Time-varying processes in stock assessment: A bridge to ecosystem-based reference points

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Why use stock assessments for ecosystem reference points?

1. Compare ecosystem advice with advice with existing assessment methods

2. Stock assessments...
   - ... are ubiquitous worldwide
   - ... have strong link to management
   - ... have existing capabilities to
Sensitivity to time-varying process

Questions

1. How sensitive are management targets to changing productivity?
2. What process has the greatest impact?

Approach

1. Simulate population given life-history theory
2. Change parameters and record impact on management targets
Sensitivity to time-varying process

Life history model

• Input parameters
  – Natural mortality rate (M)
  – Recruitment compensation (max. recruits per recruit)

• Life history invariants
  – $M \rightarrow a_{mat}$
  – $M \rightarrow k$
  – MRPR $\rightarrow$ steepness
Sensitivity to time-varying process

Mortality

All ages

$F_{MSY(NEW)}/F_{MSY(OLD)}$

$SB_{MSY(NEW)}/SB_{MSY(OLD)}$

- Long-lived
- Medium-lived
- Short-lived
Sensitivity to time-varying process
Questions

1. How sensitive are management targets to changing productivity?
2. What process has the greatest impact?

Conclusions

1. Most parameters can cause a greater-than-proportional change on targets
2. Mortality has the greatest impact!
Meta-analysis and time-variation

Proposal: Use existing single-species models for meta-analysis

Database of assessment models | Single species assessment

C | B

D

E

A
Meta-analysis and time-variation

Process

1. Assemble comparable stock assessments
2. Link using shared recruitment deviations
3. Estimate parameters for all models simultaneously
4. Explore impact for data-poor stocks
Meta-analysis and time-variation

<table>
<thead>
<tr>
<th>Common name</th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sablefish</td>
<td>1965-2010</td>
</tr>
<tr>
<td>Bocaccio</td>
<td>1954-2010</td>
</tr>
<tr>
<td>Canary rockfish</td>
<td>1960-2010</td>
</tr>
<tr>
<td>Darkblotched</td>
<td>1975-2009</td>
</tr>
<tr>
<td>Dover sole</td>
<td>1960-2009</td>
</tr>
<tr>
<td>Petrale sole</td>
<td>1959-2007</td>
</tr>
<tr>
<td>Pacific ocean perch</td>
<td>1952-2008</td>
</tr>
<tr>
<td>Widow</td>
<td>1978-2009</td>
</tr>
</tbody>
</table>
Meta-analysis and time-variation

Optimize each single-species model:
1. Sablefish
2. Bocaccio
3. Canary rockfish
4. Darkblotched
5. Dover sole
6. Petrale sole
7. Pacific ocean perch
8. Widow

Optimize each shared recruitment dev:
Meta-analysis and time-variation

Shared index

Fit to species in model

Without index

With index
Meta-analysis and time-variation

Shared index

-1.5 -1.0 -0.5 0.0 0.5 1.0 1.5

Year


Fit to new data-poor species

Yelloweye

Recruitment deviations

-3 -2 -1 0 1 2 3

Blackgill

Recruitment deviations

-3 -2 -1 0 1 2 3

Without index

With index
Meta-analysis and time-variation

Conclusion

1. Can use stock assessment database for ecosystem analysis

Next steps

1. Applying to other processes
2. Using index in stock assessments to account for ecosystem-level processes
How do time-varying parameters relate to ecosystem reference points?

Photo credit: Jonny Armstrong
How do time-varying parameters relate to ecosystem reference points?

Ecosystem reference points

– Needed to account for relationships excluded from single-species rules

Responses:

1. Develop new models
   – Ecosystem models
   – Pressure/response analysis

2. Adapt existing models
   – Account for interactions
How do time-varying parameters relate to ecosystem reference points?

#1: Mixed-effects modelling

- Can account for residual variation in ecological processes
- Calculate “Variance explained” by covariates

How do time-varying parameters relate to ecosystem reference points?

#2: Managing for variability

- Equilibrium is a stationary distribution!

Acknowledgements

Content:

Elasticity: Cole Monnahan, Jason Cope

Recruitment: Ian Stewart, Ian Taylor, Andre Punt

Individual growth: Ole Shelton, Coilin Minto

Stationary distributions: Olaf Jensen, Ray Hilborn

Organizers

Elliot Hazen, Jennifer Boldt, Robert Blasiak, Mary Hunsicker