Shell management – a fundamental limitation to oyster rebuilding and restoration in the Chesapeake Bay

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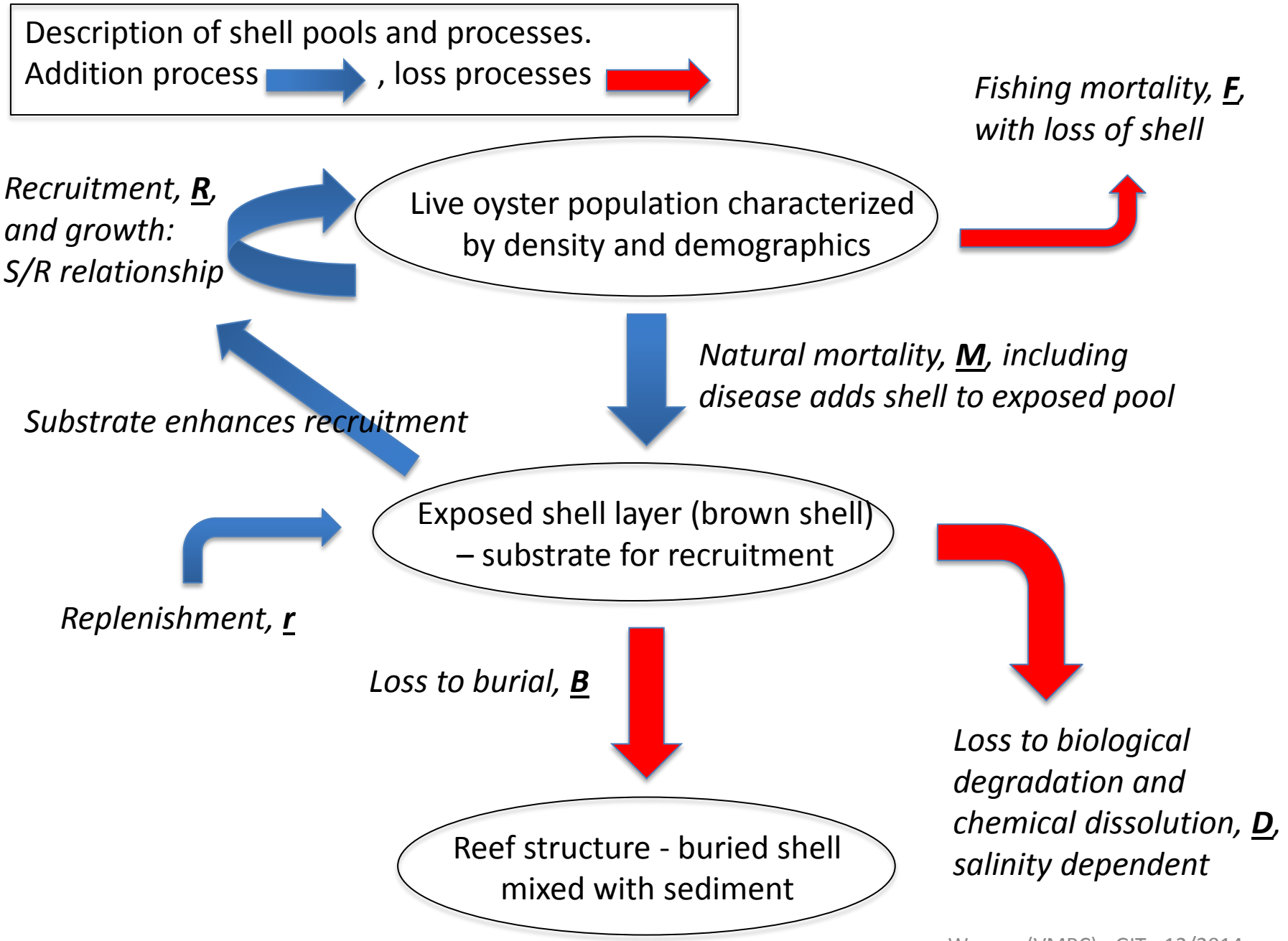
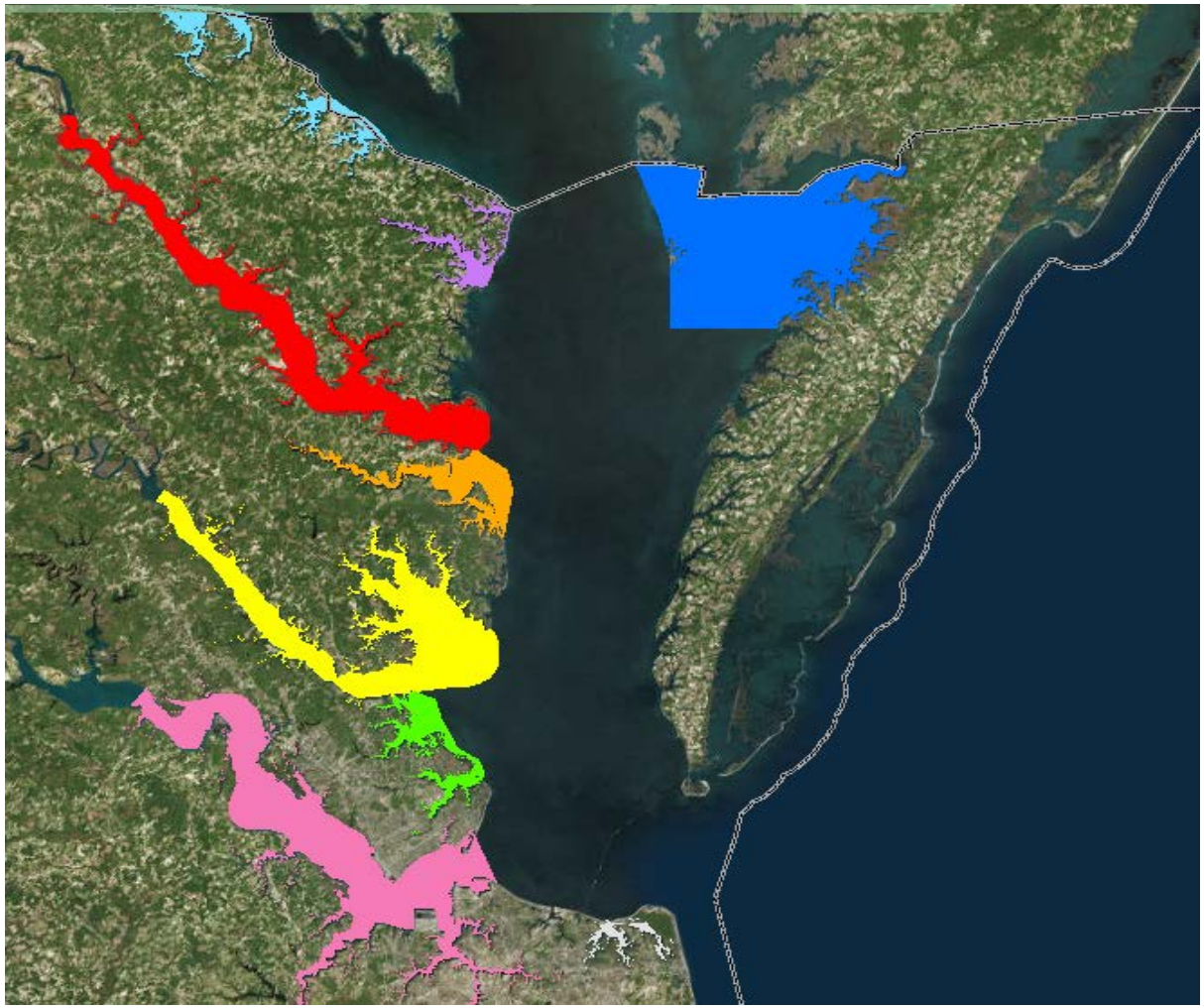
Virginia Institute of Marine Science


