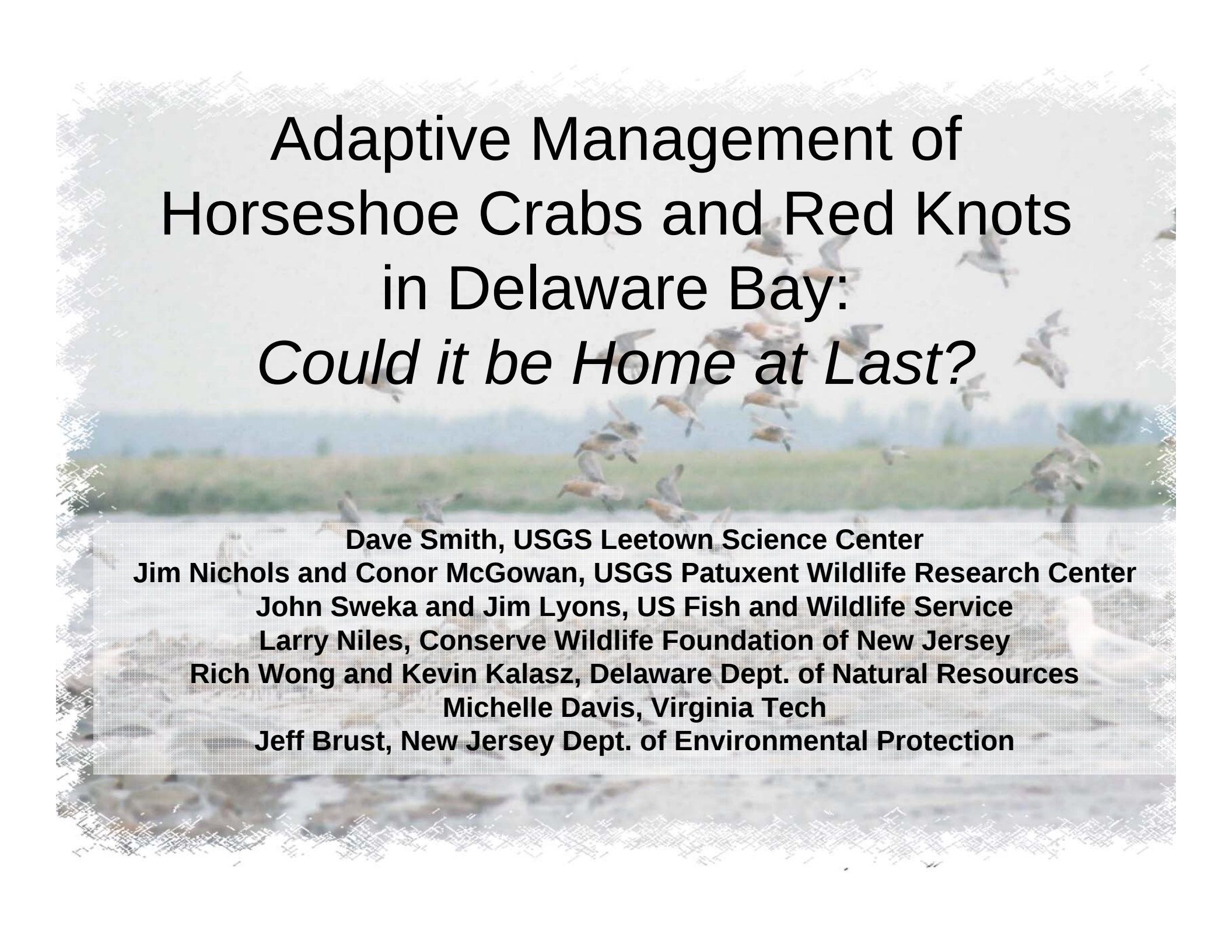




Adaptive Management of Horseshoe Crabs and Red Knots in Delaware Bay: *Could it be Home at Last?*

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John Sweka and Jim Lyons, US Fish and Wildlife Service

Larry Niles, Conserve Wildlife Foundation of New Jersey

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Michelle Davis, Virginia Tech

