Adaptive Harvest Management for Pink-Footed Geese

2015 Progress Summary

Fred Johnson and Jesper Madsen

Svalbard Pink-Footed Goose International Working Group
Ghent, Belgium
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U.S. Department of the Interior
U.S. Geological Survey

AHM framework components

- A management objective
  - for evaluating management strategies
- A set of decision alternatives
  - that are realistic and under the managers' control
- A set of models and associated probability weights
  - that describe how the system evolves over time
- A monitoring program
  - to make state-dependent decisions
  - to learn by comparing observations with model predictions

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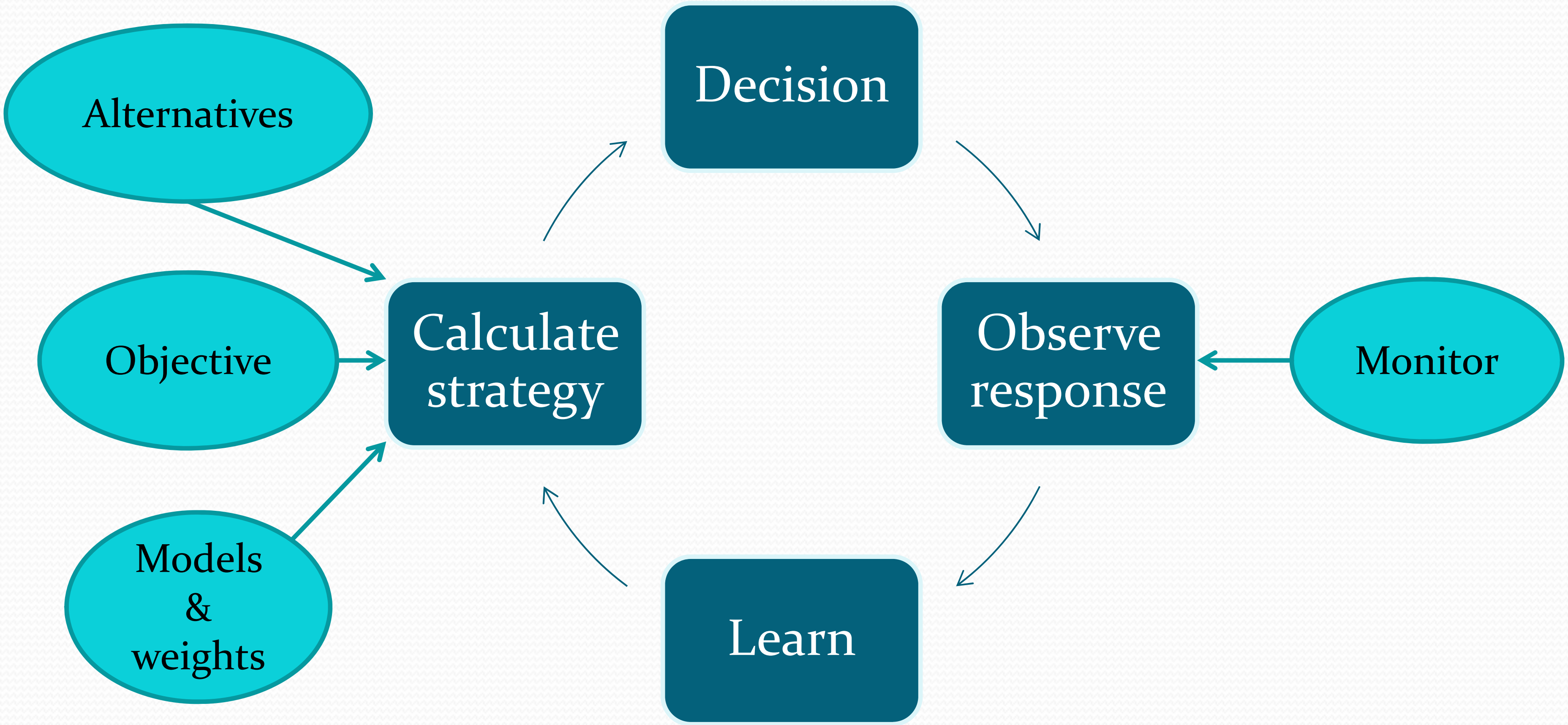
AHM process



Alternatives
Objective
Models & weights
Calculate strategy
Decision
Observe response
Monitor
Learn

2013-2015 harvest quota

- 2013 system states
  - 8.1k Young
  - 73.5k Adults
  - 8 TempDays
- Model weights
  - Density-dependent survival: p = 0.0004
  - Density-dependent reproduction: p = 0.1461
  - TempDays (survival): p = 0.4600
  - TempDays (reproduction): p = 0.3295
- Optimal harvest for 2013-15 seasons = 15k
  - 2013 harvest = 10.62k
  - 2014 harvest = 13.99k

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2015 Update

- Results differ slightly from 2015 AHM Progress Summary
- Based on revised harvest estimates from Denmark (14 October 2015)

	2012	2013	2014
original	8,580	9,262	13,200
revised	8,600	8,800	12,200

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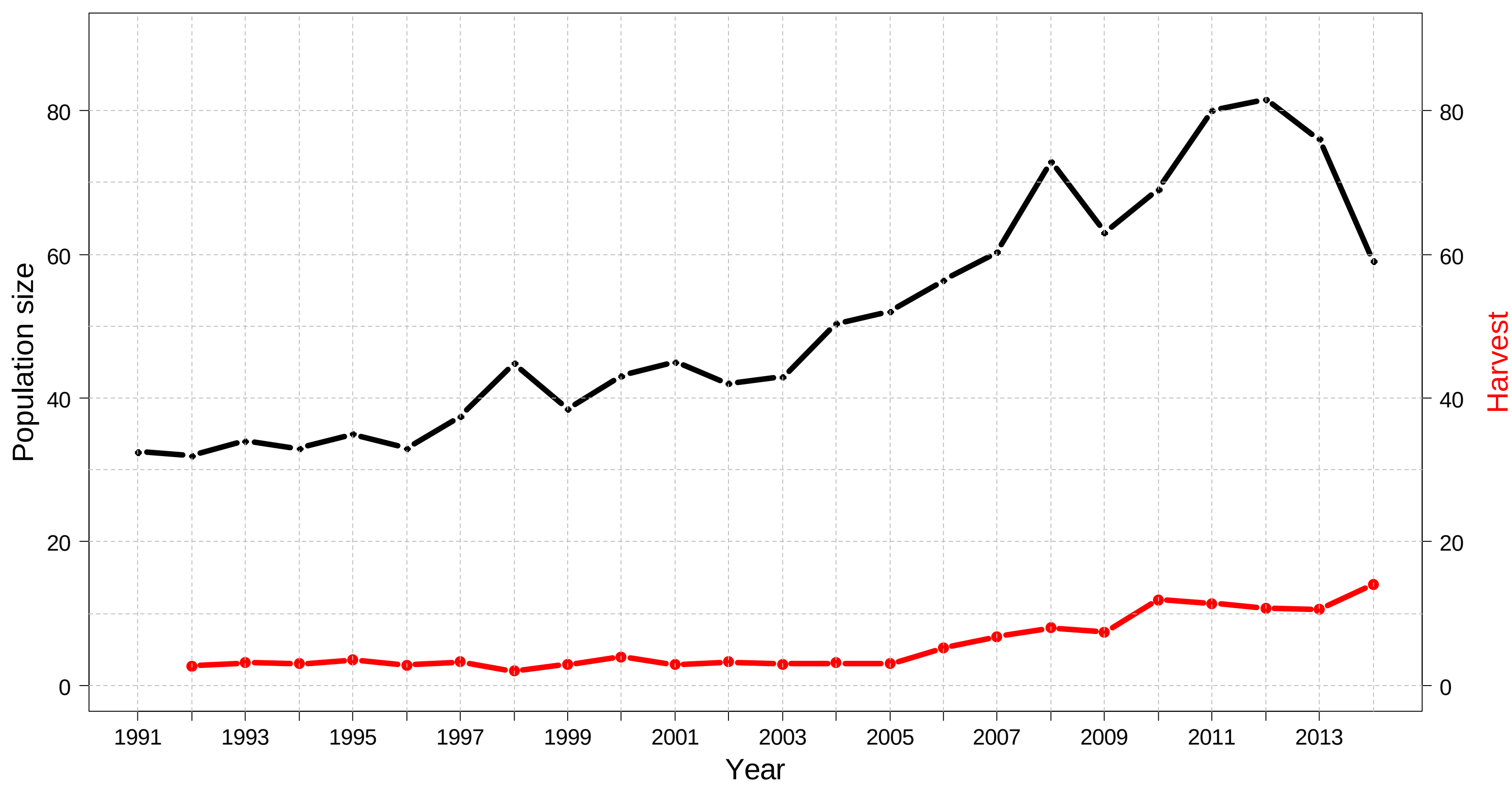
Population size & harvest



