The dids, dos, don’ts and developments of data-limited catch limits

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QUEST
Quantitative Ecology and Socioeconomics Training Program
Outline

• Background
• Definitions: What is data-limited?
• Innovations of data-limited methods
• Post-innovation stages
• Summarize the dids, dos, don’ts and developments
Applied stock assessment

- Parameters
- Data
- Stock Assessment model
- Derived outputs
- Management
Assessing fisheries stocks through time

1890s-ish
- Simple mark-recapture
- Length compositions
- Age/size structured models

Time/Complexity
- Integrated analysis
- Simulation testing
- Multi-species models
- Temporal-spatial models
- Ecosystem models

Present-ish
Assessing stocks through time

- Space/Seasons/Ecosystem included
- Size/age/stage-structured models
- Aggregated production models
- Simple life history equilibrium models
- Index only

U.S. National Assessment Levels (SAIP 2001)
Assessing stocks through time

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Are these stocks “sick ducks”?

U.S. National Assessment Levels (SAIP 2001)
Overfishing Limit

Maximum amount that can be caught in a year *without resulting in overfishing.*
Overfishing Limit

Maximum amount that can be caught in a year without resulting in overfishing.

Acceptable Biological Catch

Incorporates scientific uncertainty.

* Determined by scientists on regional technical committees. *
2007: Magnuson-Stevens Reauthorization

Overfishing Limit

Acceptable Biological Catch

Annual Catch Limit

Maximum amount that can be caught in a year without resulting in overfishing.

Incorporates scientific uncertainty. Determined by scientists on regional technical committees.

The amount that can be caught in a given year, set by policymakers. *Can’t exceed the ABC.*
2007: Magnuson-Stevens Reauthorization

All stocks needed annual catch limits (ACLs)

• Few exceptions

• ACLs required for stocks subject to overfishing by 2010.

• For stocks “in the fishery” by 2011.
Stock assessments through time

Example: PFMC Groundfish FMP

- **Data-rich**
- **Data-limited**

**Mix of data-limited & -rich**

**Data-rich dominated**

Year

<table>
<thead>
<tr>
<th>Year</th>
<th># of assessments</th>
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<tbody>
<tr>
<td>1982</td>
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<td>1985</td>
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<td>2009</td>
<td></td>
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<tr>
<td>2012</td>
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Stock assessments through time

Example: PFMC Groundfish FMP

<table>
<thead>
<tr>
<th>Year</th>
<th># of assessments</th>
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<tbody>
<tr>
<td>1982</td>
<td>Data-limited dominated</td>
</tr>
<tr>
<td>1985</td>
<td>Mix of data-limited &amp; -rich</td>
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<tr>
<td>1988</td>
<td>Data-rich dominated</td>
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<td>1991</td>
<td>Data-rich</td>
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<tr>
<td>2009</td>
<td>Data-rich</td>
</tr>
<tr>
<td>2012</td>
<td>Data-rich</td>
</tr>
</tbody>
</table>

Legend:
- Blue: Data-rich
- Green: Data-limited
- Orange: Mix of data-limited & -rich

DL-DR Mix
Why weren’t these stocks previously assessed?

• Not valuable in a socioeconomic, human-centric way.

• No data or little data
  ▪ Not target of fisheries or surveys
  ▪ Not enough catch

• Not enough resources
  ▪ Stock assessment scientists
  ▪ Not enough time and money

• Ecological value slowly being incorporated
Definitions: What is “data-limited”? 
Defining assessment approaches

Data-rich methods
- Age/size structured
- Catch, biological compositions, Indices, etc.

Data-moderate methods
- Catch; Index or limited biological compositions

Data-poor methods
- Catch only; length comps; no catch; no length comps
Defining assessment approaches

- **Data-rich methods**
  - Age/size structured
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- **Data-moderate methods**
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- **Data-poor methods**
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One person’s trash is another person’s less smelly trash
Fisheries in space: A Bayesian assessment of a commercially exploited fish stock on the Jupiter moon Europa.

SUMMARY

The use of Bayesian statistical methods in quantitative fisheries stock assessment has become increasingly common in recent years. Such methods can provide information on the uncertainty in the estimates of key stock parameters, which is crucial for making informed decisions about the sustainability of fishery operations. However, using such methods requires comprehensive information on the process and environmental parameters that influence fish populations. In this study, we have developed a Bayesian model to assess the sustainability of a fish stock on the Jupiter moon Europa. Our model incorporates information on the environmental conditions and the behavior of the fish populations, which has led to more accurate predictions of the sustainability of the fish stock.