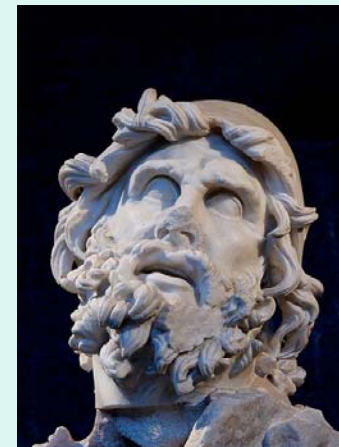
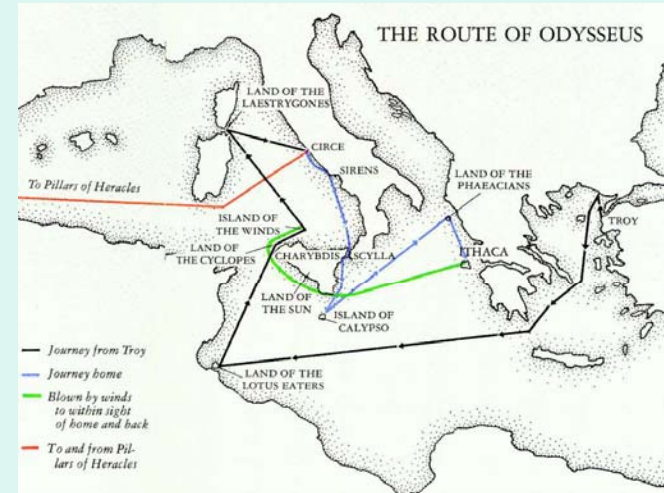
Jeff Brust, New Jersey Dept. of Environmental Protection

The Odyssey

- “Well the danger on the rocks is surely past
Still I remain tied to the mast
Could it be that I have found
my home at last”

Refrain from Home at Last by
Steely Dan

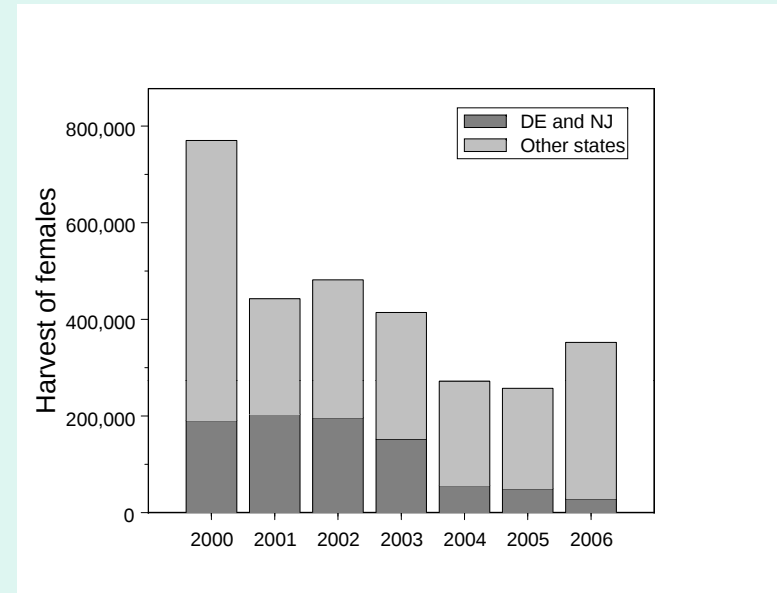
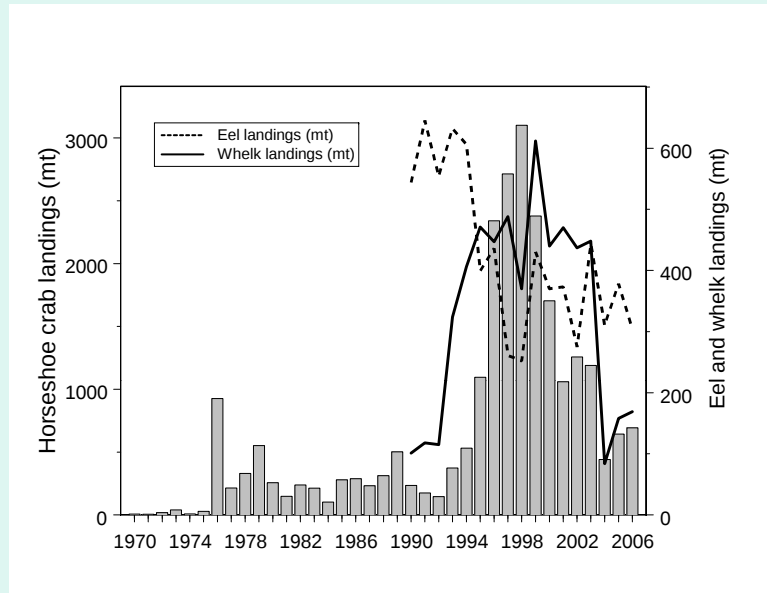
- *Odysseus in this case is an amalgam, a composite.*



