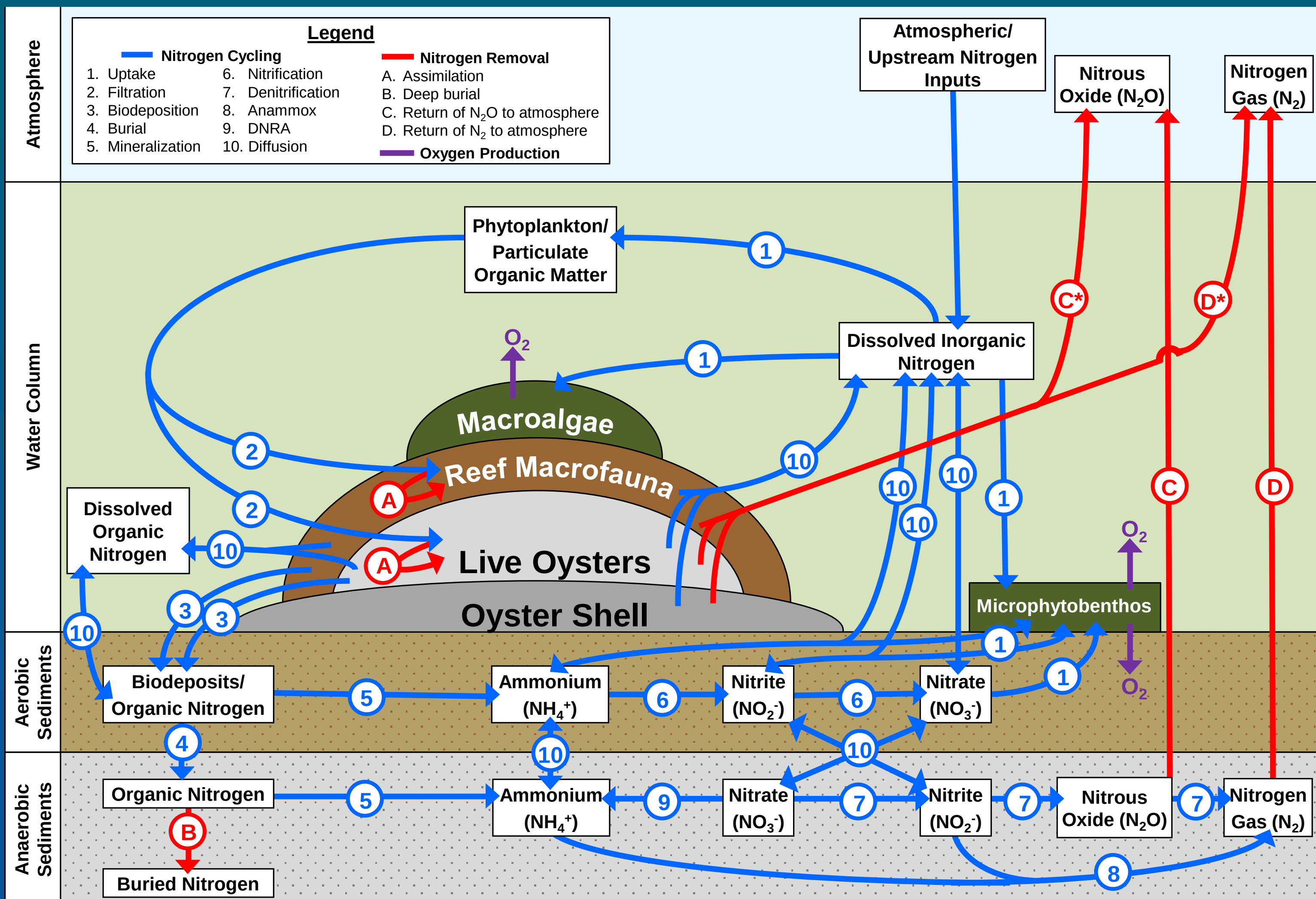