Population size

Date	Observed	Model prediction
November 2014	73.7k	
May 2015	59.0k	72.1
November 2015	74.8k	70.3

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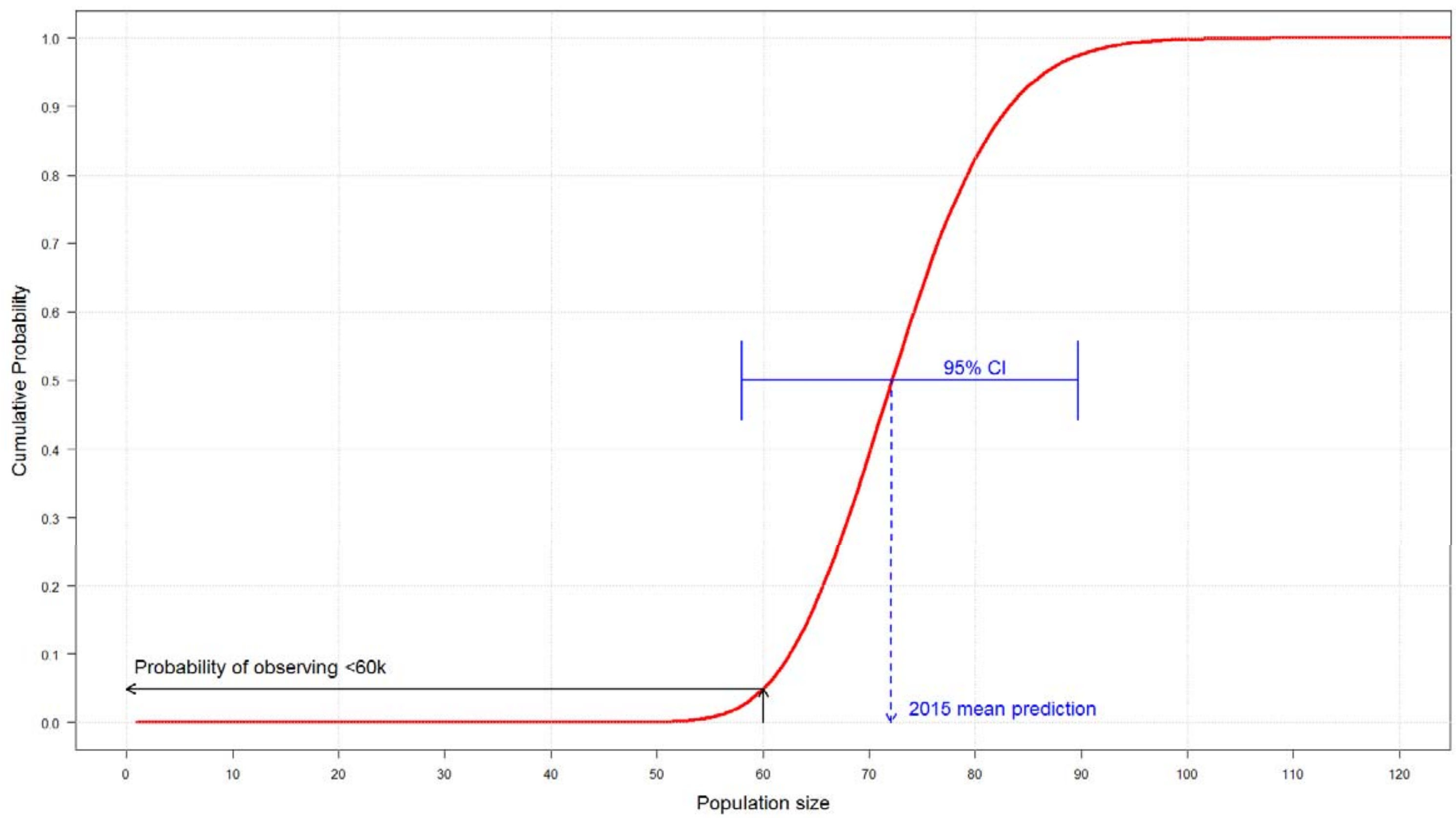
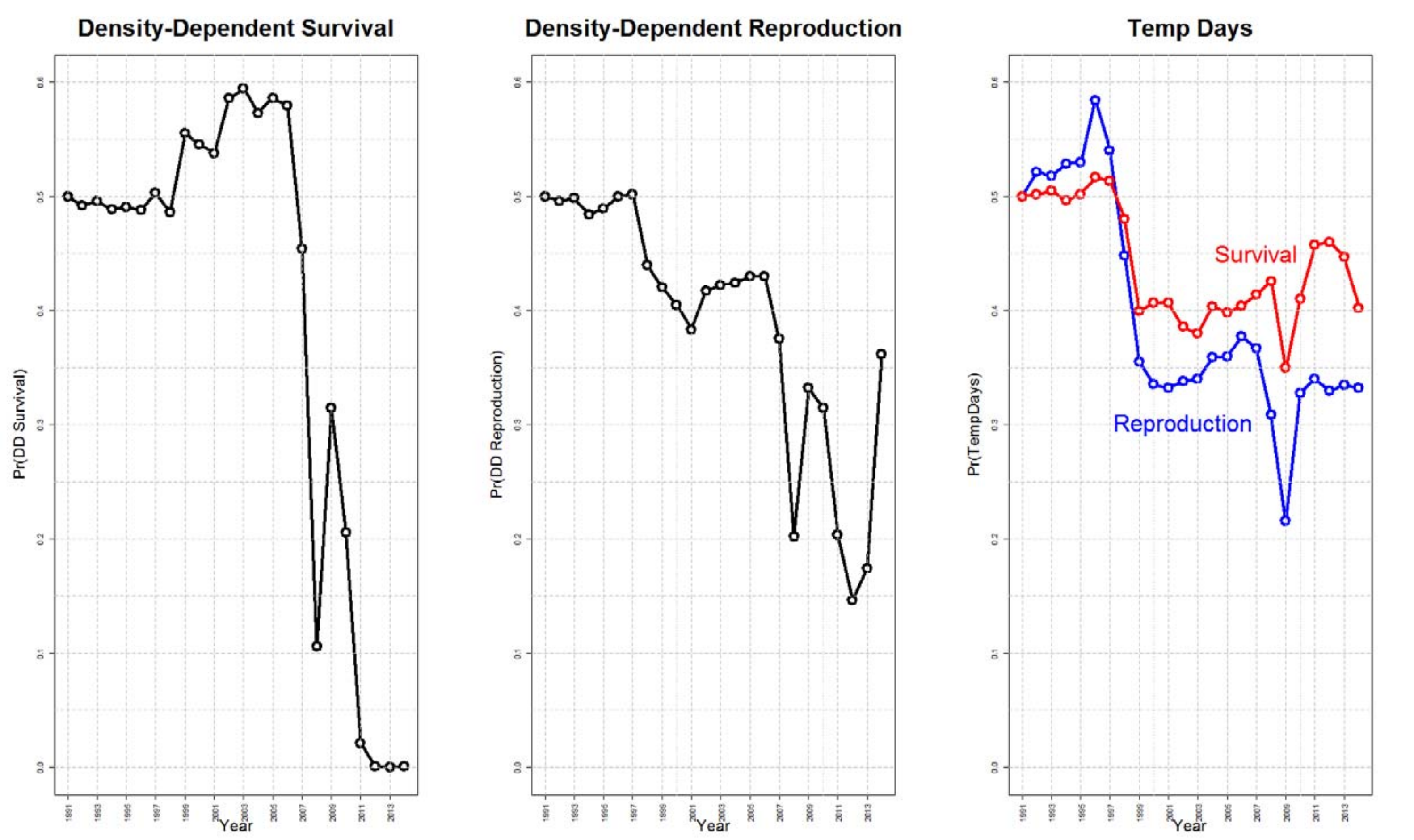
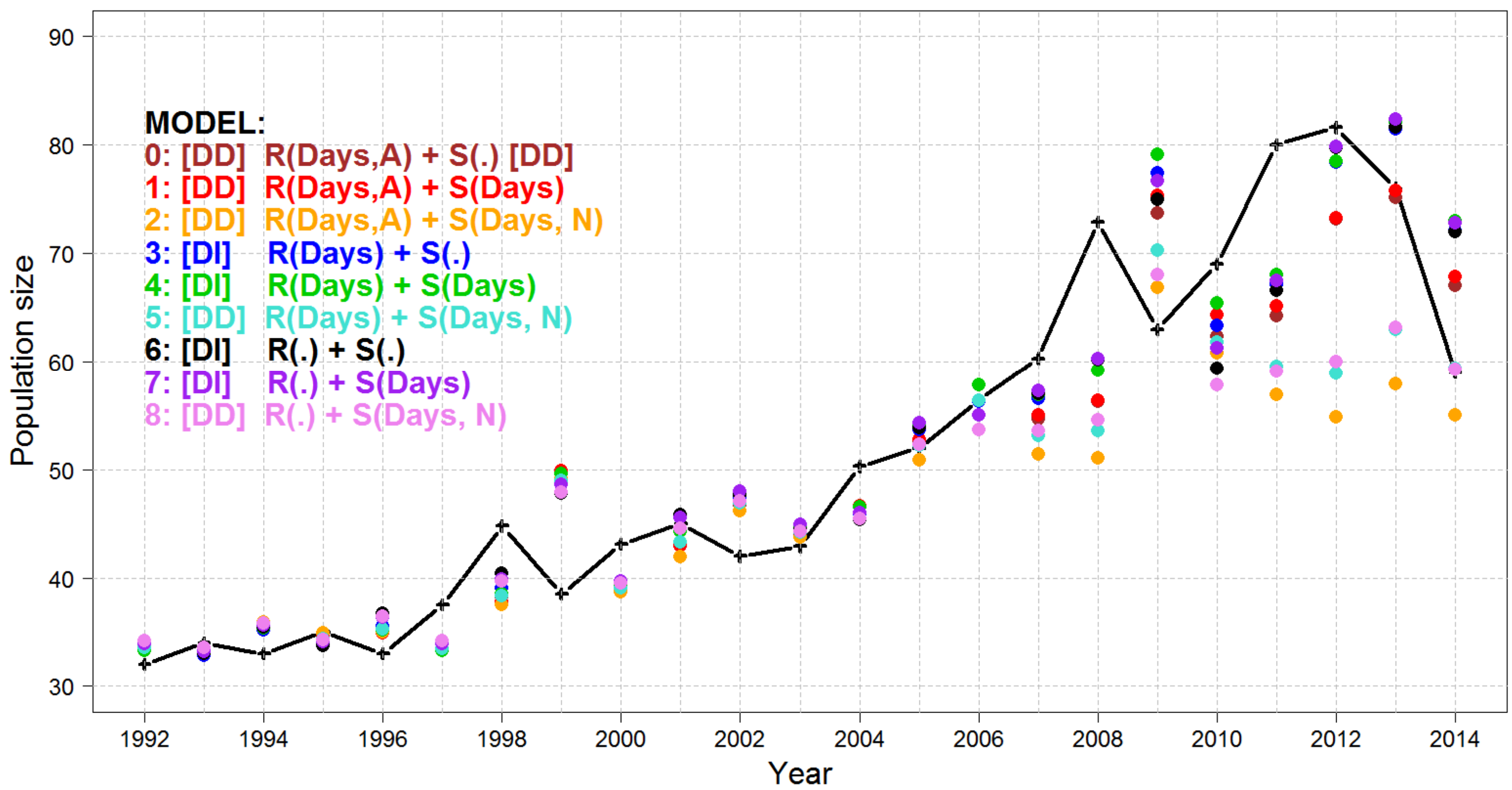
Was the decline expected?