Description of shell pools and processes.
Addition process , loss processes
Fishing mortality, F, with loss of shell
Recruitment, R, and growth: S/R relationship
Live oyster population characterized by density and demographics
Natural mortality, M, including disease adds shell to exposed pool
Substrate enhances recruitment
Exposed shell layer (brown shell) – substrate for recruitment
Replenishment, r
Loss to burial, B
Loss to biological degradation and chemical dissolution, D, salinity dependent
Reef structure - buried shell mixed with sediment

VOSARA

http://cmap.vims.edu/VOSARA/VOSARA_Viewer/VOSARA.html



Input

New Shells and Recruitment

Input

New Concrete and Recruitment

Input

Oysters and Mortality

Loss

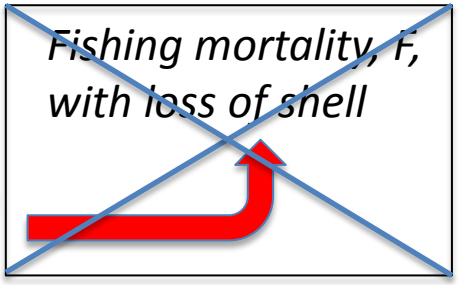
Burial, Biological Degradation,and Dissolution of Shell

Loss
Biological degradation-boring sponge

Shell Degradation Process

Loss
Concrete-Loss of Attachment Locations

#1. Natural reef with accretion, no F, no r, shell accretes
As M>(B+D), **system stable** over extended periods.

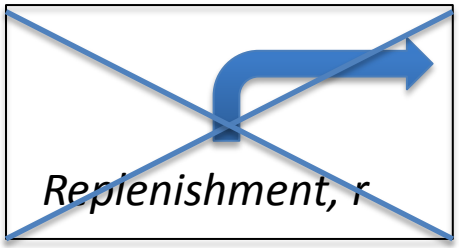


Recruitment, R, and growth: S/R relationship

Live oyster population characterized by density and demographics

Natural mortality, M, adds shell to exposed pool

Substrate enhances recruitment



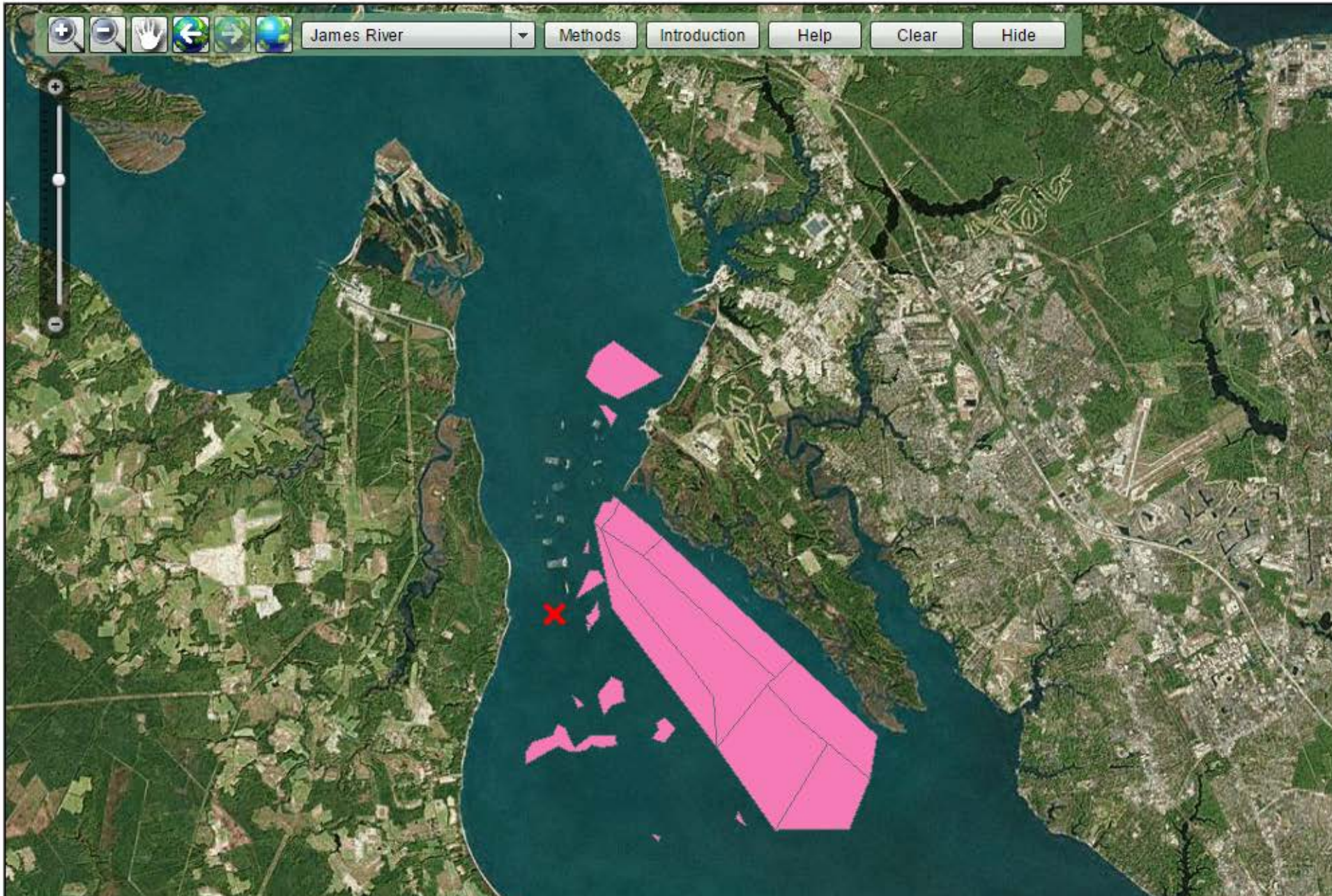
Exposed shell layer (brown shell) – substrate for recruitment

