

Are we adequately managing the oyster resources of Delaware Bay?

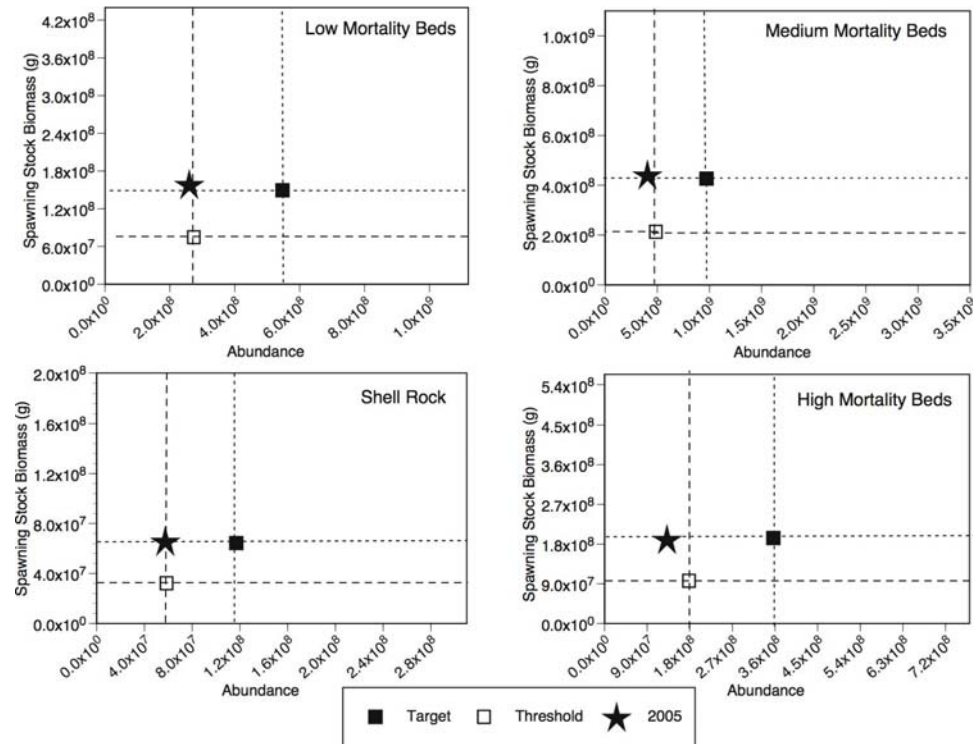
The Approach!

Biological reference-point based management

Target and threshold abundance and biomass levels set

Fishing mortality controlled by F -based management

The goal: $P\left(\frac{dN}{dt} \geq 0\right) = 0.75$



The Enemies to Success

Dermo disease mortality

Low recruitment

Decline in habitat integrity

What does Dermo do?