Learning


Density-Dependent Survival
Pr(DD Survival)
Year
Density-Dependent Reproduction
Pr(DD Reproduction)
Year
Temp Days
Pr(TempDays)
Survival
Reproduction
Year

Observation vs. predictions



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Emergency Closure Process

- For year i = 2013, 2016, 2019…
  - Determine the optimal harvest target at the start of the 3-year cycle
  - Implement target
  - For year j = i+1, i+2
    - Use monitoring data to update model weights by comparing observed and predicted population sizes
    - Conduct an optimization for a 1-year decision
    - If the optimal harvest > 0, continue with 3-yr harvest target
    - If the optimal harvest = 0, consider emergency closure
  - End
- End

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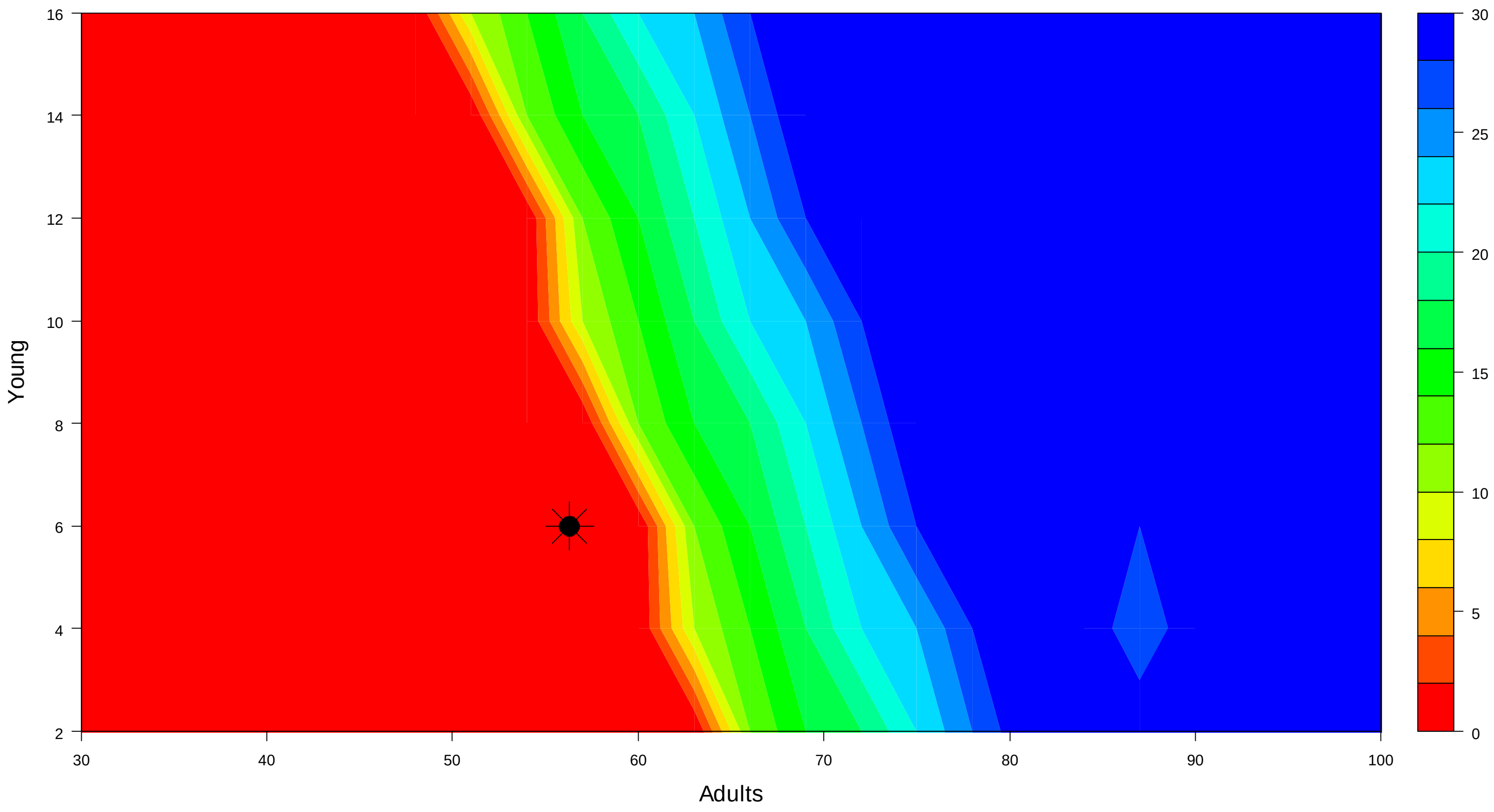
2015 Closure criteria



Population prediction 2016

Strategy	Hypothetical Harvest	Predicted Population	95% Confidence Limit
Stick with target	15.0	51.7	41.5 – 64.2
Average prior to Jan hunting in Denmark	11.2	55.5	44.6 – 68.9
Needed for N=60	6.7	60.0	48.2 – 74.5
Only Norway harvest	2.5	64.2	51.6 – 79.8
Closed season	0.0	66.7	53.6 – 82.9

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Simulated performance of 3-year and 1-year harvest strategies

Performance statistic	3-year	1-year
Mean # of years between harvest quota change	5.6 years	2.5 years
Mean change in harvest quota	10.6k	2.2k

The 3-year strategy helps stabilize harvest quotas, but at a cost of much larger quota changes.