Keywords: Fisheries, Stock Assessment, Uncertainty, Bayesian.
Defining assessment approaches

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Data-poor methods
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More Definitions: Stock complex

- A species grouping for management purposes
  - May or may not be based on ecological or fisheries interactions
- Managed as a conglomerate “stock”
- Stock complex catch levels calculated
  - Over all stocks combined
  - Additive over individual stocks
Nationally: 504 catch limits

<table>
<thead>
<tr>
<th>Method</th>
<th>Number of catch limits based on method</th>
<th>Percentage of catch limits based on method</th>
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<tbody>
<tr>
<td>Data-rich</td>
<td>150</td>
<td>30%</td>
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<tr>
<td>Data-moderate</td>
<td>59</td>
<td>11%</td>
</tr>
<tr>
<td>Data-poor</td>
<td>295</td>
<td>59%</td>
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Method distribution varies greatly by region

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<tr>
<th></th>
<th>NEFMC</th>
<th>MAFMC</th>
<th>SAFMC</th>
<th>GMFMC</th>
<th>CFMC</th>
<th>HMS</th>
<th>PFMC</th>
<th>NPFMC</th>
<th>WPFMC</th>
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<tr>
<td>Data-Rich</td>
<td>28</td>
<td>8</td>
<td>14</td>
<td>9</td>
<td>0</td>
<td>3</td>
<td>46</td>
<td>38</td>
<td>4</td>
</tr>
<tr>
<td>Data-Mod</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>48</td>
<td>1</td>
</tr>
<tr>
<td>Data-poor</td>
<td>2</td>
<td>1</td>
<td>47</td>
<td>25</td>
<td>23</td>
<td>37</td>
<td>106</td>
<td>13</td>
<td>41</td>
</tr>
</tbody>
</table>

Innovations of data-limited methods
Started with:

Data-poor control rule
• Restrepo et al. (1998)

Windfall ratios
• Alverson and Pereyra (1969)
• Gulland (1970)

Stock reduction analysis
• Kimura and Tagart (1982)
• Walters et al. (2006)
Started with:

Data-poor control rule
  • Restrepo et al. (1998)

Windfall ratios
  • Alverson and Pereyra (1969)
  • Gulland (1970)

Stock reduction analysis
  • Kimura and Tagart (1982)
  • Walters et al. (2006)

Turned into:

Scalar approaches
  • Berkson et al. (2011)

DCAC
  • MacCall (2009)

DB-SRA
  • Dick and MacCall (2011)
from Berkson and Thorson. 2014. ICES Journal of Marine Science
Innovation of data-limited approaches
Grouping data-limited approaches

- Input/Data types
- Static vs dynamic
- Baseline vs non-baseline
- F vs catch (management units)

Organizing may help the how and why methods are used (see “Implementation”)
Post-innovation stages
During/after innovation, there is:

- **Improvement**
  - Input parameters
  - Harvest control rules (including uncertainty estimation)
- **Evaluation**
  - Simulation testing
  - Management Strategy Evaluation
- **Implementation**
  - Toolboxes
  - Application planning
- **Standardization**
Improvements: inputs parameters

Thorson et al. 2012

$\frac{SB_{MSY}}{SB_0}$

Zhou et al. 2012

$F_{MSY}/M$

Hamel in press

$H_{MSY}/H_0$

Cope et al. in press

Depletion

Vulnerability
Improvements: Harvest control rules (HCRs)

- Decision rule that modifies catch
- Uses references points
- Incorporates uncertainty
- Oft needed connection between D-L method and management
- May improve poorly performing D-L method

Dowling et al. 2008
Evaluation: Simulation testing

Parameters

Data

Operating model (OM: “true state”)

Stock Assessment model

Derived outputs

Performance metrics

Management
Testing methods: Comparison tests

Performance relative to OM or benchmark assessment

Focuses on method performance

Cope et al. in press
Evaluation: Management strategy evaluation

Parameters → Operating model (OM: “true state”) → Stock Assessment model → Derived outputs → Management (control rule)

- **Data**
- **Parameters**
- **Stock Assessment model**
- **Derived outputs**
- **Management (control rule)**

**Performance metrics**
Testing methods: Management strategy evaluation

- Performance relative to OM
- Focuses on method AND control rule performance
Implementation

• DLMtool (R; T. Carruthers) toolkit
  ▪ [http://cran.r-project.org/web/packages/DLMtool/index.html](http://cran.r-project.org/web/packages/DLMtool/index.html)
  ▪ Choose models given data
  ▪ MSE mode

• Science for Nature and People (SNAP)
  ▪ D-L group [http://www.snap.is/groups/data-limited-fisheries/](http://www.snap.is/groups/data-limited-fisheries/)
  ▪ Application-based
  ▪ Resource evaluation

• Using multiple models
• Not everyone is an innovator
Standardization?

Newman et al. 2014
Why don’t we have standardization?

• Regional Councils have a history of doing things their own way.
• The data, stocks, and fisheries are unique by region.
• We’re still in the innovation stage.
Summary/Considerations: the dids, dos, don’ts, and developments
Summary - Context

• Era of rigid mandates

• Era of limited resources
What did we do?

- Created a lot of acronyms
- Held a lot of workshops
Summary: Developments

- Improve inputs
- Ways to test performance
- D-L methods
  - DL Toolboxes
  - Resource evaluation
- Decision rules (e.g., HCRs)
- Application
Suggestion

• Do’s
  ▪ Consider multiple methods
  ▪ Be creative/continue innovation
  ▪ Simulation/MSE testing
  ▪ Compare to benchmark assessments
  ▪ Seek best practices
  ▪ Common framework approach

• Don’ts
  ▪ Avoid “Shotgun” approach
  ▪ Pseudo-replication
  ▪ Beware stock complexes
End with two questions

- Will the need to conduct stock assessments on data-limited stocks go away?

- For the students attending: Are you spending 59% of your time in relevant courses learning about these methods?
Questions