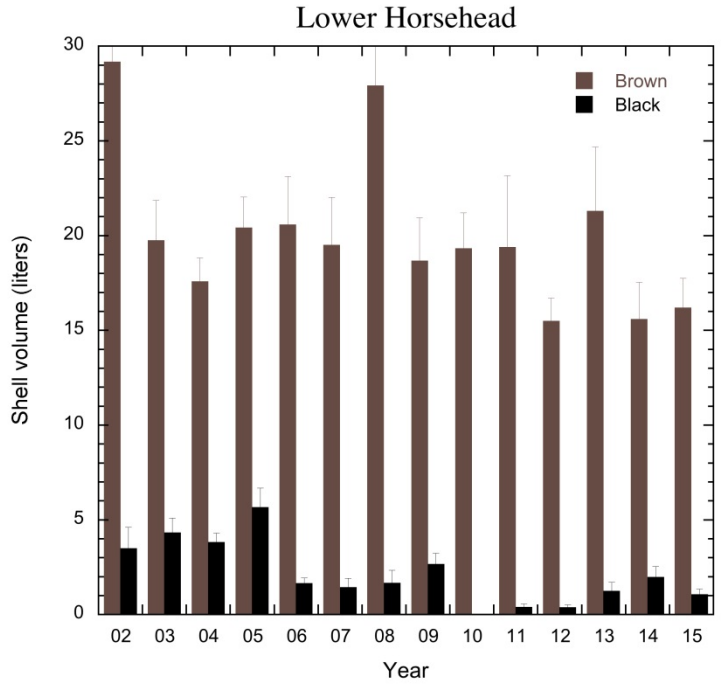
Loss to burial, B

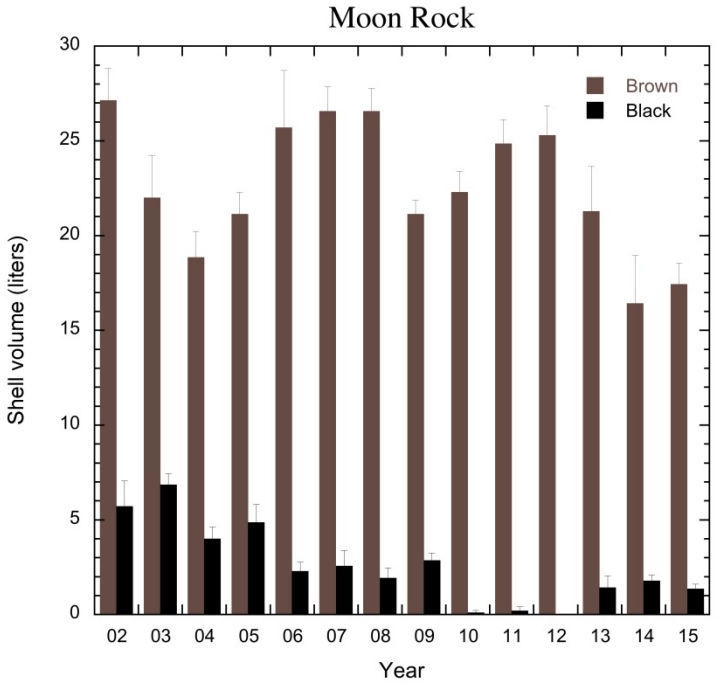
Loss to biological degradation and chemical dissolution, D, salinity dependent

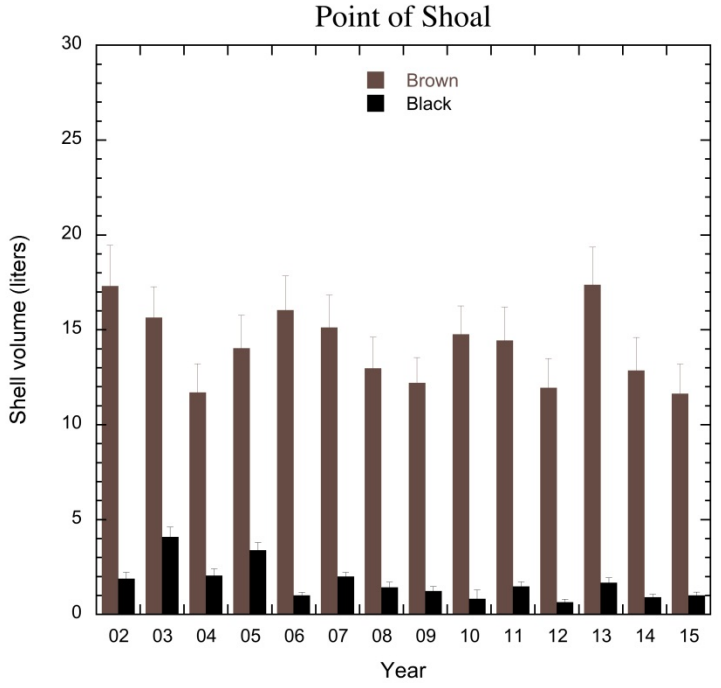
Reef structure - buried shell mixed with sediment

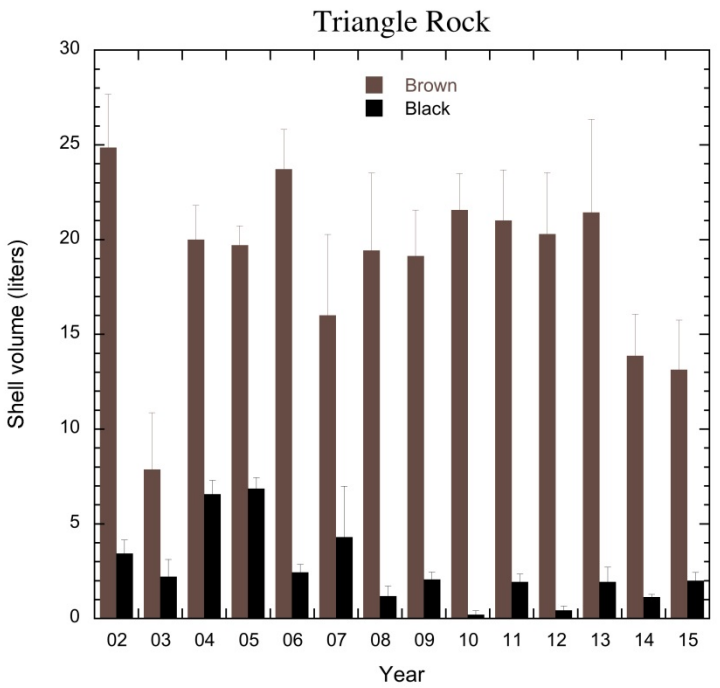
Virginia Oyster Stock Assessment and Replenishment Archive (VOSARA)