Outline

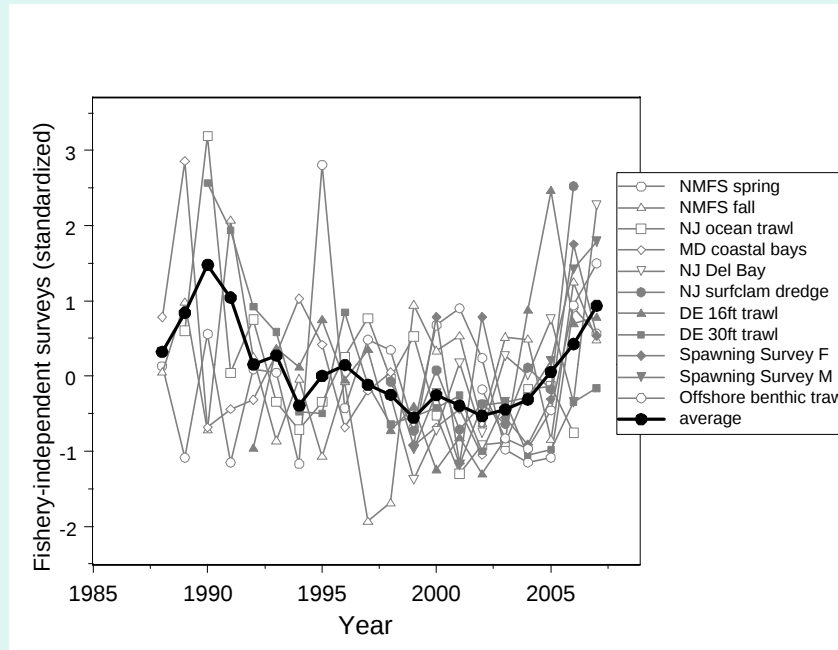
- Quick review of status and trends
- Where we've been: past management framework
- Where we're going: adaptive management framework
- What obstacles lie ahead: *Are we home at last?*

Bait harvest



- Harvest increase during 90's was driven by whelk fishery
 - Whelk and hsc landings are positively correlated ($r = 0.76$, $P = 0.01$)
 - Eel and hsc landings are negatively correlated ($r = -0.83$, $P = 0.002$)
- Harvest decrease during 2000's was prompted by declines in hsc and shorebird abundance
- Currently, there is a moratorium on harvesting female horseshoe crabs within Delaware Bay states
- Males are harvested under restrictions