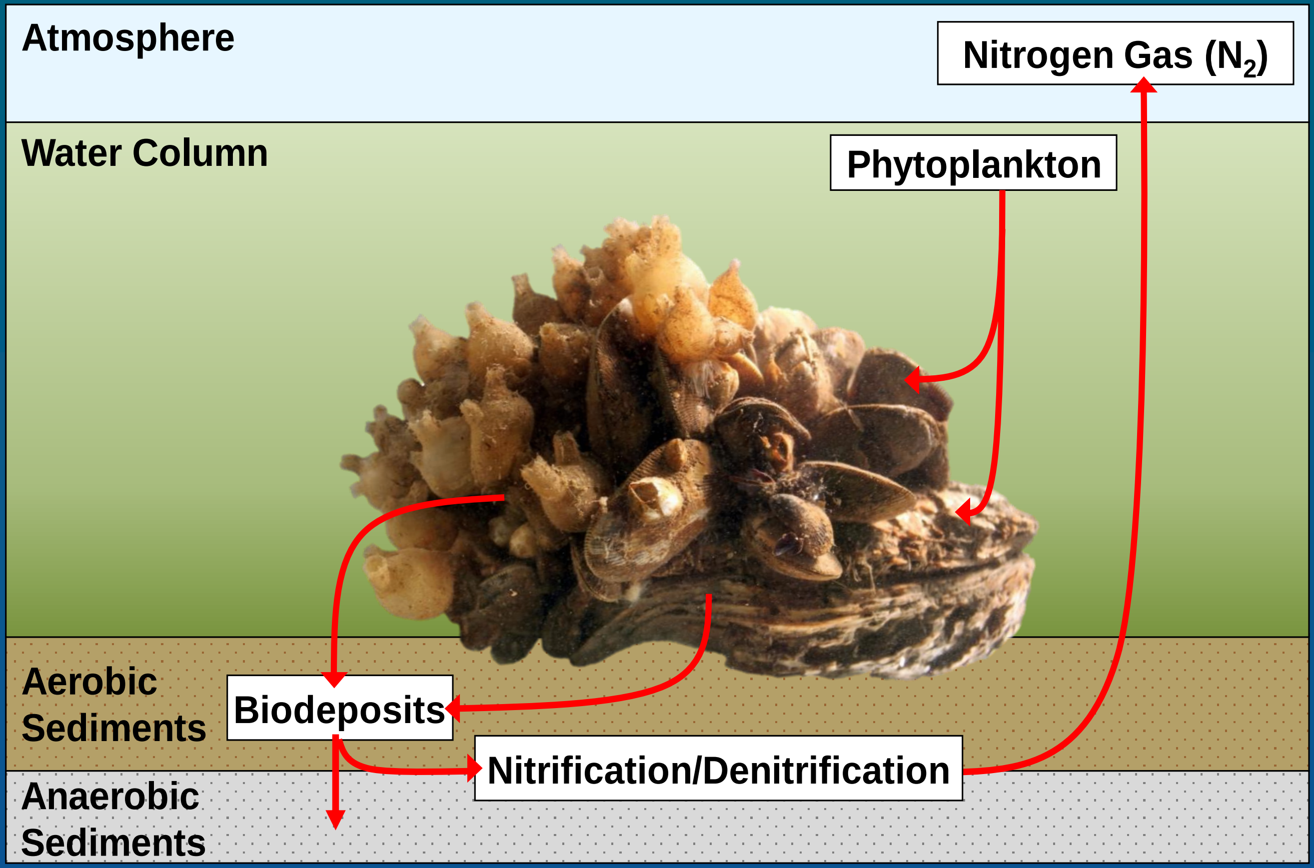
# Nitrogen Cycling