Increased mortality reduces generation time

--thus lifetime reproductive potential declines

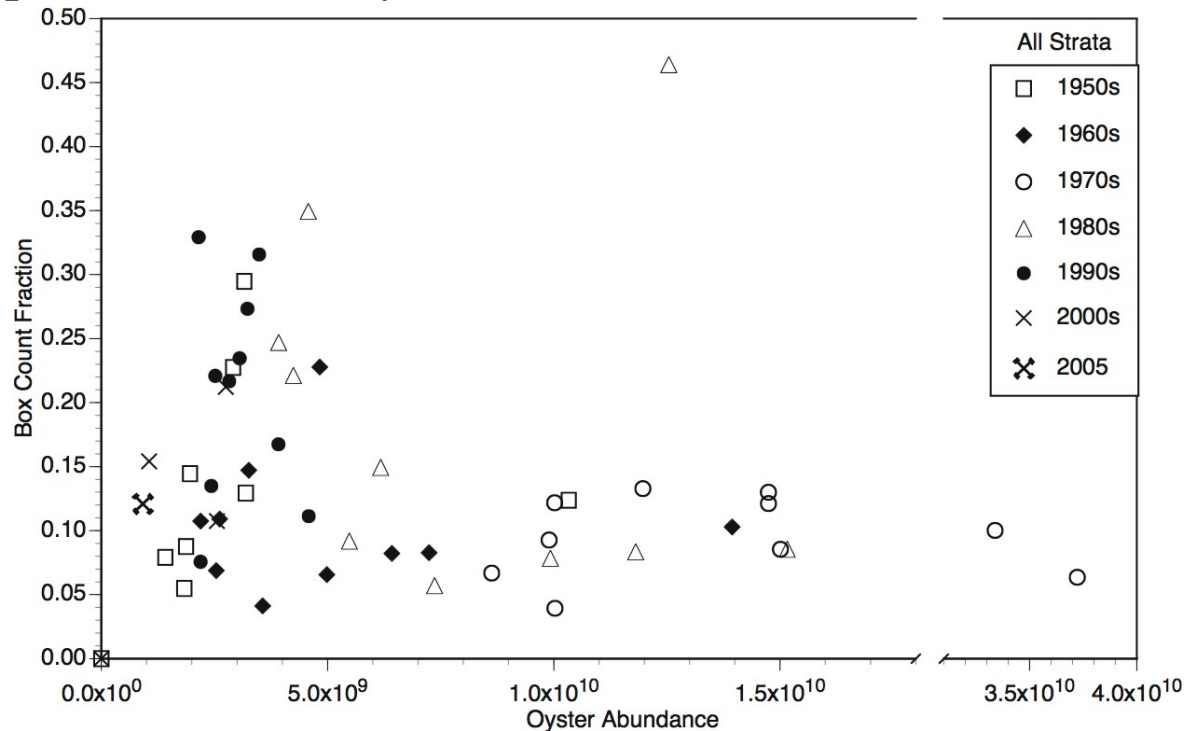
Mortality targets females

--thus lifetime reproductive potential declines

Increased mortality reduces abundance

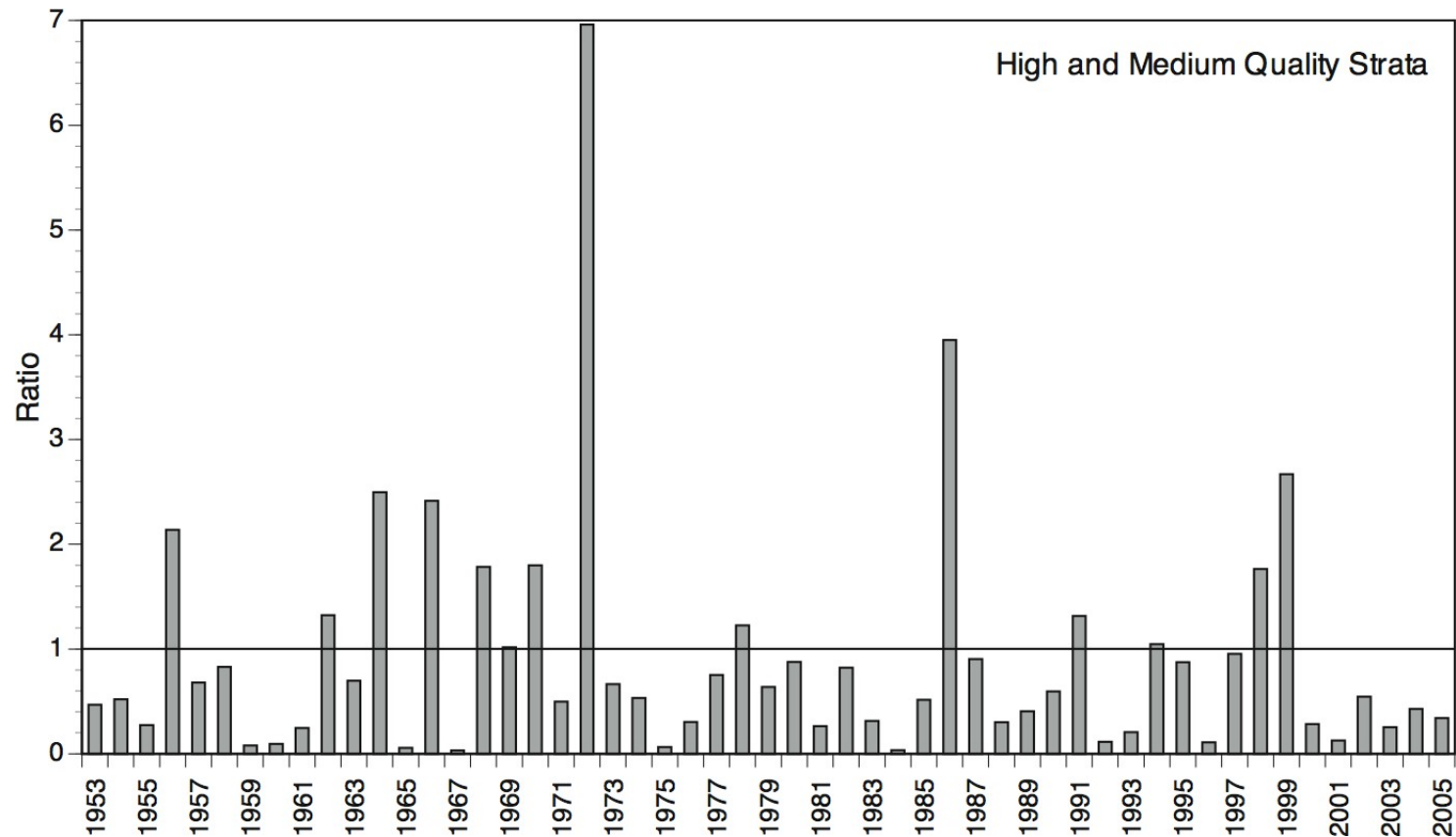
--Ambit of population dynamics response to increased mortality low