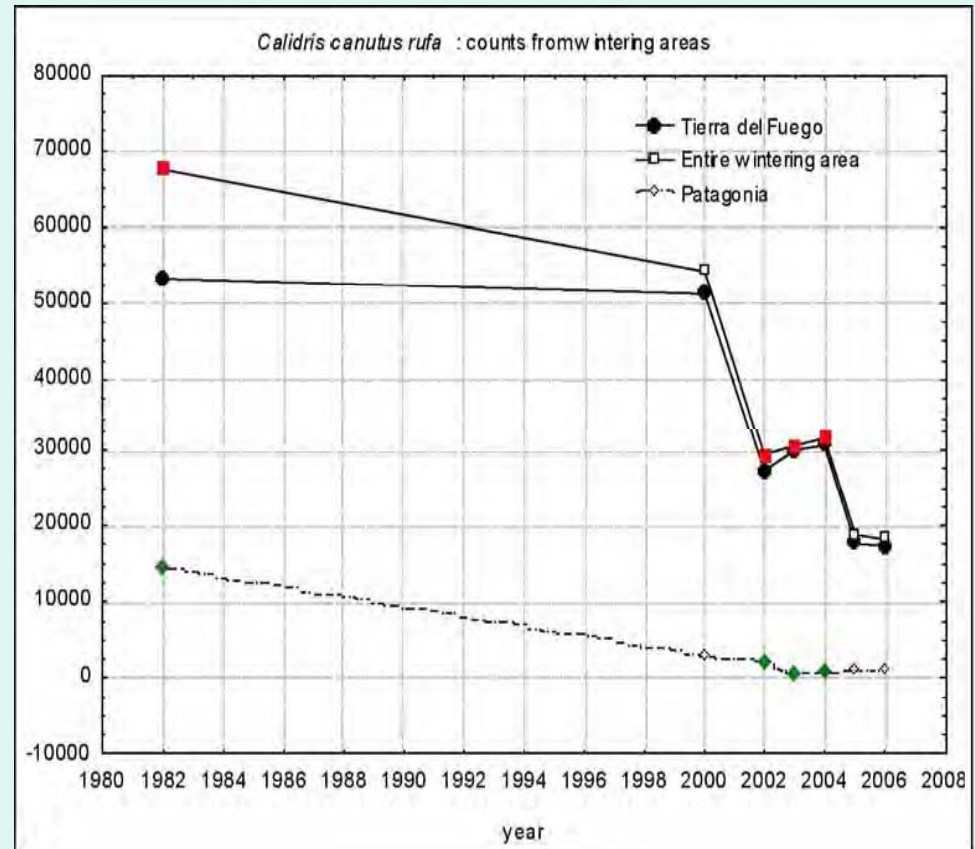
Population response



Demographic group	Significant positive trends 1999-2006 (no neg trends)	Assessment
Adult females	1 of 4	Stable or increasing
Adult males	3 of 4	Increasing
Juveniles	3 of 3	Increasing

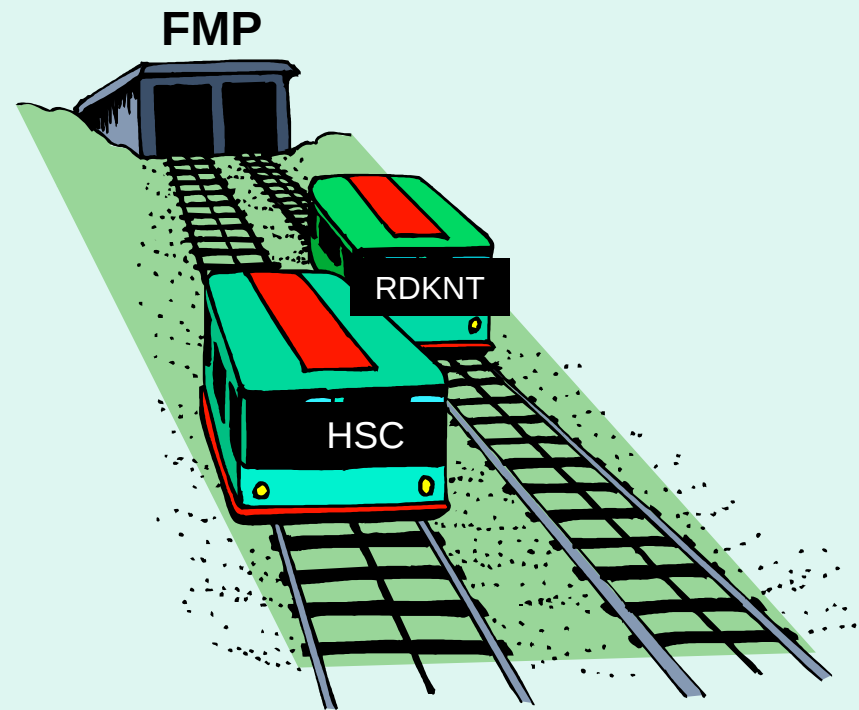
However, red knots continue to decline

- HSC egg availability remains temporally and spatially patchy
- In 2006, the red knot was named candidate for Endangered Species Act protection