From Kellogg et al. 2014

# Removal Pathways




From Kellogg et al. 2014

Assimilation

Burial

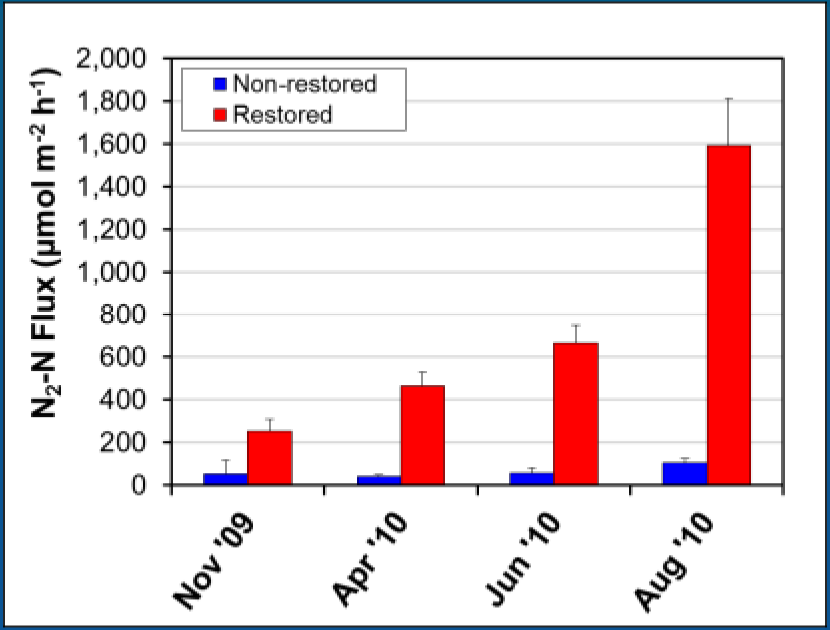
Denitrification

# Denitrification studies – Choptank

Kellogg et al. (2013) studied a restored oyster reef in the Choptank River, MD

533 lbs. N per acre were stored in the tissues and shells of oysters, but this included high densities of oysters up to 7 years old.

496 lbs. N per acre per year is lost through denitrification.




At this rate, if 23% of the suitable bottom in the Choptank River were restored with comparably healthy oyster reefs, it would equal the entire nutrient reduction target for that tributary.

**Wow!**

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# Denitrification studies - Reefs

| Source | Location | Conditions | Measured value | Values | Comments |
|---|---|---|---|---|---|
| Piehler and Smyth 2011 | Intertidal oyster reefs in NC | Feb., May, July & Oct. measurements; intertidal mudflat reference sites | $N_2$ flux in cores containing reef sediments, but no shell. | Reference site<br>-4.5 µmol N $m^{-2}$ $d^{-1}$<br>Oyster reefs<br>17.8 µmol N $m^{-2}$ $d^{-1}$ | Denitrification significantly enhanced on intertidal oyster reefs |
| Kellogg et al. 2013 | Subtidal restored reef in the Choptank River | Oyster density – 131 $m^{-2}$ | N2 flux in chambers with reef materials | Reference site<br>39-105 µmol N $m^{-2}$ $d^{-1}$<br>Oyster reefs<br>252-1592 µmol N $m^{-2}$ $d^{-1}$ | Denitrification greatly enhanced on restored reef |
| Sisson et al. 2010 | Natural and restored reefs in Lynnhaven River. Intertidal & shallow subtidal | 7 small reefs with varying oyster density: 47 – 576 $m^{-2}$ | $N_2$ flux in chambers with reef materials | Reference site:<br>0 µmoles $m^{-2}$ $hr^{-1}$<br>Reef sites:<br>0 -324 µmoles $m^{-2}$ $hr^{-1}$ | Positive relationship between denitrification and total oyster biomass |
| Kellogg et al. (in prep.) | Shallow subtidal experimental oyster reefs | Experimental oyster reef densities = 0 to 250 oysters $m^{-2}$ | $N_2$ flux in chambers with reef materials | Reference site:<br>65 µmoles $m^{-2}$ $hr^{-1}$<br>Reef sites:<br>298-800 µmoles $m^{-2}$ $hr^{-1}$ | Positive, asymptotic relationship between oyster soft tissue biomass and denitrification |
| Kellogg et al. (on-going study) | Intertidal experimental oyster reefs | Experimental oyster reef densities = 0 to 250 oysters $m^{-2}$ | $N_2$ flux in chambers with reef materials | Reference site:<br>87-123 µmoles $m^{-2}$ $hr^{-1}$<br>Reef sites:<br>139-814 µmoles $m^{-2}$ $hr^{-1}$ | Weak relationship between DNF rates and oyster biomass. Lower than subtidal rates. |

