Decision Analysis for Management of Horseshoe Crabs and Shorebirds in Delaware Bay

Heuristic: When in the weeds…

A pint will improve your perspective.

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Is Adaptive Management Appropriate?

- There is a mandate to take action in the face of uncertainty.
- There is institutional capacity to sustain an adaptive program.
- There is a real choice to be made.
- There is an opportunity to apply learning.
- Clear and measurable management objectives can be identified.
- There is high value of information for decision making.

However, there are limitations, which might make adaptive management inappropriate or unacceptable.

- Conflict among stakeholders including commercial watermen and shorebird conservation advocates might be irresolvable and currently management actions are being determined by the courts
- Given the risk for red knot extinction (predicted for extinction in 2010) any harvest is unacceptable to some stakeholders and learning-based decision making might also be unacceptable

Decision Problem

- The Atlantic States Marine Fisheries Commission (ASMFC) decides repeatedly to regulate harvest of horseshoe crabs within Delaware Bay and along the Atlantic coast by level, area, and season consistent with continued use by current and future generations of the fishing and non-fishing public, migrating shorebirds, and other dependent wildlife, including federally listed sea turtles.
- State agencies in New Jersey and Delaware will decide whether, where, and how to protect shorelines within Delaware Bay using shore-parallel structures (e.g., bulkheads) and beach nourishment.
- State agencies in New Jersey and Delaware will decide whether, where, and how to control disturbance of migrating shorebirds during the stopover. Sources of disturbance can be human or non-human.
- The USFWS will decide whether to list the red knot as an endangered species under the Endangered Species Act.

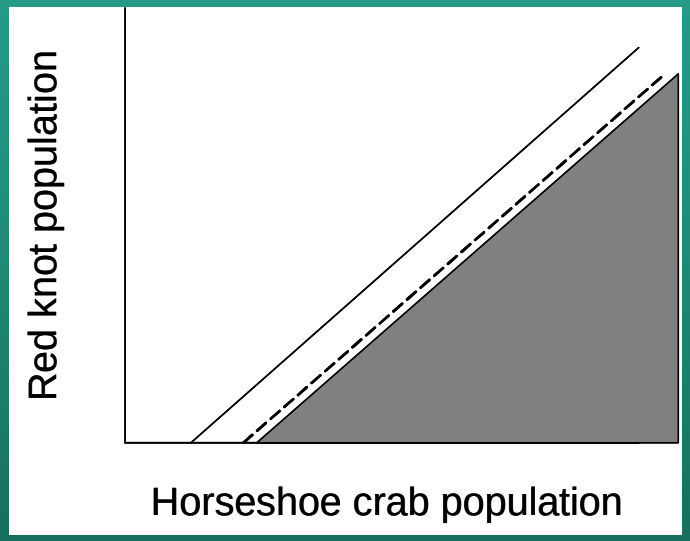
Decision Structure: *Alternative Actions*

- Management actions include regulating harvest, habitat management through beach nourishment, control of disturbance both human and non-human, and listing of red knot as an endangered species.
- Alternative harvest actions include level of harvest for males and females, how long to maintain the moratorium, when and how to harvest within the season (e.g., no harvest prior to 7 June), and how to regulate biomedical harvest.

Decision Structure: *Objectives*

- Ensure sufficient eggs for shorebirds, including red knots, taking into account environmental uncertainty while allowing surplus horseshoe crabs to be harvested.
- Objective statement: Maximize allowable harvest of horseshoe crabs constrained by 90% of early arriving red knots reaching 180g by 28 May.