--potential fecundity increase $\leq 2x$



The Result

Population is sensitive to recruitment failure and population collapse



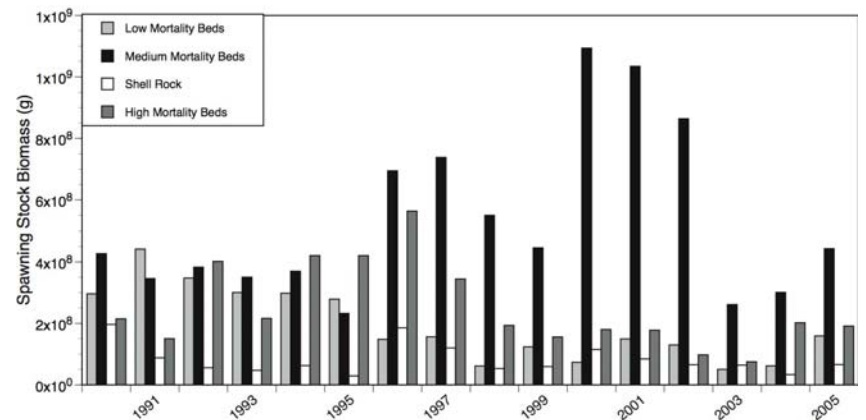
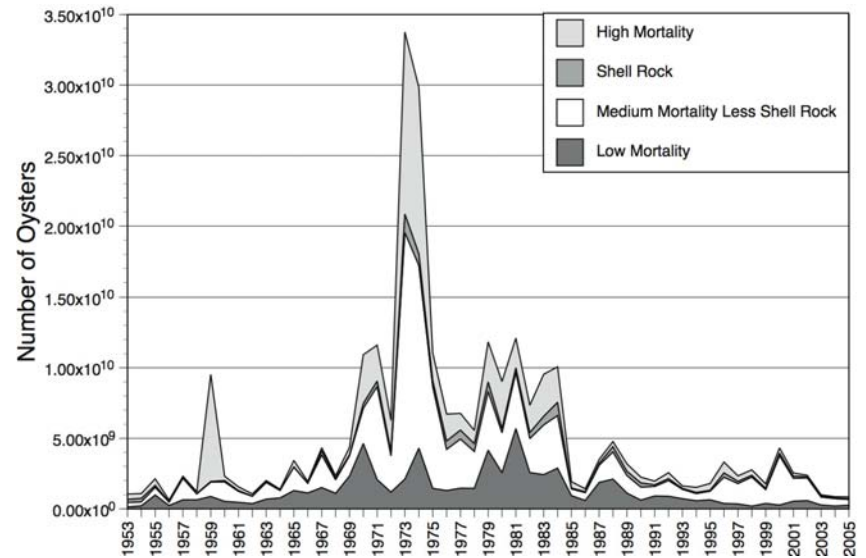
What does low recruitment do?

Abundance declines

--Abundance is near an all-time low

The population ages

--Stable biomass indicates an aging population



The Result

Population is sensitive to epizootic mortality and population collapse

The decline in habitat integrity!

OYSTERS NEED SHELL

BUT SHELL IS NOT PERMANENT

The lesson of taphonomy!