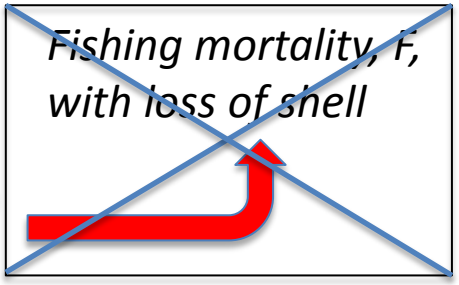

Lower Horsehead
Brown
Black
Shell volume (liters)
0
5
10
15
20
25
30
02
03
04
05
06
07
08
09
10
11
12
13
14
15
Year


Moon Rock
Brown
Black
Shell volume (liters)
0
5
10
15
20
25
30
02
03
04
05
06
07
08
09
10
11
12
13
14
15
Year


Point of Shoal
Brown
Black
Shell volume (liters)
0
5
10
15
20
25
30
02
03
04
05
06
07
08
09
10
11
12
13
14
15
Year


Triangle Rock
Brown
Black
Shell volume (liters)
0
5
10
15
20
25
30
02
03
04
05
06
07
08
09
10
11
12
13
14
15
Year

#2. Natural reef, no F, no r, but increased M due to disease. Decreased oyster longevity, lower shell addition rate to exposed layer, no accretion as M<(B+D), **system fails**.

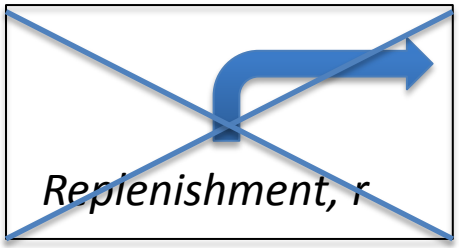


Recruitment, R, and growth: S/R relationship

Live oyster population characterized by density and demographics

Natural mortality, M, including disease adds shell to exposed pool

Decreased substrate enhancement



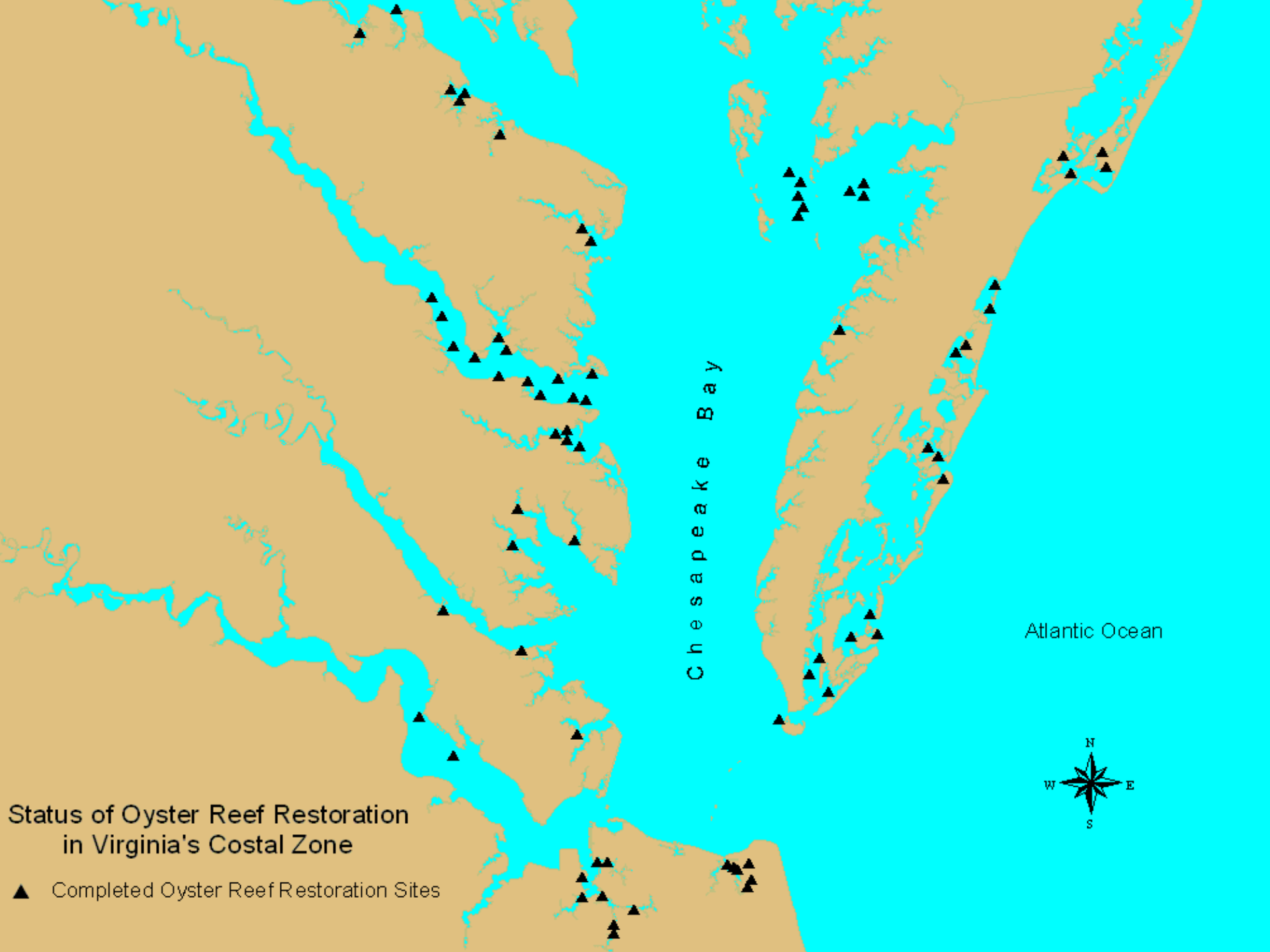
Exposed shell layer (brown shell) – substrate for recruitment

