mseR: software for rapid closed-loop simulation of single-species harvest strategies

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Overview

Stock assessment → Management strategy evaluation

**mseR**: fast progress on realistic problems

Application to data-moderate BC Pacific herring stocks
Stock assessment: NOAA view(1)

"Best assessment approach"
Low stakeholder engagement
Manager/stakeholder confusion
Management strategy evaluation - positive perceptions

Multiple hypotheses
High stakeholder engagement
Management-oriented
Management strategy evaluation - **negative perceptions**

- Slow, laborious
- Highly technical
- Expensive
- Manager/stakeholder confusion
Management strategy evaluation: **Lean MSE Approach**

Choose Breadth vs Depth initially

Build prototypes and iterate

Educate stakeholders/managers
mseR: Models and Graphical User Interfaces

Simulation

Viewing

Performance
mseR: 3 R commands

`guiSim()`

`guiView()`

`guiPerf()`
mseR: Workshops, applications, directions

**DFO Workshops - Biologists and Managers (50:50)**
Ottawa 2009 (30 participants)
Halifax 2009 (20 participants)
Vancouver 2013 (25 participants)

**Applications**
Atlantic cod, snow crab, Atlantic surf clam, Greenland halibut, Atlantic herring, Porbeagle shark, Atl Lobster, George’s Bank scallop, Pollock, BC spot prawn, Scotia-Fundy haddock, Alt halibut, BC Pacific herring, Rock sole, Pacific hake, Pacific cod, Patagonian toothfish

**Future directions**
GitHub (Fall 2015)
Migration
- Tcl/TK to Shiny interface (for web-based apps)
- base plot to ggplot for most graphics
Length-based methods
Non-TAC fisheries
**mseR**: single-species, output TAC fishery

- Operating model hypotheses
- Realistic data and errors
- Time-delays
- Information feedback
- Performance evaluation
mseR: Application to BC herring

...5 major stocks
...$20-40 million landed value
...Industrial and First Nations conflicts
...Model-based assessments
...Wide fluctuations in recruitment
natural mortality
growth
...3/5 stocks closed 30-45% of years
mseR: Operating model...equilibrium properties

Reference Points

guiSim()
**mseR: Operating model...realism**

**Time-varying parameters (random walk + trend)**
- natural mortality
- cohort-specific growth
- selectivity
- catchability
- survey CVs

**Operating model initialization**
- automatic to target depletion
- user inputs and time-series
  - abundance-at-age (t=1)
  - recruitment deviations
  - natural mortality
  - fishing mortality
  - growth rates
mseR: Historical Mt, projected random walk + trend
mseR: Management Procedure options

**Data**
- abundance index
- age composition
- size composition
- flexible collection frequency/timing

**Method (assessments)**
- empirical estimators (MA,KF)
- model-based (SP,SCA,DD)
- MLE, Bayes, MCMC
- choose 2 Methods per MP

**Harvest control rules (HCR)**
- empirical/historical
- MSY, B0 based F
- Decision-tables
- Uncertainty adjustments
- TAC floors and ceilings
mseR: Forage fish HCR options for BC herring

guiSim()
**mse**R: Forage fish HCR options for BC herring

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**Estimated Stock Status**

**Intended Removal Rate (F)**

Sim11  Rep 4/100  Scenario: IncM-HisG, MP: LF.1.4 WCVI_mseRBat19

**Target F**

Lenfest2

\[ F = 0.5F_{MSY} \]
mseR: Forage fish HCR options for BC herring

GUI Sim()
**mseR**: Simulated herring assessments

The image shows a graphic interface with various data representations. The interface includes a table with columns labeled `B0`, `Bmsy`, `MSY`, `Mfmsy`, `F0`, `F91`, `F40`, `Fm`, and `Fc`. Below the table, there are several graphs with biomass and spawning patterns over years. The graphs illustrate retrospective biomass estimates and true spawning biomass (SSB). The interface also includes options for simulating and assessing herring populations with different scenarios and control rules.
mseR: SSB, Catch, F outcomes (Increasing M)

**Lenfest2**

- Biomass and Index
- Catch (metric tons)
- Fishing mortality

**Current DFO**

- Biomass and Index
- Catch (metric tons)
- Fishing mortality

Sim11 Rep 1/100  Scenario: IncM-HisG, MP: LF.2 SOG_mseRBat19

Sim8 Rep 1/100  Scenario: IncM-HisG, MP: DFO.1 SOG_mseRBat16
mseR: SSB, Catch, F outcomes (Increasing M)

**Lenfest2**

- Biomass and Index
- Catch (metric tons)
- Fishing mortality

**Current DFO**

- Biomass and Index
- Catch (metric tons)
- Fishing mortality

Sim11  Rep 1/100  Scenario: IncM-HisG, MP: LF.2 SOG_mseRBat19

Sim8  Rep 1/100  Scenario: IncM-HisG, MP: DFO.1 SOG_mseRBat16
mseR: Performance envelopes

**Lenfest2**

- Year: 65, 70, 75, 80
- Depletion
- Catch

**Current DFO**

- Year: 65, 70, 75, 80
- Depletion
- Catch

Simulation details:
- Sim1 Reps: 100
- Scenario: IncM-HisG, MP: DFO.1
- Tue May 12 17:59:43 2015

Simulation details:
- Sim1 Reps: 100
- Scenario: IncM-HisG, MP: LF.2
- Tue May 12 18:00:12 2015

`guiPerf()`
mseR: Realized fishing mortality

\textbf{Lenfest2}

\textbf{Current DFO}

\texttt{guiPerf()}

\texttt{Sim 1  Reps: 100  Scenario: IncM-HisG, MP: DFO.1  Thu May 12 18:23:51 2015}

\texttt{Sim 1  Reps: 100  Scenario: IncM-HisG, MP: LF.2  Thu May 12 18:22:25 2015}
Constant M

Increasing M

Batch/Parallel

**LRP**

- 0.25B₀
- 0.30B₀
- 0.40B₀
- 0.40B<sub>MSY</sub>

- 0.25B₀
- 0.30B₀
- 0.40B₀
- 0.40B<sub>MSY</sub>
Constant M

Increasing M

Batch/Parallel

Probability of biomass < LRP

LRP

0.25B₀

0.30B₀

0.40B₀

0.40B_{MSY}

0.25B₀

0.30B₀

0.40B₀

0.40B_{MSY}
Lean MSE lessons for BC herring fisheries

First Nations and academics look to conservation science for generic HCRs

There are no "generic" fisheries

mseR simulations for 5 BC herring stocks suggest that generic HCRs could make things worse
Lean MSE lessons for BC herring fisheries

mseR output is consistent with other simulation and assessment work for BC herring

Model-based assessments and quota fisheries may not be appropriate for majority of BC herring stocks

Iteration 1: fixed target $F < 0.225$ may be the only option until alternative MPs developed
Thank you from the mseR team!

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