--Shell degrades at an exponential decay rate

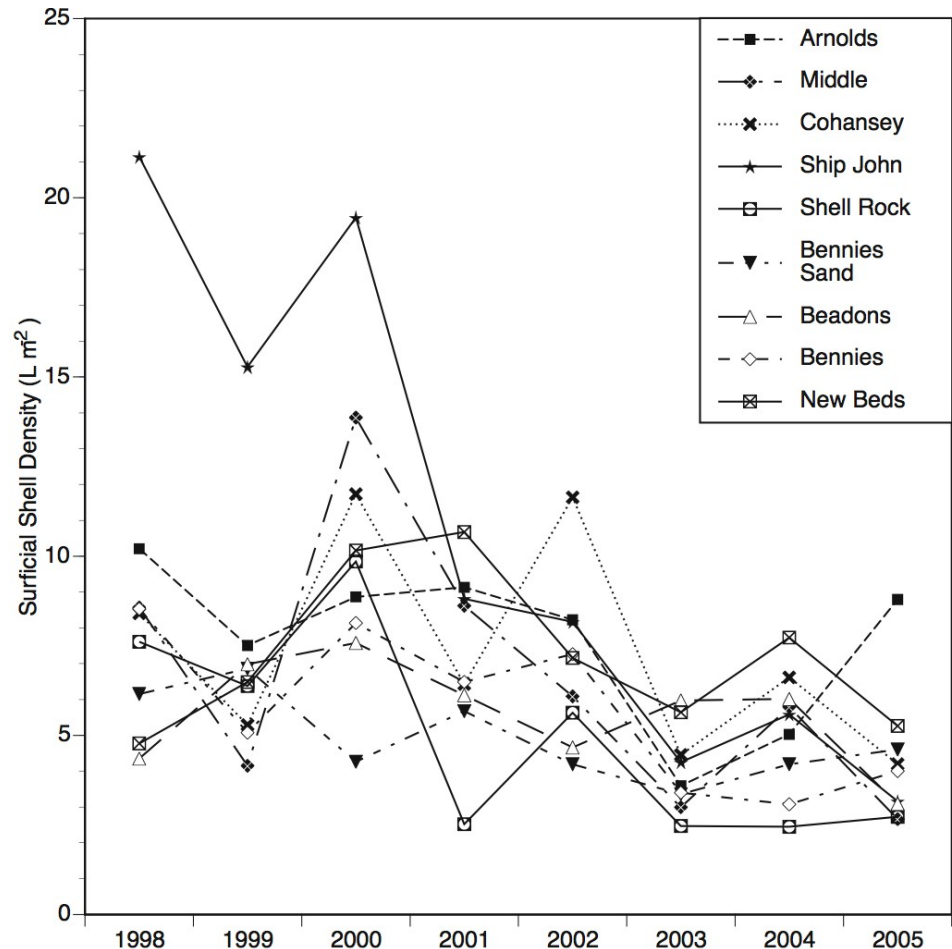
Shell is added when animals die (*b*)

Shell is lost through taphonomic decay (*l*)

Habitat integrity is controlled by the balance

$$-\frac{dS}{dt} = (b(t) - l)S$$

But today, $l > b$



What controls l and b

For habitat to be stable

Oysters must recruit **AND** oysters must die!

What should our management goals be?

$$\text{Goal 1: } P\left(\frac{dB}{dt} \geq 0\right) = 0.75$$

$$\text{Goal 2: } P\left(\frac{dS}{dt} \geq 0\right) = 0.75$$

The Impediment to Success!

OYSTERS MAKE THE SUBSTRATE UPON WHICH THEY DEPEND
AND

UNLIKE ALL OTHER SUCH ANIMALS, OYSTERS DO NOT PROTECT THE
SUBSTRATE THEY MAKE

A model for habitat integrity

$$\frac{dN}{dt} = -(m(t) + f(t))N + r(N)$$

$$\frac{dS}{dt} = (b(t) - l)S$$

where $\frac{dN}{dt}$ is a balance between natural mortality m , fishing mortality f , and
recruitment r

Under the constraint!

$$\frac{dN}{dt} = 0$$

$$\frac{dS}{dt} = 0$$

The stability point!

For the oyster resource to have a long-term future both the animal and the habitat must be retained

Habitat is only stable when

$$S_s = \frac{\gamma m_o N_s}{l}$$
$$N_s = \beta \left(\frac{1 - \log_e m_o}{\alpha} \right)$$

Where γ is a conversion parameter,
 s indicates steady state,
 α and β are recruitment parameters

With the understanding that shell is produced only when oysters die!

$$\gamma m(t) N = b(t) S:$$

Alas for evolution!