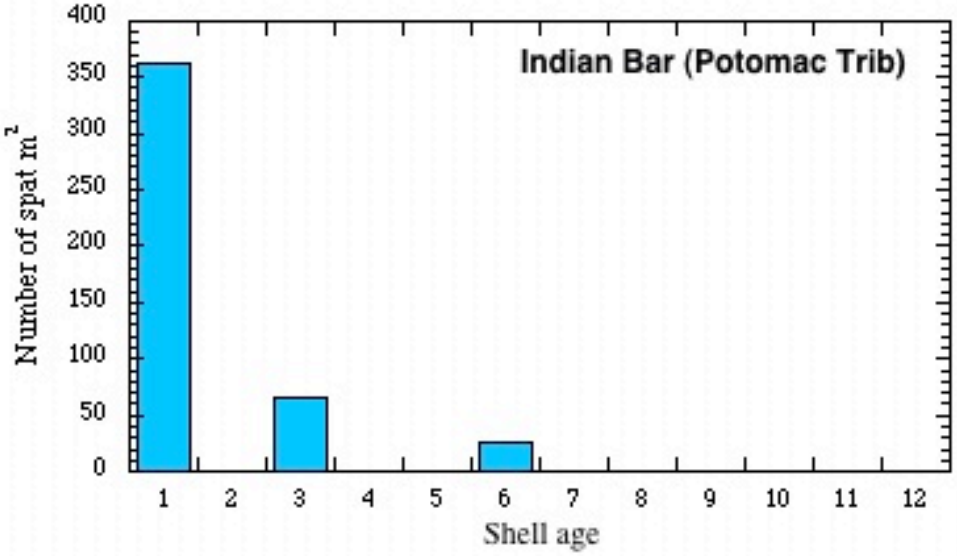
Loss to burial, B

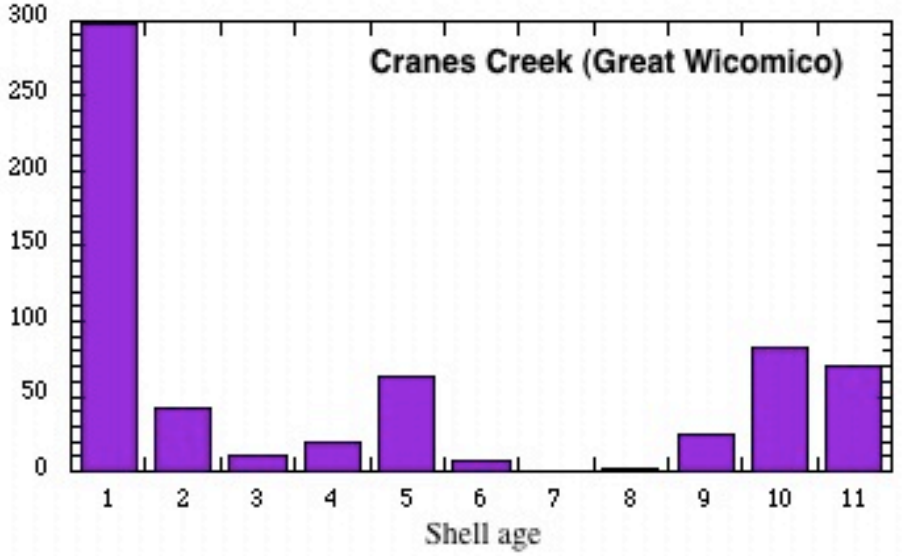
Loss to biological degradation and chemical dissolution, D, salinity dependent

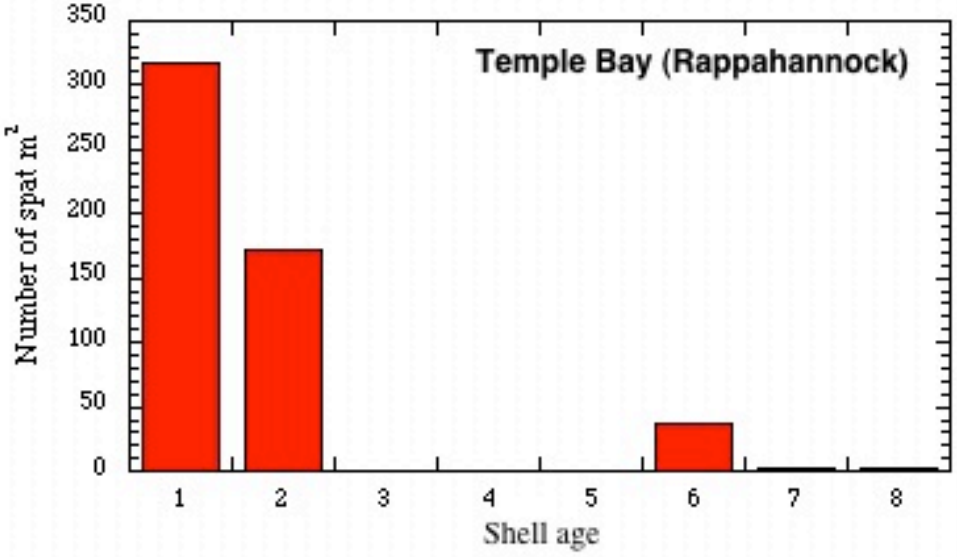
Reef structure - buried shell mixed with sediment

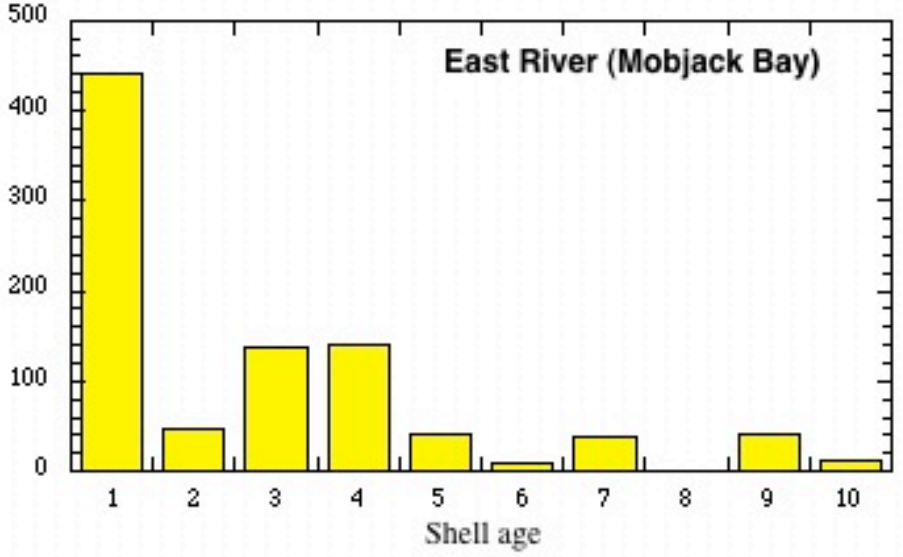
SUBMERGED
DANGER
REEF


Chesapeake Bay
Atlantic Ocean
N
W
E
S
Status of Oyster Reef Restoration
in Virginia's Costal Zone
Completed Oyster Reef Restoration Sites