Decision Structure: *Objectives*



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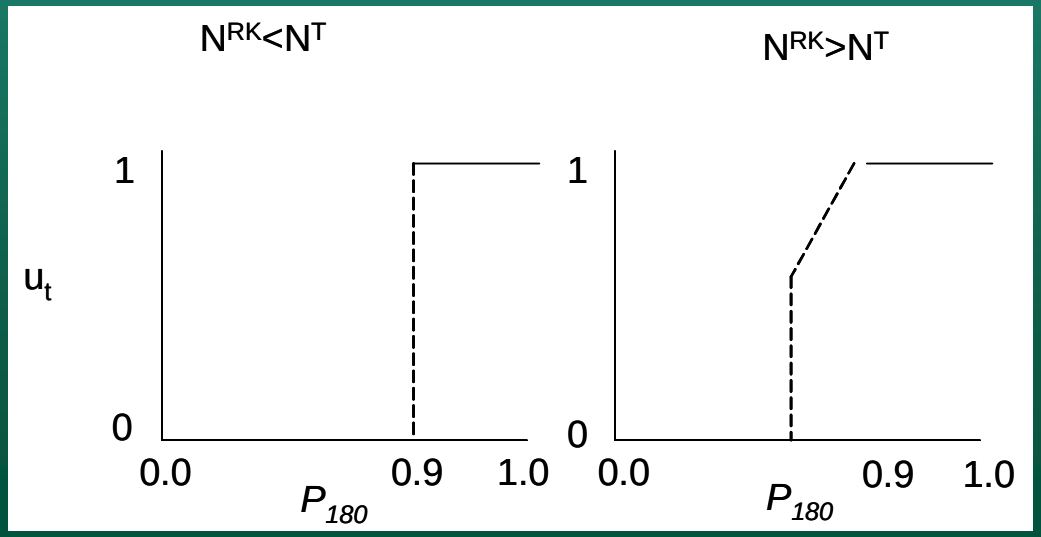
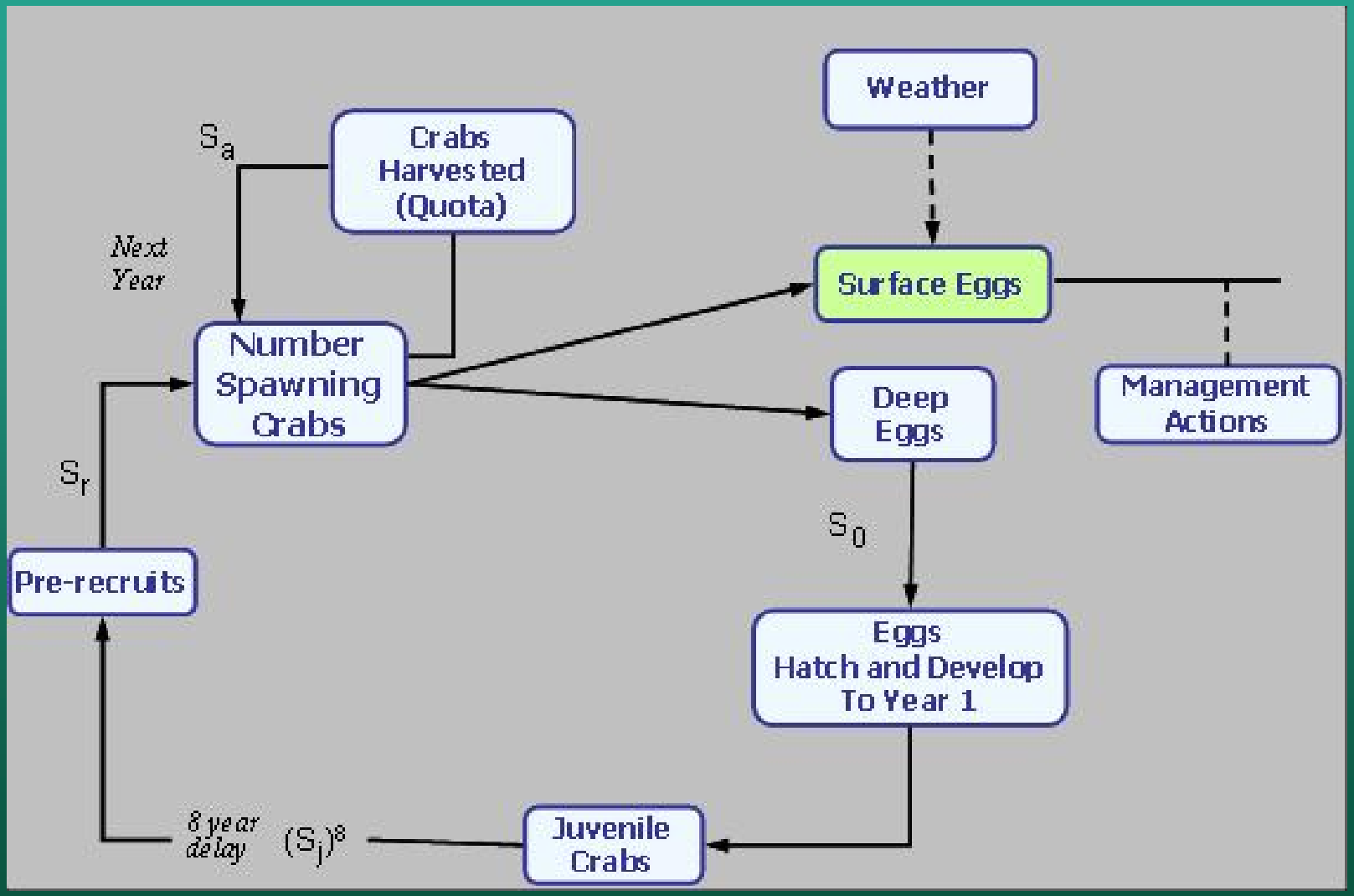
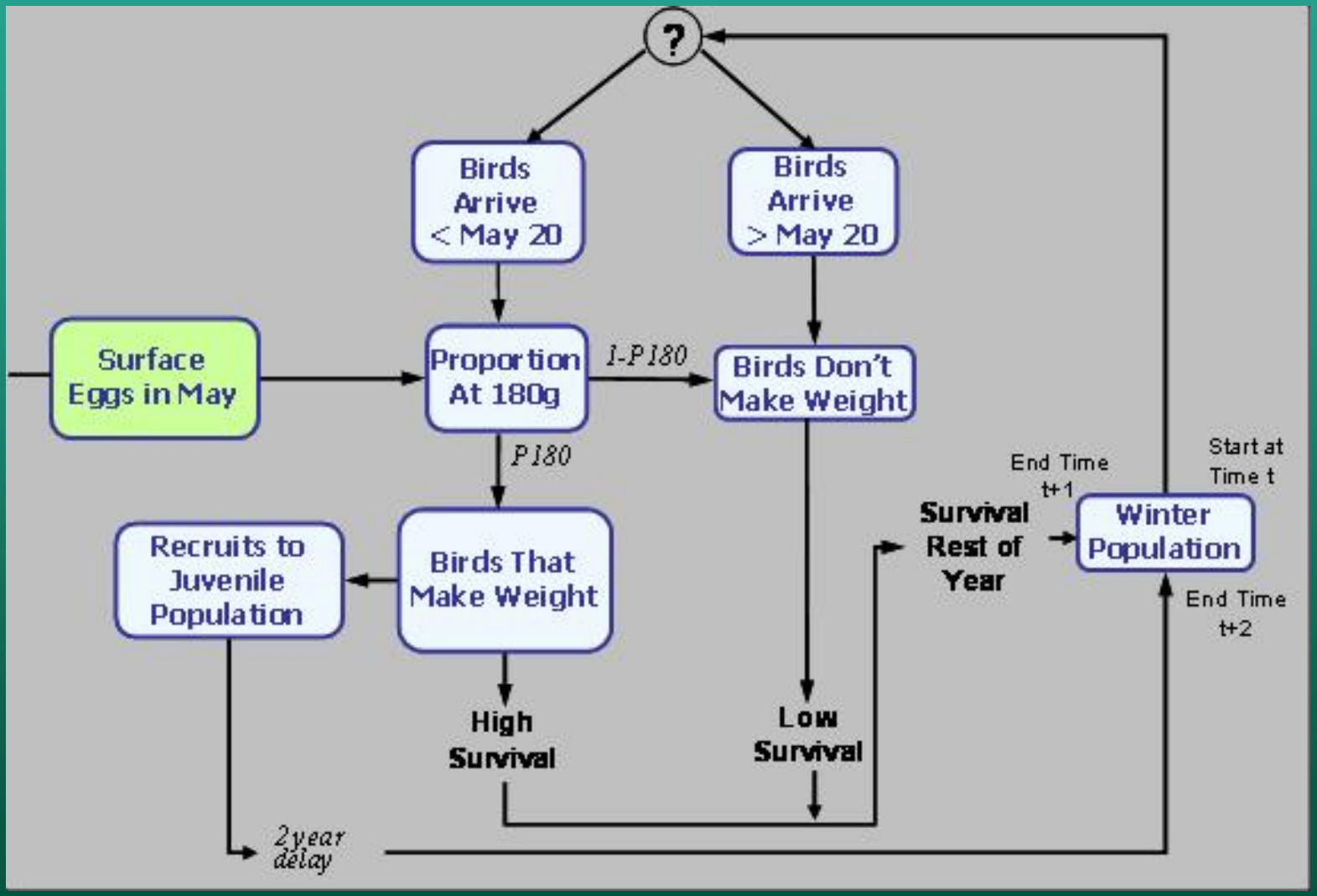