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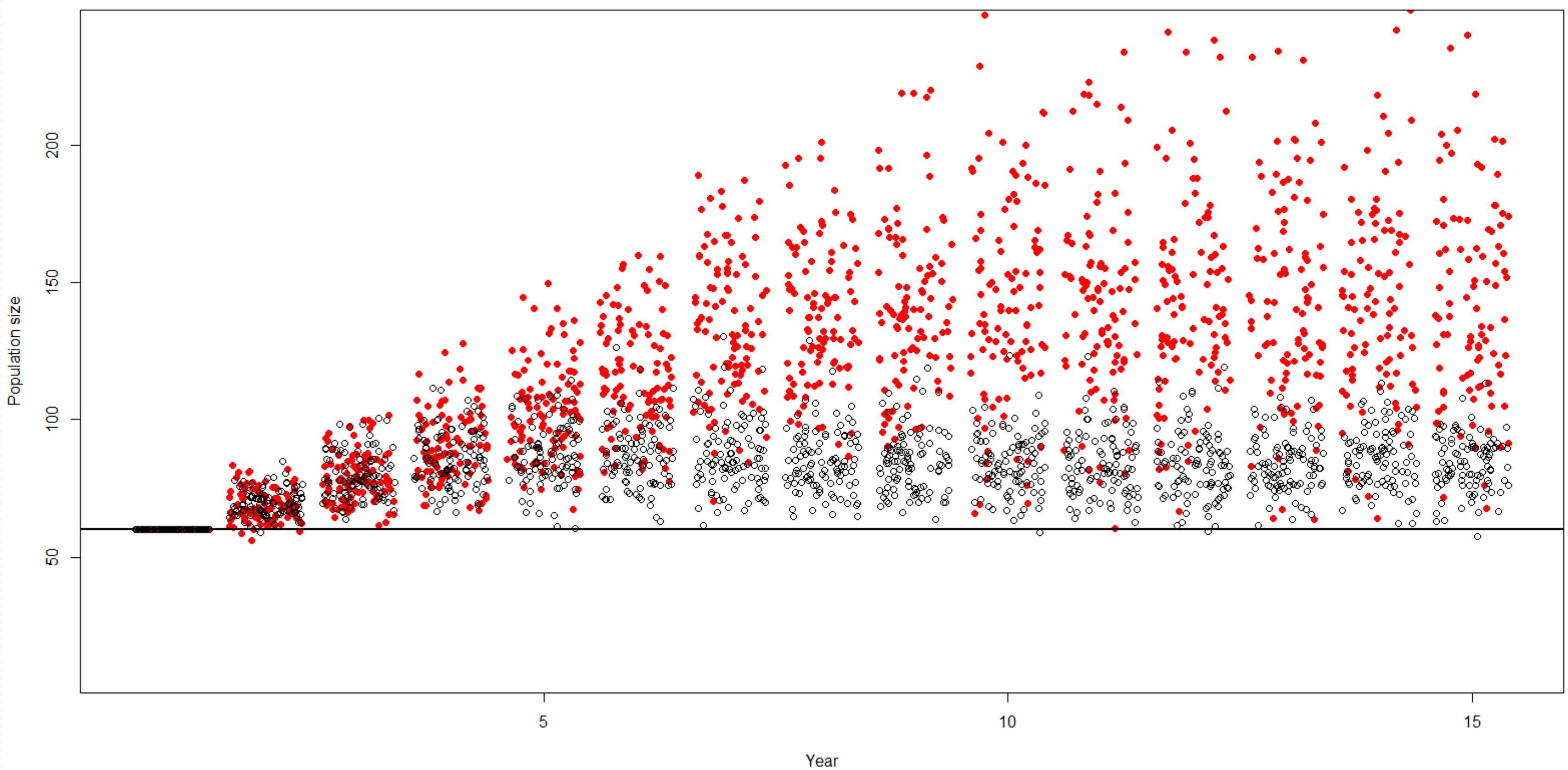
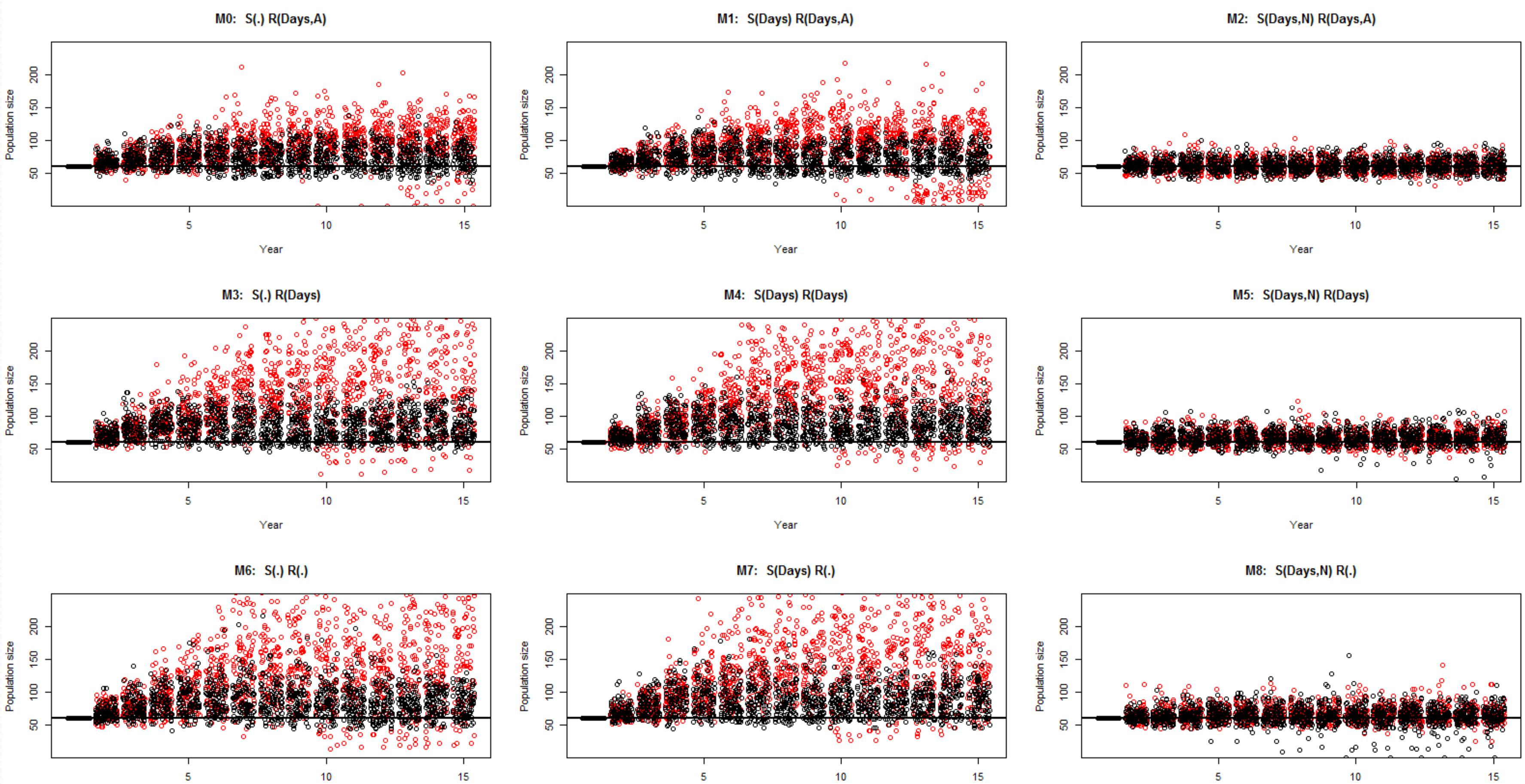
Simulated performance of 3-year (red) and 1-year (black) harvest strategies*



The 3-year strategy is much less likely to control the potential for exponential growth.