Indian Bar (Potomac Trib)
Number of spat m-2
Shell age
0
50
100
150
200
250
300
350
400
1
2
3
4
5
6
7
8
9
10
11
12


Cranes Creek (Great Wicomico)
Shell age
0
50
100
150
200
250
300
1
2
3
4
5
6
7
8
9
10
11

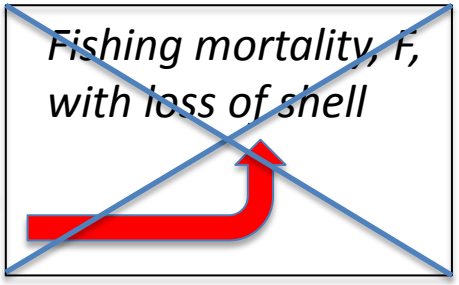

Temple Bay (Rappahannock)
Number of spat m-2
Shell age
0
50
100
150
200
250
300
350
1
2
3
4
5
6
7
8


East River (Mobjack Bay)
Shell age
0
100
200
300
400
500
1
2
3
4
5
6
7
8
9
10

Mill Creek - 2000

Mill Creek -2014

#3. Natural reef, no F, increased M (disease). Decreased oyster longevity, lower shell addition rate to exposed layer, offset by **CONTINUAL** replenishment until M=(B+D), **system stable**.



Recruitment, R, and growth: S/R relationship

Live oyster population characterized by density and demographics

Natural mortality, M, including disease adds shell to exposed pool

Increased substrate enhancement

Exposed shell layer (brown shell) – substrate for recruitment

Replenishment, r

Loss to burial, B

Loss to biological degradation and chemical dissolution, D, salinity dependent

This is the reality of sanctuaries!

Reef structure - buried shell mixed with sediment

Shell loss rates are salinity dependent and independent of supply from mortality.

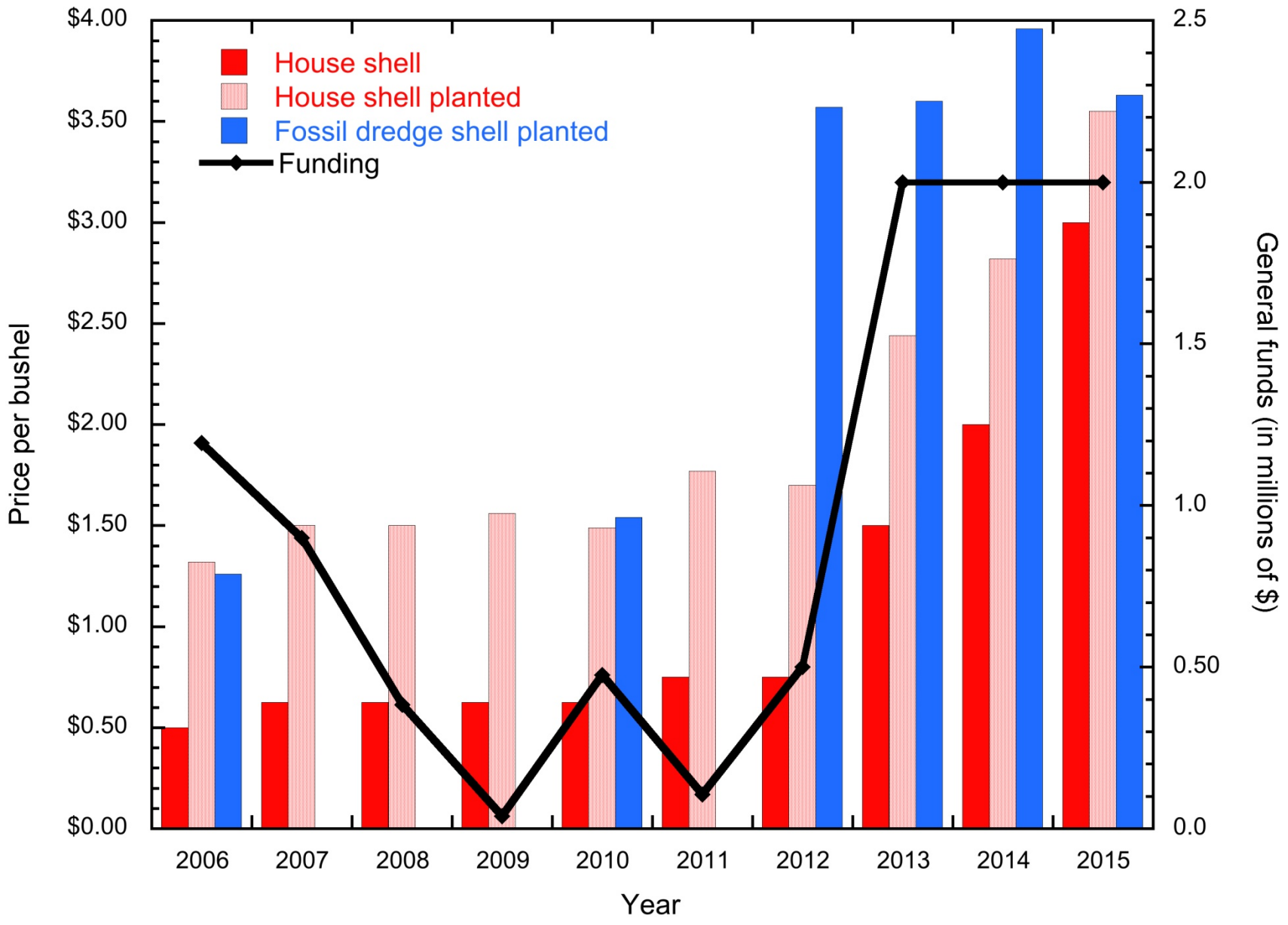
Accreting reefs require equilibrium between shell addition and loss. This requires sustained recruitment, growth and survival of oysters to large size prior to death.