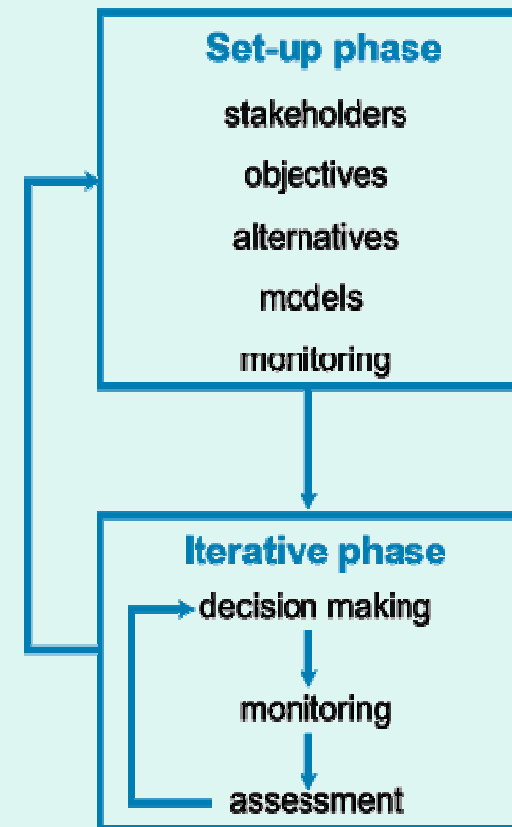
Current management

- Prior to 1998, harvest of horseshoe crabs for bait was largely unregulated and underreported
- Management of Delaware Bay horseshoe crabs and migratory shorebirds has followed traditional species-specific assessments with only qualitative linkages between them
- During this time, the management process has been marked by dispute, stealth issue advocacy, and ad hoc decision making



An adaptive management framework for horseshoe crabs and red knots

- Development began in 2007
- Adaptive management is a structured approach for making linked decision
- Requires participation of stakeholders
- Emphasizes transparency and explicitness
- Designed to improve understanding of how a resource system works, so as to achieve management objectives.



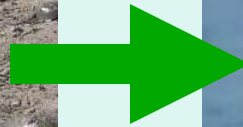
Statement of the Objective

- Regulate a sustainable harvest of horseshoe crab populations and provide sufficient horseshoe crab eggs to support population recovery goals for Delaware Bay shorebirds, which forage on horseshoe crab eggs.
- Multiple objectives:
 - hsc harvest and sustainable hsc population
 - recovered red knot population
- Trade-off between hsc harvest and hsc eggs available for red knot energetics