* model-averaged

Simulated performance of 3-year (red) and 1-year (black) harvest strategies*



The currently favored models lack density dependence and exhibit exponential growth and decline.

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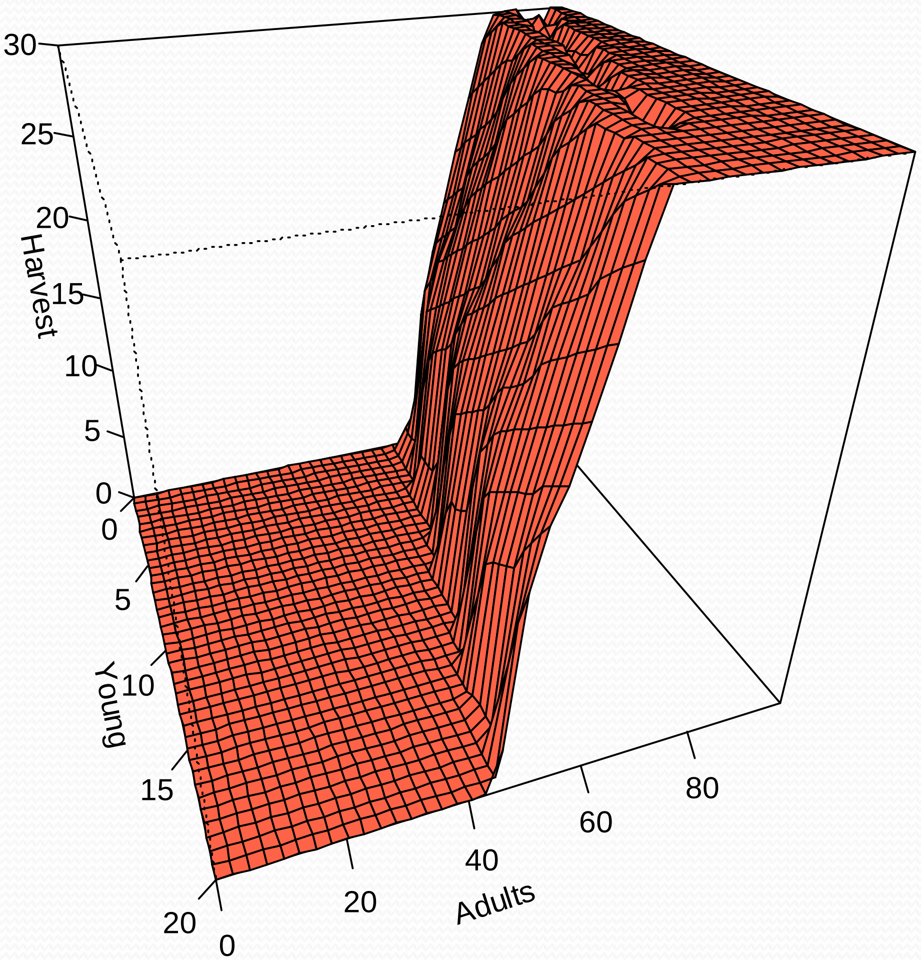
* model-specific

Closed seasons are becoming more likely

- Harvest strategies (both 1- and 3-year) are becoming more knife-edged
- A result of population dynamics that lack density dependence and the desire to keep population size within a narrow range (exponential growth and decay are very difficult to manage)
- The result is extreme variability in harvest quotas
- Later today we will discuss a way to address this problem



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Looking ahead

- How good are our population models?
- Are there ways to dampen variability in harvest quotas (and reduce the chances of closed seasons)?
- What do we need to do to prepare for 2016?

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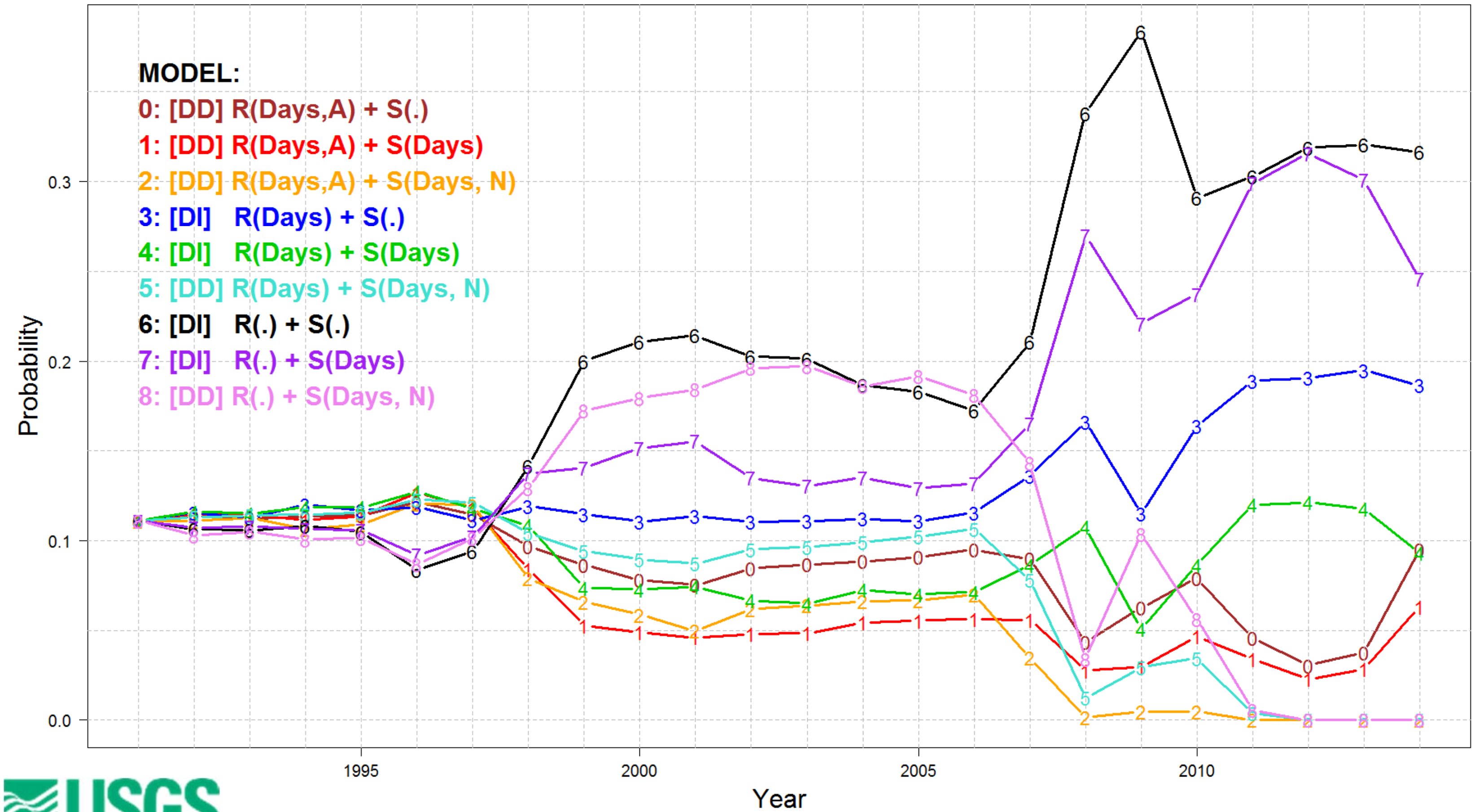
How good are our models?