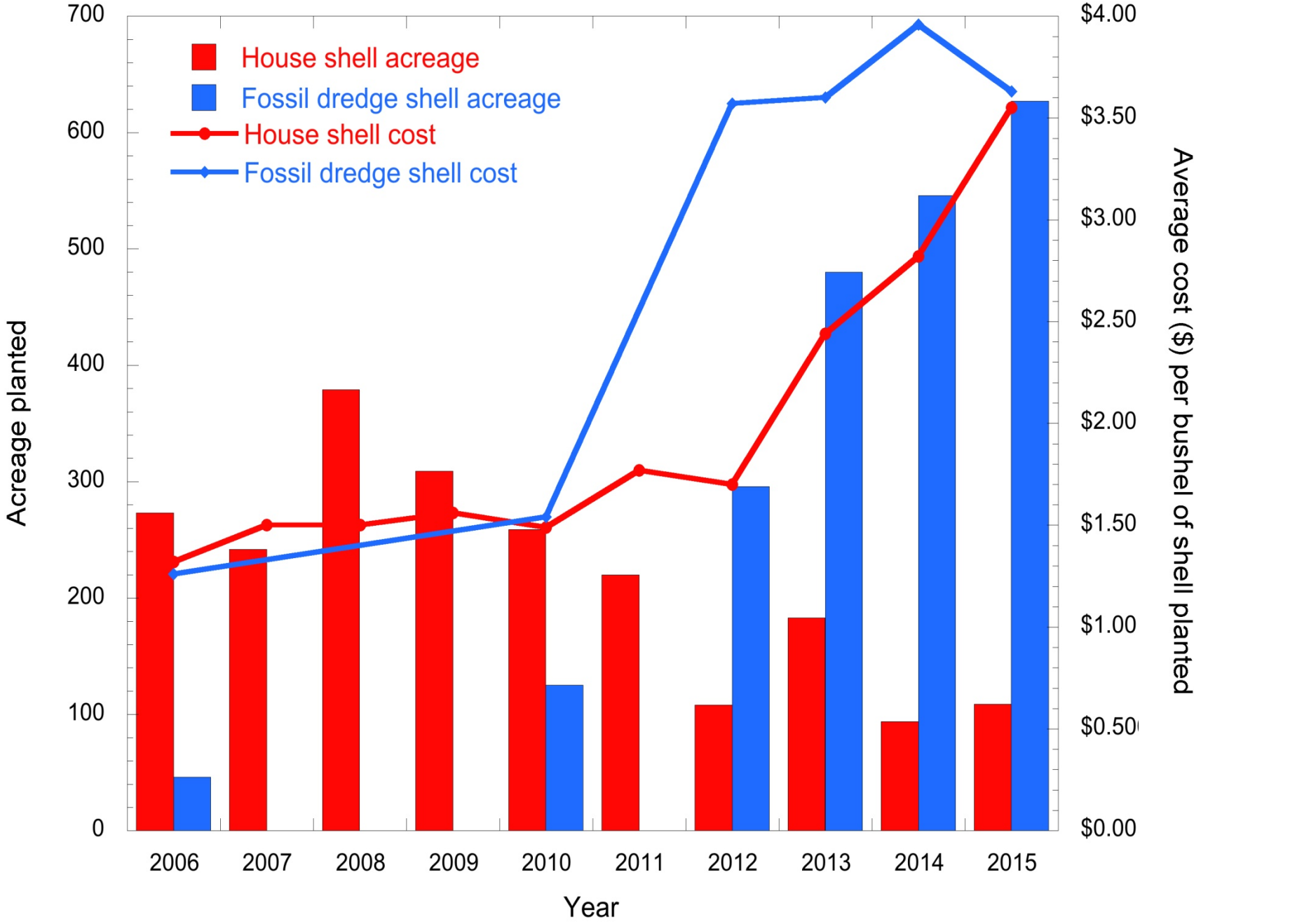
Offsetting inadequate shell supply from natural processes through repletion (r) is NOT a single addition process – it requires CONTINUING addition forever.

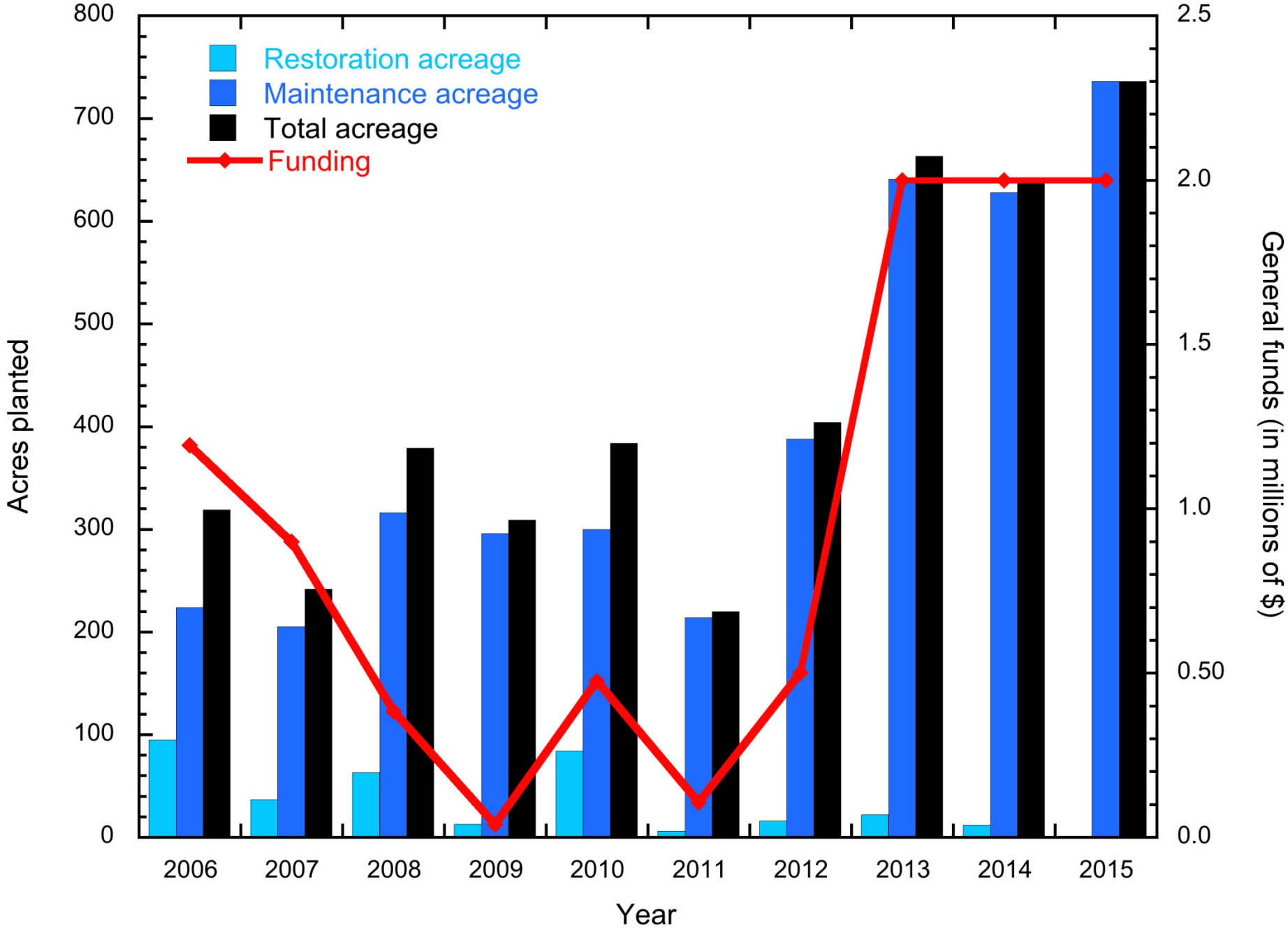
A single replenishment action to suitable bottom is NOT restoration.