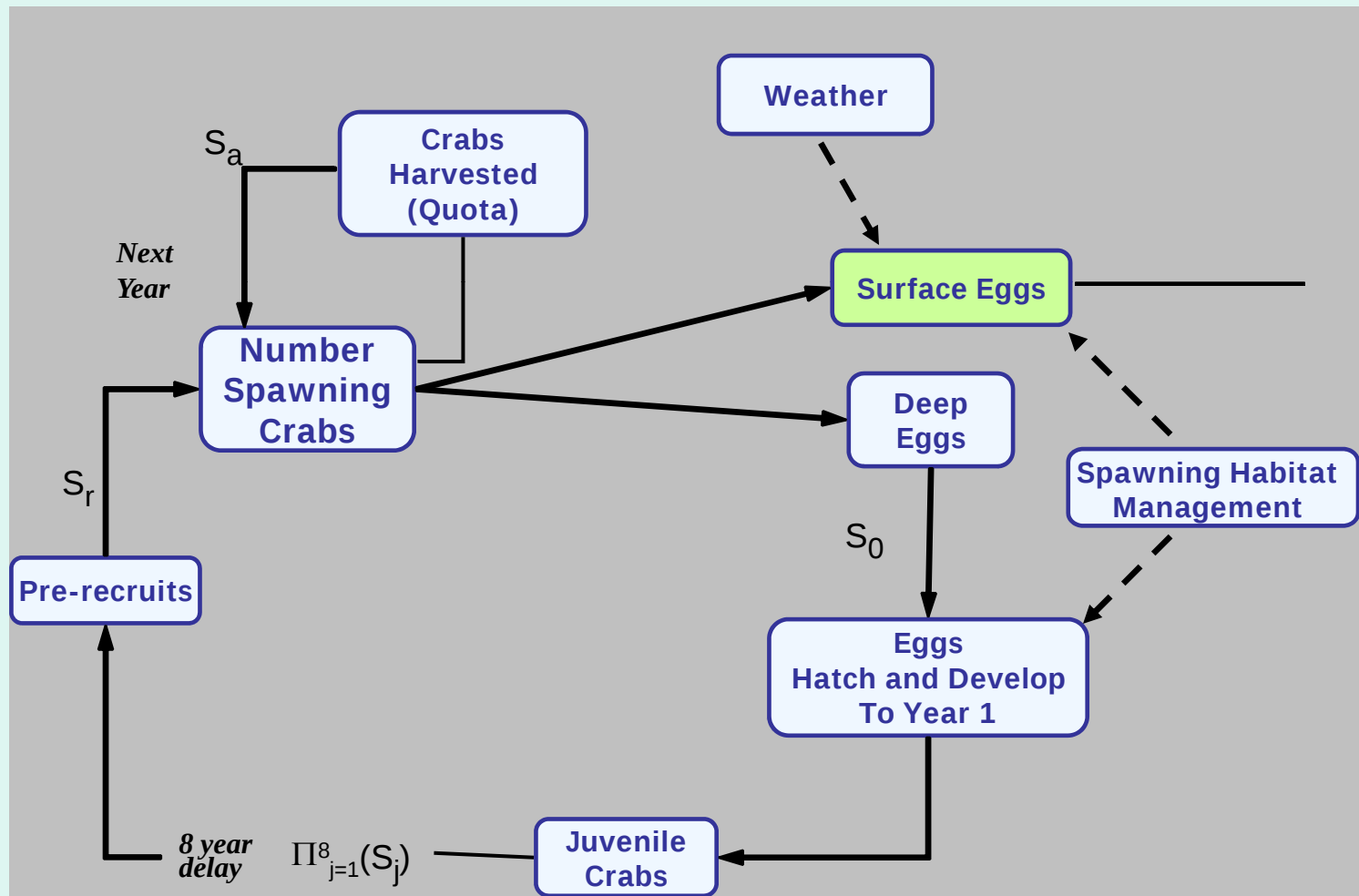
Management alternatives

- Alternatives should:
 - result in different benefits and costs;
 - be based on feasibility and political palatability; and
 - be limited in number and remain static for some period of time.
- The working group agreed that management alternatives should include and have specified these levels:
 - No harvest
 - Less than current Delaware Bay population harvest
 - Current Delaware Bay population harvest
 - More than current Delaware Bay population harvest
 - Record Period Landings (RPL)

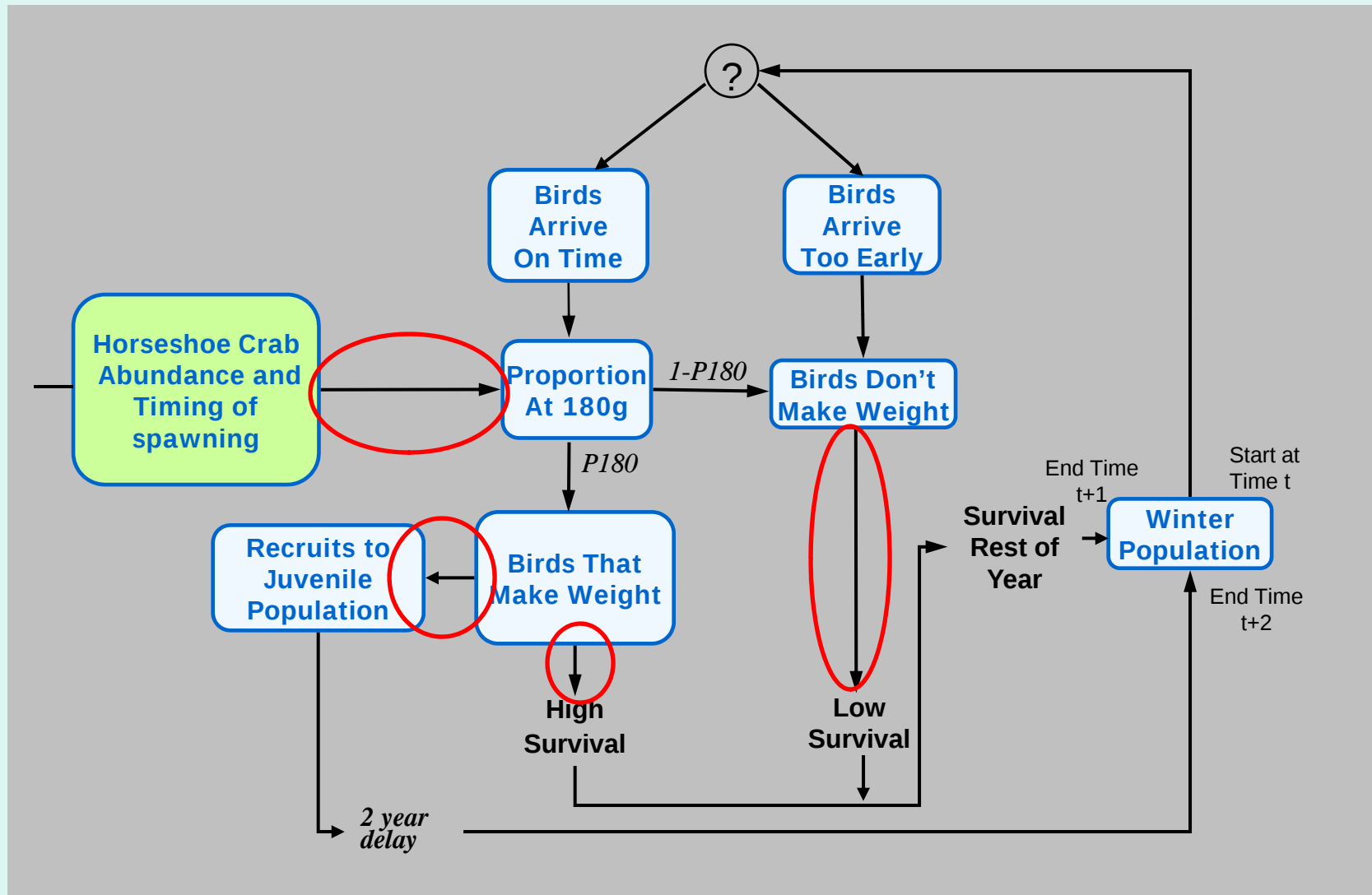
Linking Horseshoe Crabs and Red Knots to Predict Consequences of Management Alternatives