Horseshoe Crab



Red Knot


?
Birds Arrive < May 20
Birds Arrive > May 20
Surface Eggs in May
Proportion At 180g
1-P180
Birds Don't Make Weight
P180
Recruits to Juvenile Population
Birds That Make Weight
High Survival
Low Survival
Survival Rest of Year
End Time t+1
Winter Population
Start at Time t
End Time t+2
2 year delay

Decision Structure: *Predictive Model*

The predictive model has four components:

1) a horseshoe crab dynamics model
2) a model that links horseshoe crab abundance to egg availability
3) a model that links egg availability to the proportion of early arriving red knots that reach 180g by 28 May
4) a red knot dynamics model that relates proportion making weight to red knot adult survival and reproduction.

Decision Analysis: *Optimization*

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

Decision Analysis: *Insights*

- Linking horseshoe crab population to red knot weight gain during the stopover isolates the Delaware Bay effect on red knot population growth
- Horseshoe crab population growth sensitive to juvenile survival
- Red knot population growth sensitive to adult survival
- Red knot population slow to recover

Uncertainty

Table 3. Sources and types of uncertainty highly influential to the predictive model and decision structure.

Source of uncertainty	Type of uncertainty
1) Relationship between spawning density and egg availability, and then relationship between egg availability and P_{180} Or 2) Relationship between spawning density and P_{180}	Structural and process
3) Relationship between departure weight and red knot survival and recruitment	Structural and process
4) Horseshoe crab spawner-recruit relationship	Structural and process

Next Steps

- October 2007, a meeting of the Horseshoe Crab and Shorebird Technical Committees of the ASMFC will be held. At that meeting, a SDM approach will be introduced and promoted. Facilitation and consultation is needed to increase the chance for building consensus and support for the SDM approach.
- Funding is being sought to support development and implementation of an SDM approach over the next two years.