Change in model weights over time



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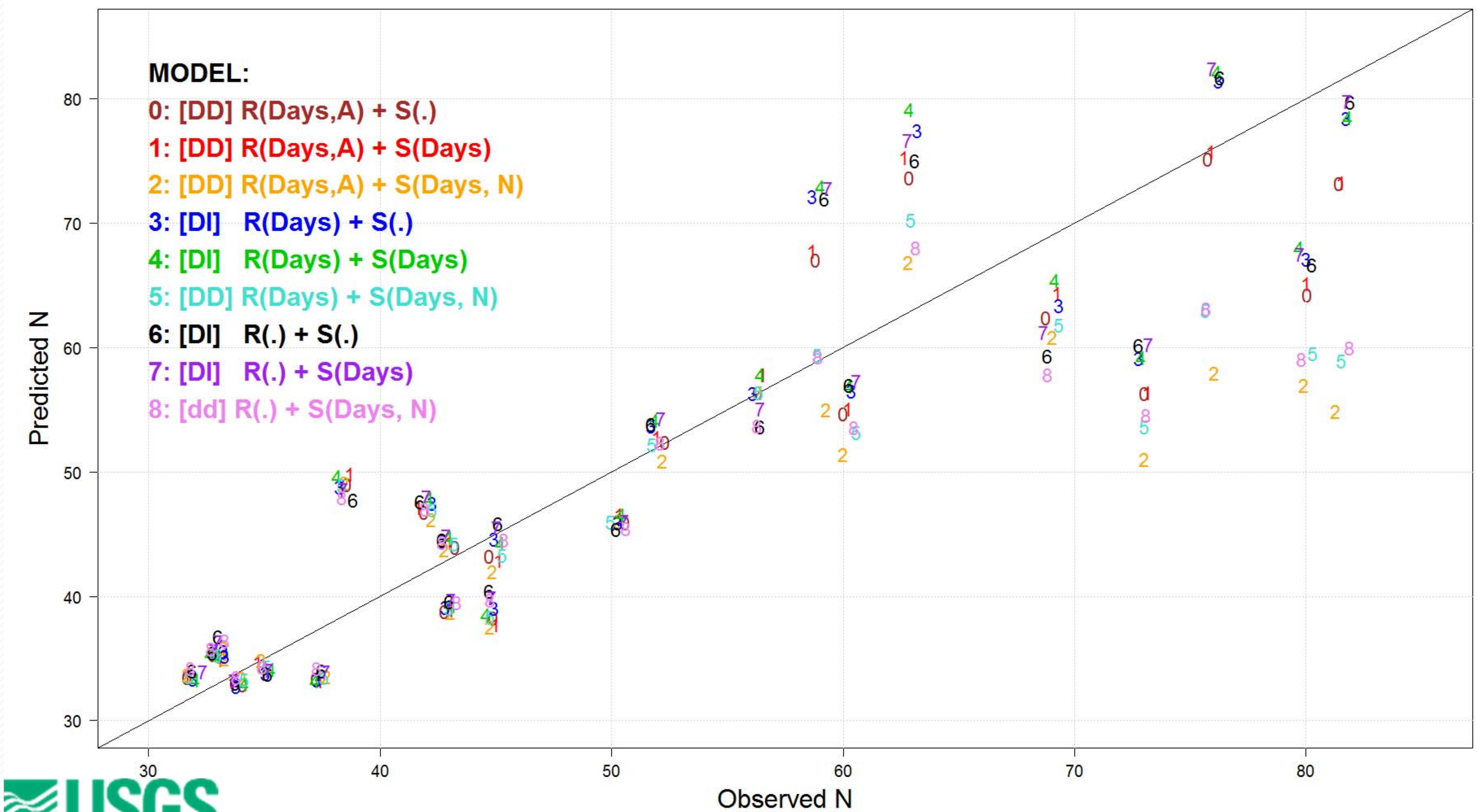
How good are our models?



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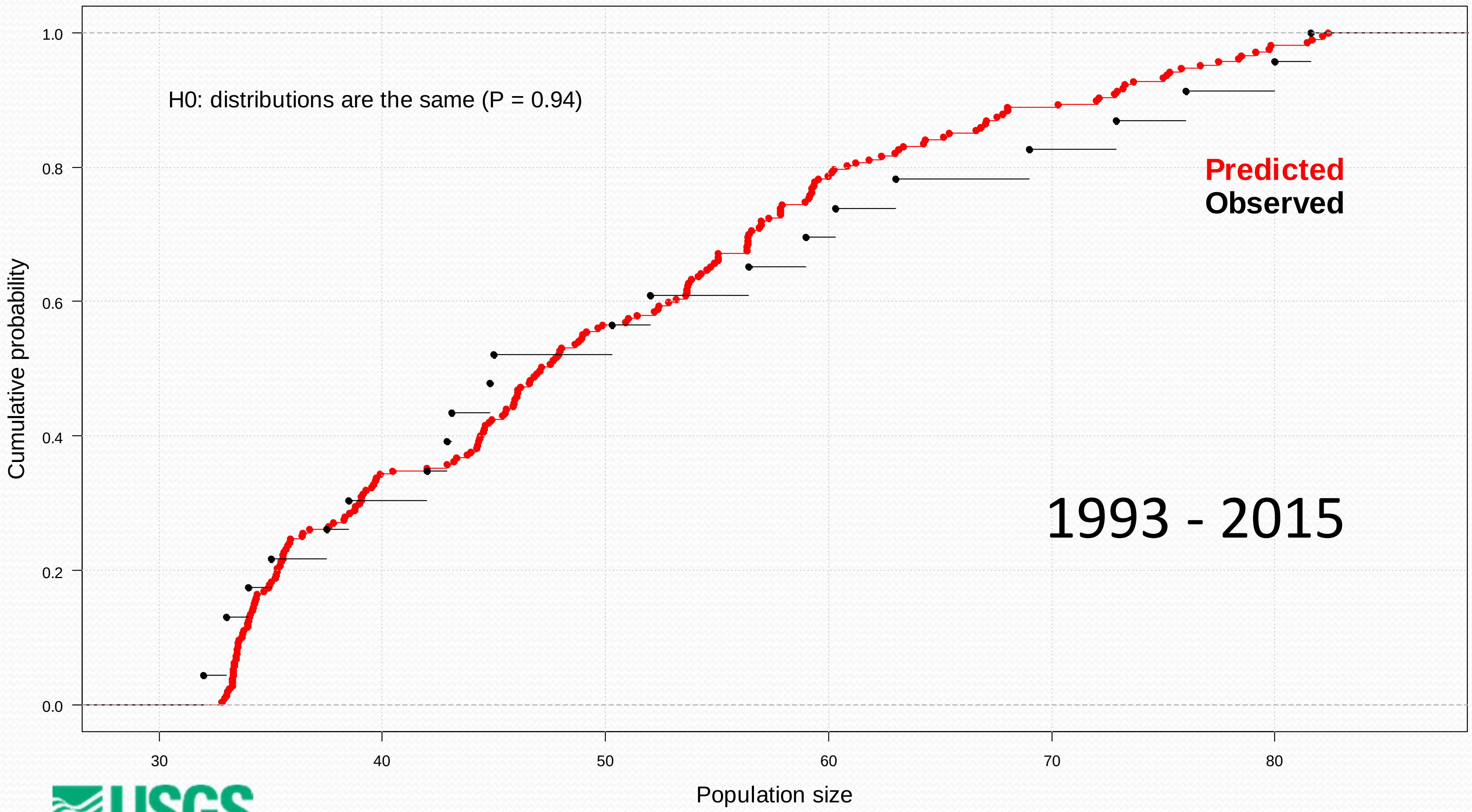
Are distributions of predicted and observed population sizes the same? (Kolmogorov-Smirnov test)