Conceptual Model: Horseshoe Crab



Red Knot



Population models

- Red knot
 - Age-structured model
- Horseshoe crab
 - Stage-structured model
 - Logistic growth based on surplus production model
- Parameters
 - Estimated with new data
 - Taken from literature
 - Expert opinion
- Sensitivity analysis to evaluate models

Population models

- Initial simulations have been conducted
- Magnitude of effect of hsc harvest on red knot viability depends on
 - Strength and shape of red knot weight gain function
 - Difference in survival between fat (>180 g) and skinny (<180 g) birds
 - Horseshoe crab harvest

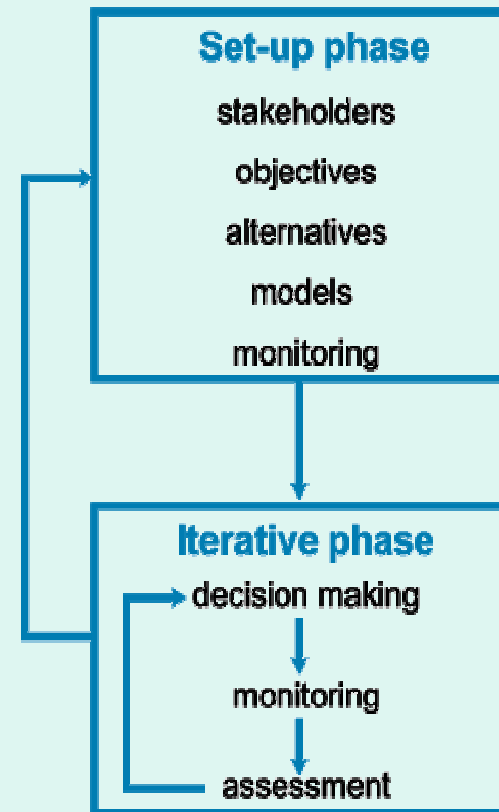
Decision Analysis:

Optimization through Stochastic Dynamic Programming

RK Popn				
HSC Popn	Low	Medium	...	Very High
Low	moratorium	moratorium		moratorium
Medium	moratorium	conservative		conservative
...				
Very High	moderate	moderate		liberal