Shell is maximized at the primordial mortality rate

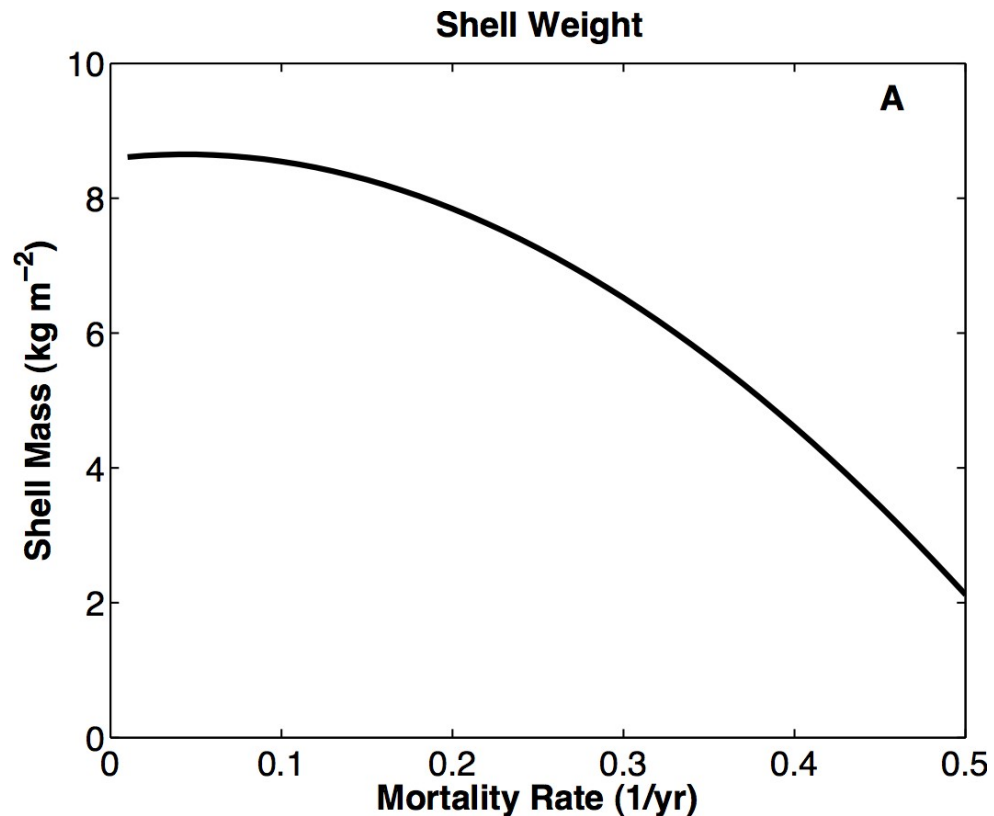
Why?

To survive

-- oysters must maximize shell and shell decays

The decay rate requires

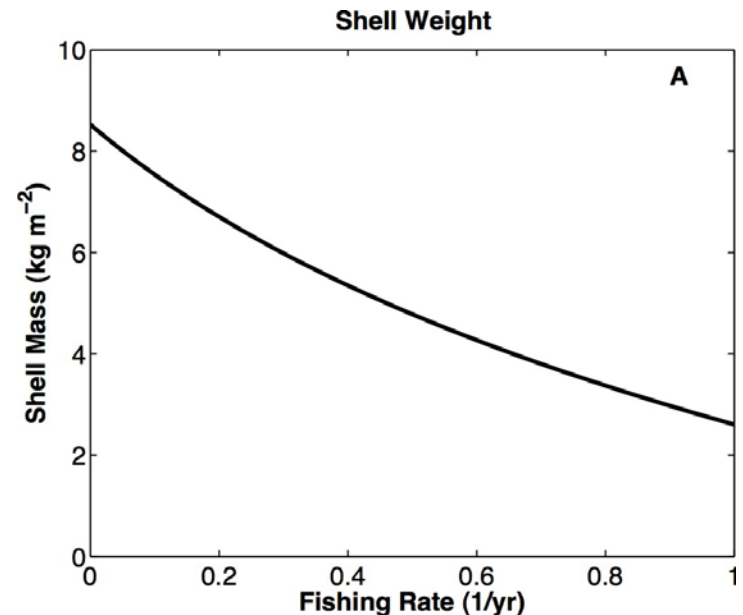
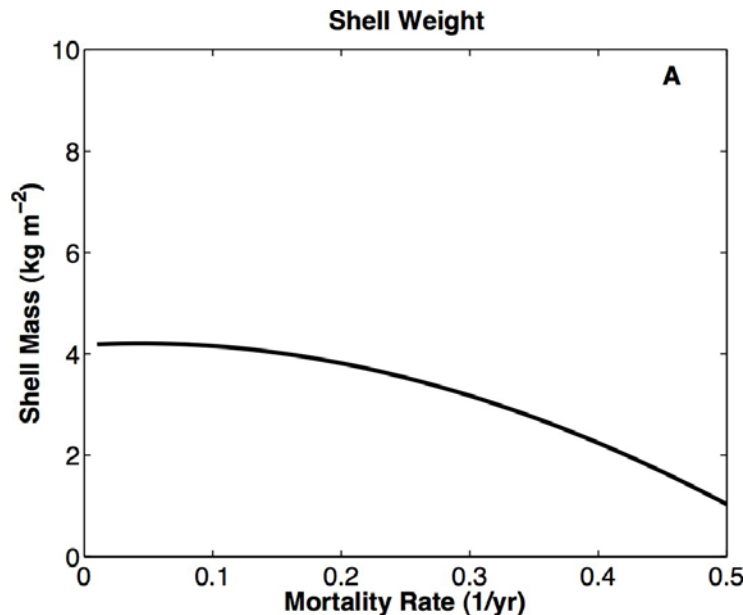
-- an offsetting generation time and mortality rate