1) DNF rates on oyster reefs are generally greater than those at reference sites.
2) The amount of DNF enhancement is highly variable.

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# Status of the Science

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journal homepage: www.elsevier.com/locate/ecss

Invited feature

## Use of oysters to mitigate eutrophication in coastal waters

M. Lisa Kellogg [a,*], Ashley R. Smyth [a], Mark W. Luckenbach [a], Ruth H. Carmichael [b,c], Bonnie L. Brown [d], Jeffrey C. Cornwell [e], Michael F. Piehler [f], Michael S. Owens [e], D. Joseph Dalrymple [c], Colleen B. Higgins [b]

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## NOAA and Partners Evaluate Oyster Nutrient Removal as Best Management Practice for the Chesapeake

Posted on November 19th, 2015 (12 months ago) in Best Management Practices, Coastal Pollution, Coastal Resilience, General Information, Hypoxia & Eutrophication, Water Quality

Scientists from NCCOS and the Northeast Fisheries Science Center were selected by the Chesapeake Bay Program Water Quality Goal Implementation Team, along with university researchers, federal, state and local resource managers, to serve on the Oyster Best Management Practice Expert Panel. The charge to the 13 member panel, conducted by the Oyster Recovery Partnership, is to evaluate the potential and feasibility of using oysters as a Best Management Practice (BMP) for nutrient removal in Chesapeake Bay based on available science.