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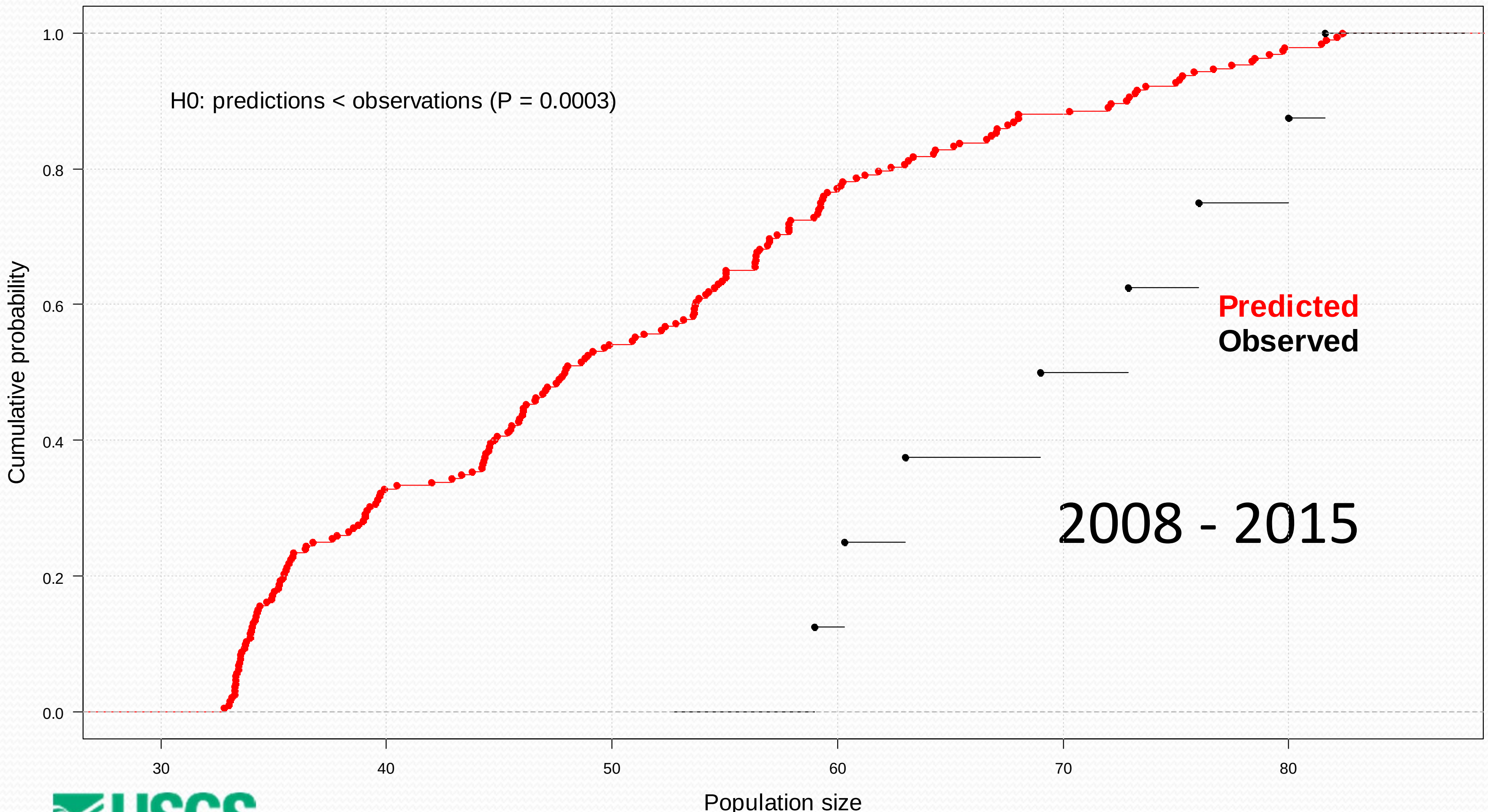

Can we develop better models?

- An alternative modeling approach: **<u>I</u>ntegrated <u>P</u>opulation <u>M</u>odels** *(first suggested by H. Baveco, P. Goedhart, & D. Melman in review of pink-foot AHM by Dutch Ministry of Economic Affairs)*
- IPMs:
  - effectively distinguish between observation (pop. counts) and process (model) error
  - can integrate multiple sources of data into a single analysis
  - can leverage data to estimate unobserved variables (e.g. harvest rate)
  - treat uncertain quantities as continuous rather than as arbitrarily discrete (i.e., the joint posterior distribution)
  - can be updated each year using all available data (rather than just population size and harvest)
- Initial modeling work has started

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Ways to dampen variability in harvest quotas

- Set harvest quota for multiple years
  - Less responsive to changes in population status
  - More closures and larger magnitude changes in quota
- Specify a larger range of acceptable population sizes
  - Might not be acceptable to stakeholders concerned with too many or too few geese
  - Might require revision of the International Species Management Plan ???
- **Incorporate the desire for less quota variability in the objective function used for optimizing harvest strategies**
  - Allows one to specify the relative importance of population size and variability in harvest quotas
  - Likely would not require revision of the ISMP
  - Demonstrated here with a 1-year decision making cycle

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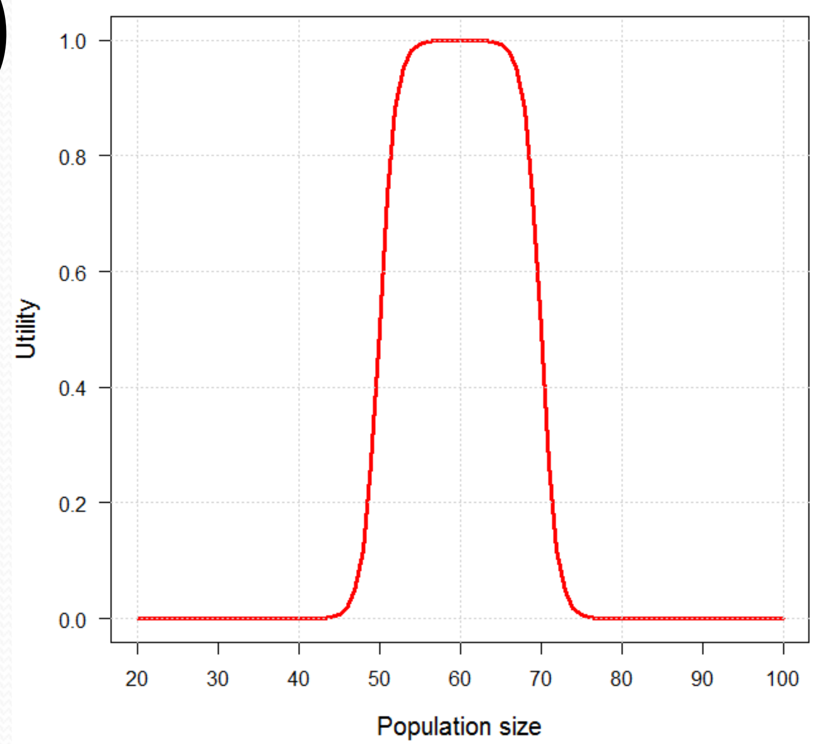
Current objective function

$$\max_{(A|x_t)} \sum_{\tau=t}^{\infty} h_\tau u_{\tau+1}(x_t, h_t)$$

- Maximize sustainable harvest
- While recognizing that potential harvest quotas resulting in unacceptable population sizes have little or no value
- Acceptable population sizes are a "soft" constraint on maximizing sustainable harvests



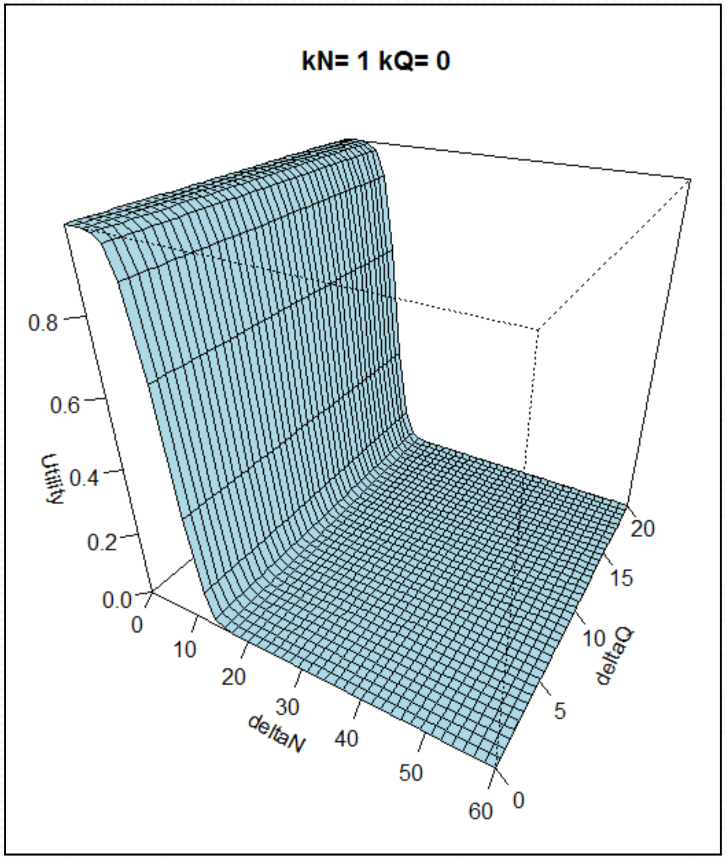
Incorporating change in quota

- What if the change in quota from one year to the next was of concern, such that large changes were undesirable?

