MSE Methods
Herring Operating Models & Control Rules

Jon Deroba - NEFSC NMFS
Atlantic Herring MSE Workshop #2
December 7-8, 2016
What is an operating model?

A (mathematical) model of the system
  herring biology
  assessment
  management (i.e., the harvest control rule we’re evaluating here)
  predators in this case
Often multiple operating models to demonstrate effect of uncertainty
What is an operating model?

The true system dynamics

Operating models

The models won’t be exactly like the stealth system, but we can learn from them
Methods Overview

The true system dynamics: our stealth bomber

Operating models
Methods Overview

Multiple operating models represent uncertainty
Defined in Workshop #1

Herring recruitment (high or low?)
Herring natural mortality (high or low?)
Herring growth (good or poor?)
Herring assessment error/bias (yes or no?)

Evaluate ABC control rules for each OM

Sarah’s presentations

Min-Yang’s presentations

Herring Fishery Yield

Herring N, B, Wt
Recruitment and Natural Mortality define Hi production and Lo production operating models.
Recruitment and Natural Mortality define Hi production and Lo production operating models.
Uncertainties

At the May Workshop we identified uncertainties:

- Herring recruitment ✓
- Herring natural mortality ✓
- Herring growth
- Herring assessment error/bias
Growth

good and poor growth operating models

[Graph showing mean weight (kg) at age for good and poor growth models]
Uncertainties

At the May Workshop we identified uncertainties:

- Herring recruitment
- Herring natural mortality
- Herring growth
- Herring assessment error/bias

<table>
<thead>
<tr>
<th>Production</th>
<th>Growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hi</td>
<td>Lo</td>
</tr>
<tr>
<td>x</td>
<td></td>
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<tr>
<td>x</td>
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Assessment Error and Bias
unbiased and biased operating models
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Uncertainties

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- Herring recruitment
- Herring natural mortality
- Herring growth
- Herring assessment error/bias

<table>
<thead>
<tr>
<th>Production</th>
<th>Growth</th>
<th>Assessment bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hi</td>
<td>Good</td>
<td>On</td>
</tr>
<tr>
<td>Lo</td>
<td>Poor</td>
<td>Off</td>
</tr>
</tbody>
</table>

- x indicates presence
- blank indicates absence
Fishery Selectivity
Questions?

The true system dynamics: our stealth bomber

Operating models
Harvest Control Rules

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Control Rules

Fishing Mortality or Catch

?  

Biomass or Abundance
Refresher

At the May Workshop we identified general characteristics for control rules:

- A broad range of shapes in terms of how catch or F respond to biomass.
  - Set-aside (as unfished) 30% of herring biomass as forage for birds and other predators
  - Reduce catch (F) beginning at 75% of the unfished SSB
  - Close the fishery (catch = 0) when SSB is at or below 40% of the unfished SSB
  - Do not close the fishery.
  - Use $B_{MSY}$ and $B_0$ as references in control rule and metrics
- Evaluate effect of setting catch annually, versus using the same catch for three or five years.
- Maintain a constant catch at 'high biomass' but cap mortality at some point as biomass declines (in control rule literature this is called conditional constant catch).
- Restrictions on the degree to which catch can change annually.
- Consider including a specific forage buffer within scientific uncertainty (ABC=OFL-forage need). However, the forage need is uncertain.
- Explore constant catch (in perpetuity).
- Minimum and max catch amounts at low and high biomass respectively.
Control Rules

- Biomass based
- Biomass based with 3 year block
- Biomass based with 5 year block
- Biomass based with 3 year block and 15% restriction
- Constant catch
- Conditional constant catch with max $F = 0.5F_{msy}$
Control Rules

biomass based

Three ‘parameters’ with many variants

- Upper biomass parameter
- Max F parameter
- Lower biomass parameter
Control Rules
biomass based

Three ‘parameters’ with many variants

Upper biomass parameter = Lower biomass parameter = 0

Fishing Mortality

Biomass or Abundance

Max F parameter
Control Rules

biomass based

Three ‘parameters’ with many variants

Upper biomass parameter = Lower biomass parameter > 0

Max F parameter
Control Rules

biomass based

Three ‘parameters’ with many variants

Evaluated 16 different values for each biomass threshold ranging from 0 to 4x Bmsy

Evaluated 10 different values for maximum F ranging from 0.1 to 1.0x Fmsy

1,360 combinations
Control Rules

biomass based

Three ‘parameters’ with many variants

![Diagram showing fishing mortality and biomass or abundance relationship](image-url)
Control Rules

Biomass based
Biomass based with 3 year block
Biomass based with 5 year block
Biomass based with 3 year block and 15% restriction
Constant catch
Conditional constant catch with max $F = 0.5F_{msy}$
Control Rules

biomass based
Control Rules

biomass based

BB 3 year

Target ABC

Year

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Control Rules

biomass based

BB 5 year
Control Rules
biomass based

BB 3 year perc

Year

Target ABC
Control Rules

status quo – biomass based with 3 year block
Control Rules

Biomass based
Biomass based with 3 year block
Biomass based with 5 year block
Biomass based with 3 year block and 15% restriction
Constant catch
Conditional constant catch with max $F = 0.5F_{msy}$
One parameter
Evaluated 10 different values ranging from 0.1 to 1x MSY
Control Rules
biomass based

CC

![Graph showing target ABC over years ranging from 1 to 24, with a horizontal line at 40000.]
Update
Conditional Constant Catch

Two parameters
Evaluated 10 different values ranging from 0.1 to 1x MSY with max F of 0.5Fmsy
Control Rules

Biomass based
Biomass based with 3 year block
Biomass based with 5 year block
Biomass based with 3 year block and 15% restriction
Constant catch
Conditional constant catch with max $F = 0.5F_{msy}$

1,360 alternatives
1,360 alternatives
1,360 alternatives
1,360 alternatives
10 alternatives
10 alternatives
5,460 alternatives

$x \times 8$ operating models
43,680
Control Rules

For each operating model, each control rule alternative was simulated for 150 years and this was repeated for 100 simulations.
Questions?

Biomass or Abundance

Fishing Mortality or Catch