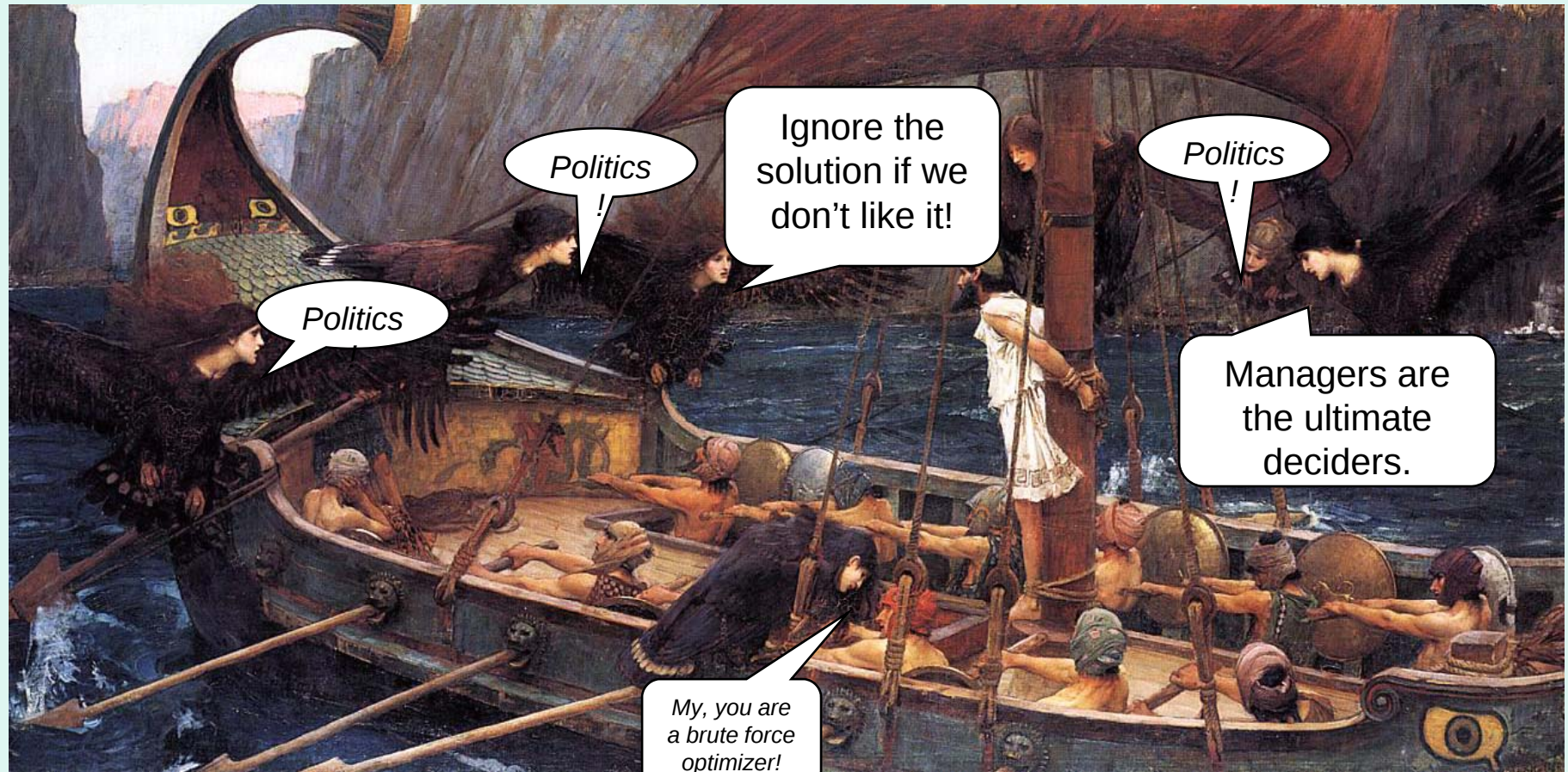
Iterative phase

- During 2009, we will complete the set-up phase
- Iterative phase involves use of models to predict optimal decision based on hsc and red knot population levels
- At times, the set-up phase can be revisited
- Models can be updated as we learn through the process of prediction and observation (monitoring)



What obstacles lie ahead?

Sirens Song



"Well the danger on the rocks is surely past
Still I remain tied to the mast
Could it be that I have found my home at last"

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