Alas for the oyster!

Any increase in mortality by disease or fishing **will**

- (1) degrade the shell bed
- (2) eventually result in habitat loss
- (3) ultimately result in loss of the oyster as a keystone species



Is there hope?



Photographs courtesy of R. Babb, New Jersey Fish and Wildlife

The addition of shell

- 1) enhances recruitment,
--thus offsetting the primary impact of Dermo disease
- 2) stabilizes habitat
--thus offsetting the primary impact of Dermo disease and
fishing

Are we winning?

NO!

A shell budget for the New Jersey oyster beds

Year	Net change in shell (L m^{-2})
1999	-0.28
2000	-0.79
2001	-0.48
2002	-0.43
2003	-0.29
2004	-0.34
2005	-0.19

Are we winning?

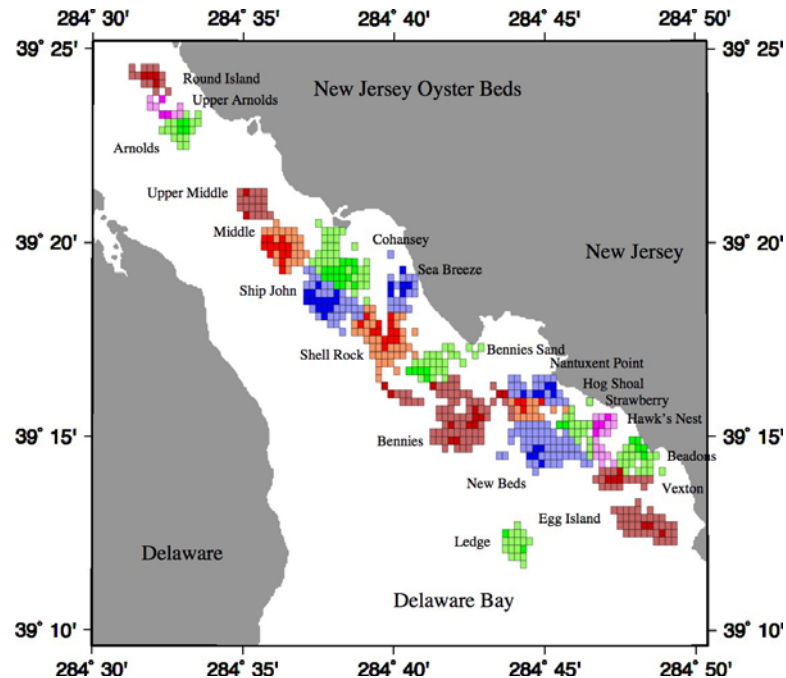
NO!

A shell budget for the New Jersey oyster beds

Year	Net change in shell (bushels)
1999	-528024
2000	-1484205
2001	-897615
2002	-810083
2003	-540684
2004	-648115
2005	-360727

But, some areas are doing better than others

Bed Region	2005 Status (in bushels)
Low Mortality Beds	-4,430
Medium Mortality Transplant Beds	-149,103
Medium Mortality Market Beds	43,062
High Mortality Market Beds	-250,255



TAKE HOME MESSAGE

If we wish to avoid loss of oyster bed habitat

If we wish to avoid loss of the oyster itself

We must plant at least 500,000 bushels
of shell annually

FOREVER