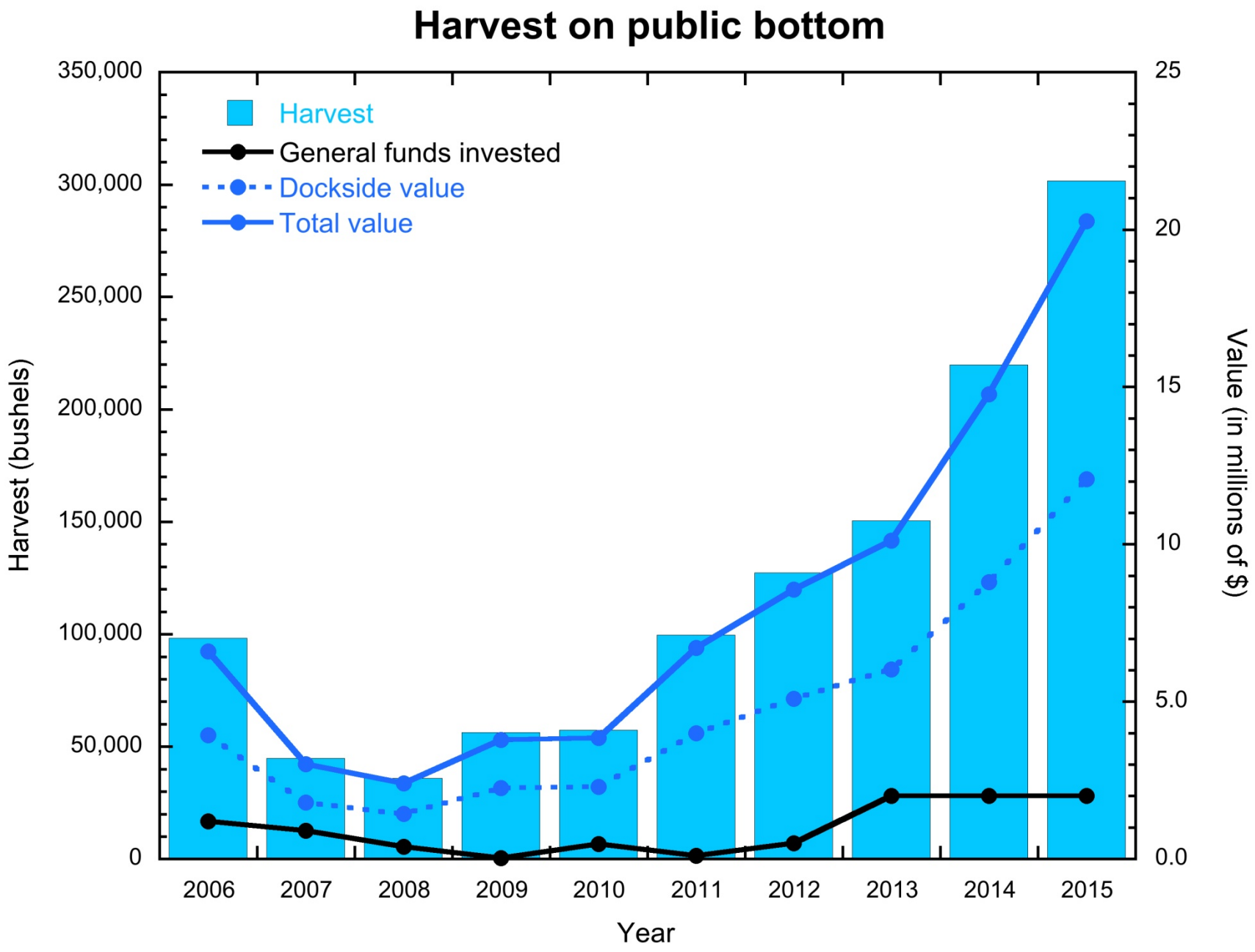
Final Thoughts

- Shell supplies are extremely limited and finite.
- Competition between restoration partners has inflated the cost of shell and oyster restoration, thereby reducing acreage that can be replenished for the dollars expended.
- Choosing to invest in new areas, while there is insufficient funding to replenish previously constructed areas, is a decision to allow previously replenished areas to degrade to an unacceptable and non functional condition.


Shell price/bu versus state funding
House shell
House shell planted
Fossil dredge shell planted
Funding
Price per bushel
$4.00
$3.50
$3.00
$2.50
$2.00
$1.50
$1.00
$0.50
$0.00
2.5
2.0
1.5
1.0
0.50
0.0
General funds (in millions of $)
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
Year


House shell acreage
Fossil dredge shell acreage
House shell cost
Fossil dredge shell cost
Acreage planted
Average cost ($) per bushel of shell planted
Year
0
100
200
300
400
500
600
700
$0.00
$0.50
$1.00
$1.50
$2.00
$2.50
$3.00
$3.50
$4.00
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015


Restoration acreage
Maintenance acreage
Total acreage
Funding
Acres planted
General funds (in millions of $)
Year
800
700
600
500
400
300
200
100
0
2.5
2.0
1.5
1.0
0.50
0.0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015


Harvest on public bottom
Harvest
General funds invested
Dockside value
Total value
Harvest (bushels)
Value (in millions of $)
Year
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
25
20
15
10
5.0
0.0
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015