- Define a new objective function as:

$$\max_{(A|x_t)} \sum_{\tau=t}^{\infty} h_\tau \begin{Bmatrix} kN \cdot u^N_{\tau+1}(x_t, h_t) + kQ \cdot u^Q_{\tau+1}(x_t, h_t) + \\ (1 - kN - kQ) u^N_{\tau+1}(x_t, h_t) u^Q_{\tau+1}(x_t, h_t) \end{Bmatrix}$$

where ***kN*** and ***kQ*** are weights expressing the relative importance of achieving the ***population goal*** and ***small changes in harvest quota***, respectively



Only Population Goal
No Quota Change
(*current objective*)

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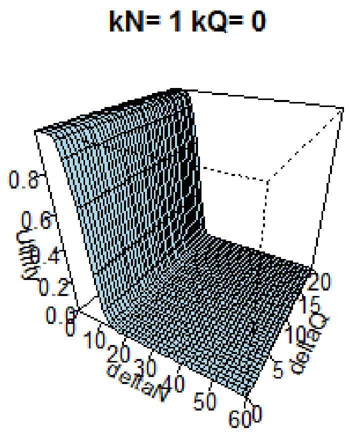
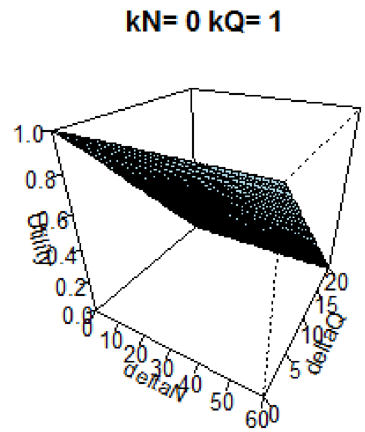
Multi-Attribute Utility

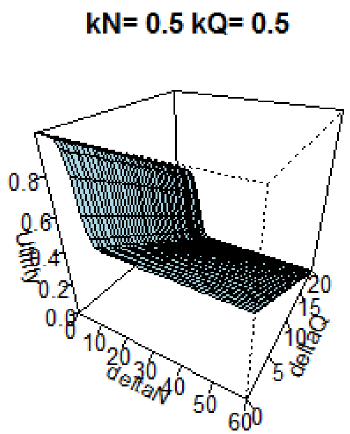
Only Population Goal
No Quota Change
(*current objective*)

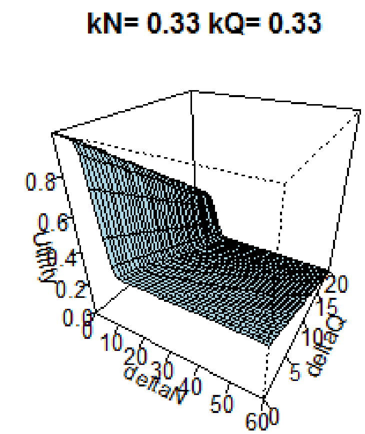




No Population Goal
Only Quota Change

½ Population Goal
½ Quota Change





1/3 Population Goal
1/3 Quota Change
1/3 Interaction

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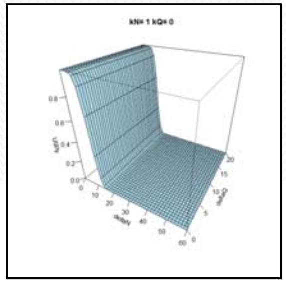
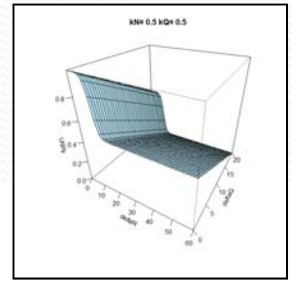
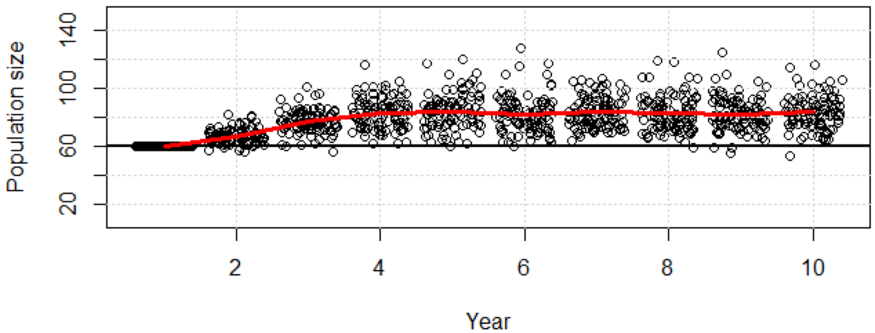
Simulated performance

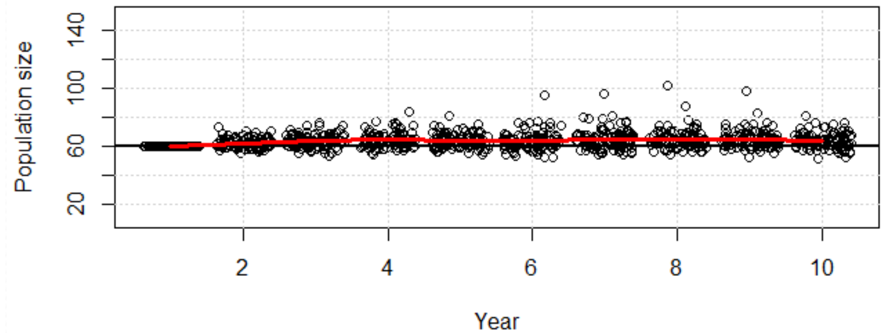
Only Population Goal
No Quota Change
(*current objective*)

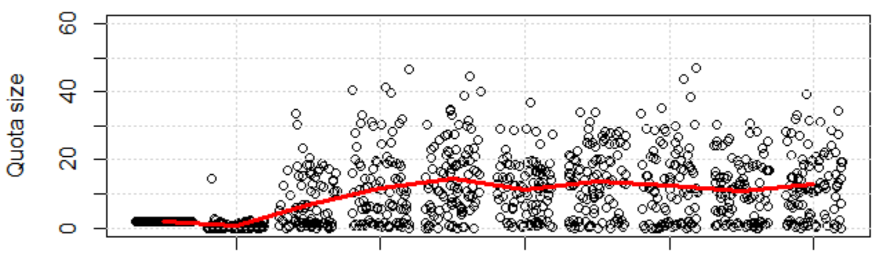


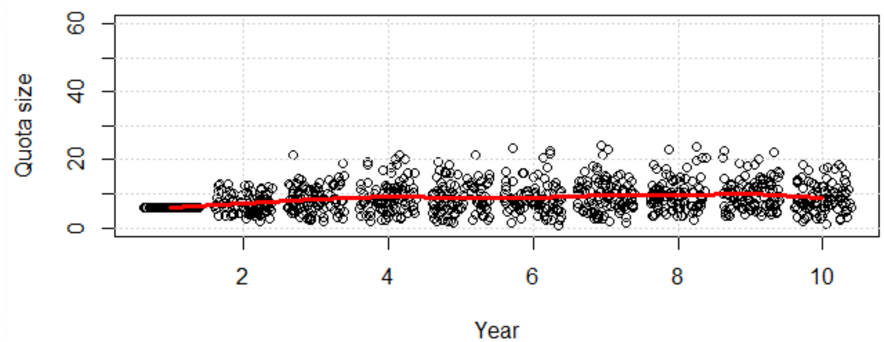
½ Population Goal
½ Quota Change











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Simulated performance

Objective	Pr(Closed)	Lag (years)	Quota (k)	Change in Quota (k)	|Pop – Goal| (k)
kN = 1.0 **kQ = 0.0**	0.70	2.11	9.78	3.36	10.4
kN = 0.5 **kQ = 0.5**	0.23	1.36	8.65	0.41	9.11

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Summary points

- Last year, projections suggested it would take 3-7 years to reduce the population to 60k
- The predicted population size this year was 72k; the observed population size of 59k was unlikely, but still plausible under the models
- Evidence for density dependence remains very weak (population has the capacity for exponential growth or decline)
- Given Adults=53k, Young=6k, TempDays=9, an emergency closure is warranted based on the agreed-upon protocol
- But, a reduced harvest of 6.7k could be expected to produce a population next year near 60k

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Preparations for 2016

- Consider whether the length of the decision-making cycle is appropriate
- Consider whether possible revisions to the objective used for optimizing harvest strategies are needed
- Continue to consider ways in which the size of the harvest can be controlled so that hunters know what to expect
- Continue making progress on improved population models

Any changes to the AHM process must be vetted and approved by the Working Group before June 2016 if they are to be implemented in the autumn of 2016.

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Acknowledgements

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- AEWA International Working Group for the Pink-Footed Goose

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