## Evaluation of the Use of Shellfish as a Method of Nutrient Reduction in the Chesapeake Bay

**A response to the request from the Management Board of the Chesapeake Bay Program**

**STAC Review Report**
**September 2013**

**STAC Publication 13-005**

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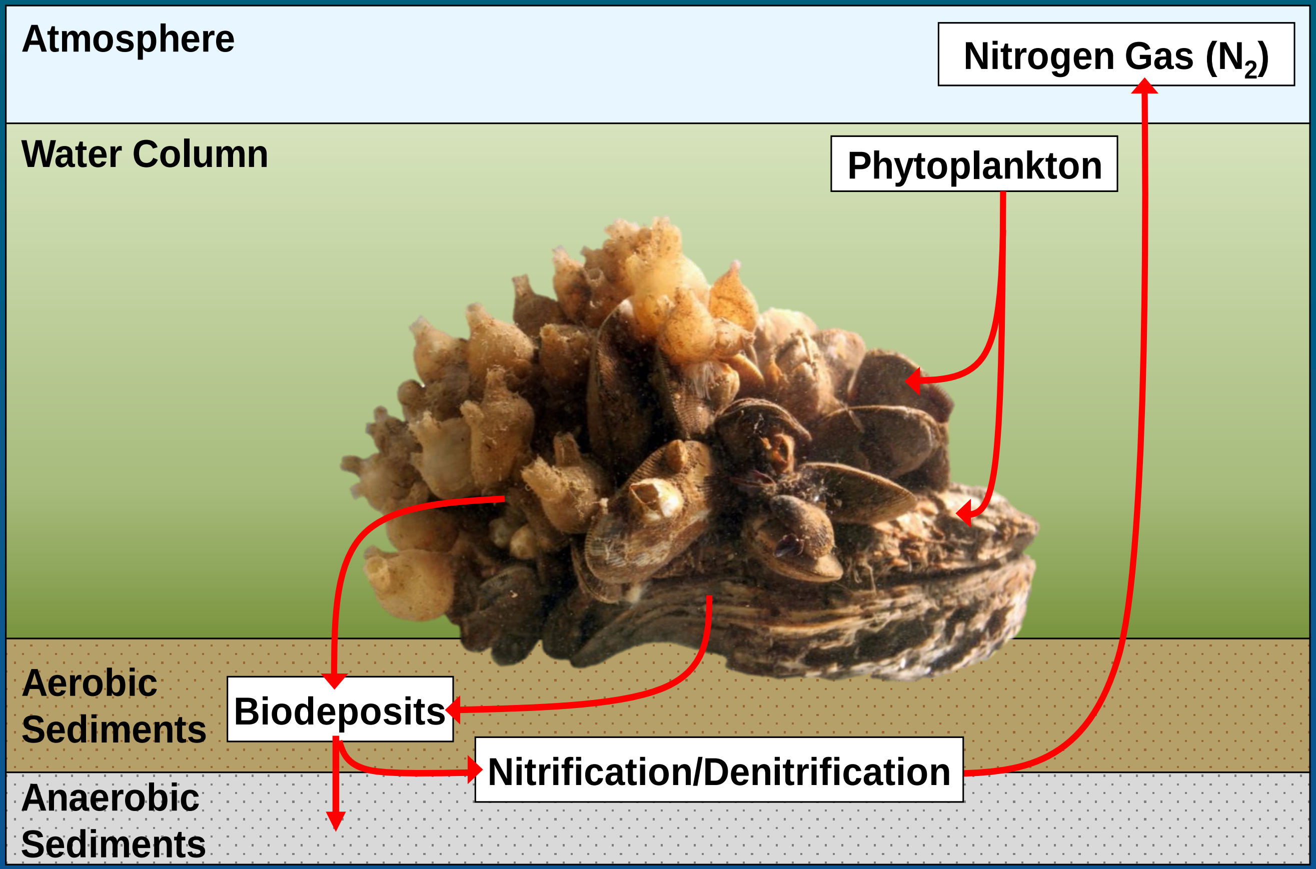
# Removal Pathways




<u>Assimilation</u>
8.2% tissue DW
0.2% shell DW

<u>Burial</u>
No field data

<u>Denitrification</u>
Potentially high, but variable

# A reality check . . .

1 Million market-sized oysters contain about 290 lbs. of N.

| Tributary | Load reduction requirements (lbs. N per year) | # oysters harvested to meet 1% of requirement annually |
|---|---|---|
| Choptank River, MD | 475,682 | 16 million |
| Rhode River, MD | 4,126 | 0.14 million |
| Lynnhaven River, VA | 1,409,078 | 49 million |
| Mobjack Bay, VA | 87,628 | 3 million |

About half of this N is contained in shells, so if the shells are returned to the water, we don't get to count them.

But, 1% reduction may be worth something to local government

50 million oysters ≈ $25 million dockside value at today's prices

At $4/lbs. for N trading credits, 50 millions oysters ≈ $60,000 on the trading market

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# Policy Issues – Water Quality

Beware of "easy fixes" to difficult problems.

Recognize the importance of sound science in informing policy.

Win-win with respect to protein production and water quality.



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# Questions?

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# Where is this going and how do we sustain it?

Ecological Restoration

- Working in some places, but not others
- Emergence of natural disease resistance
- Currently limited by the availability of shell – need alternatives

Wild Fishery Enhancement

- Dependent on success of above
- Will need to reduce latent capacity in the fishery – limited entry
- Develop & enforce quotas that are coupled to oyster abundance

Aquaculture

- Market would appear to support further growth
- Need to manage use conflicts in our coastal waters
- Must maintain a strong science-based development programs – selective breeding, disease diagnostics & public health