Identification and performance of stock-recruitment functions in state space assessment models

Working Paper 1

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Background

Introduction

- State Space Research Track Working Group (SSRTWG) is investigating performance of the Woods Hole Assessment Model (WHAM)
- Simulation studies with data generated from operating models (OMs), then fit with a series of estimation models (EMs)
- This framework allows us to evaluate how the EM fits compare to the known OM "true values", evaluate model selection, bias, precision, etc.
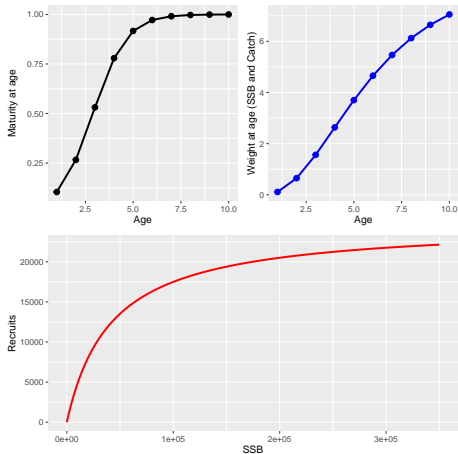
Terms of Reference (TORs) Addressed

- TOR 2: Investigate the efficacy of estimating stock-recruit functions within state-space models and their utility in generating scientific advice.

- TOR 3: Develop guidelines for including ecosystem and environmental effects in assessment models and how to treat them for generating biological reference points and scientific advice.

Outline

- 'Stock' parameters, fishery and index parameters
- OM factors and simulated data examples
- EM models
- Beta standardization
- Analysis & Results
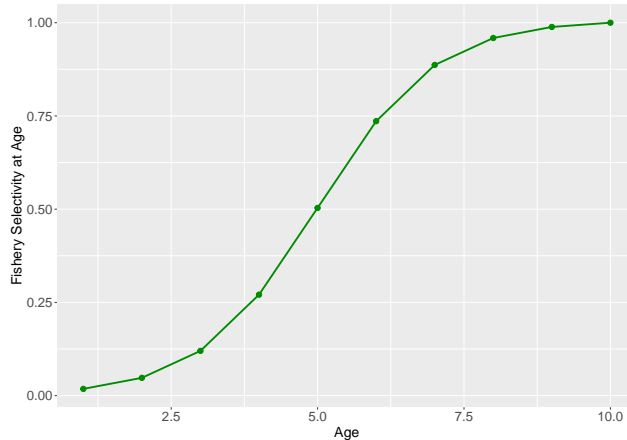- Conclusions
- Future Work

Background
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Inputs
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OM
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EM
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Analysis & Results
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Conclusions
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Future Work
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Inputs

Stock parameters for generic gadid

- Natural mortality $= 0.2$ at all ages
- Maturity, weight, natural mortality are time-invariant

Fishery and index parameters

- two fishery independent indices were also generated, taking place at 0.25, 0.75 yr
- catchability for both indices was 0.3; selectivity was same as fishery

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Inputs
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Analysis & Results
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Conclusions
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Future Work
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OM

OM factors and simulated data examples

Fhistory	R_sigma	R_cor	Ecov_effect	Ecov_cor	Obs_error
H-MSY	0.1	0.2	0.1	0.2	L
MSY	1	0.8	1	0.8	H

- These levels were combined factorially with 4 stock recruit models (all Beverton-Holt) for 256 different OM
- Factors that did not vary were the observation and process error of the Ecov (bot fixed at 0.1)

OM factor: Beverton-Holt functional (1 with no Ecov effect, 3 with effect)
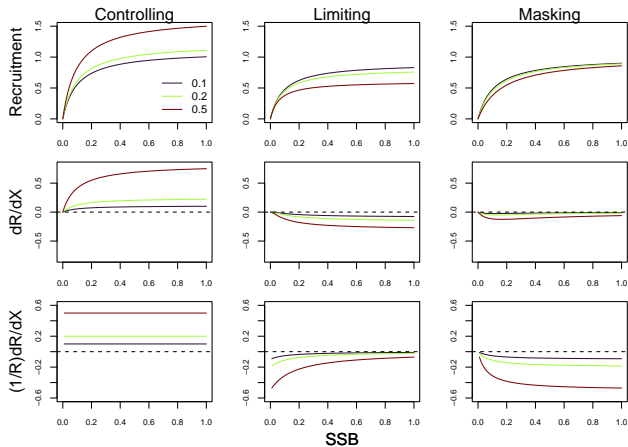
OM factor: Beta standardization
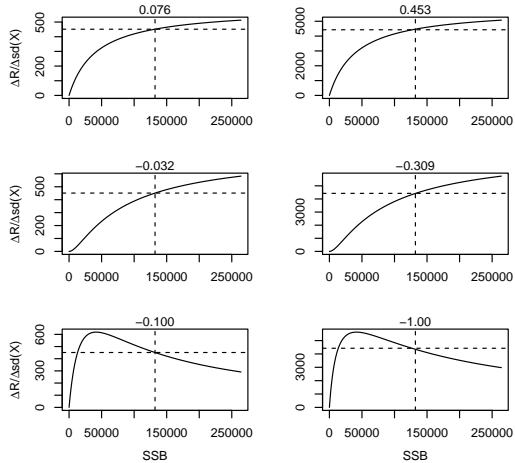
Some Example OM Simulated Data (100 data sets for each OM)

- still need to make this

Background
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Inputs
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OM
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EM
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Analysis & Results
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Conclusions
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Future Work
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EM

EM models

- All OMs used Beverton-Holt stock recruit relationship (SRR)
- For the EMs, we also fit a mean SRR with random effects
- There were 6 total EMs fit to each simulated data set (100) for all 256 OMs
- 153,600 fitted models X 2 for β unstandardized and β standardized cases

| EM	SRR	Ecov_how	Ecov	EM_mod
1	Mean	0	None	Mean_0
2	Mean	1	Controlling	Mean_1
3	BH	0	None	BH_0
4	BH	1	Controlling	BH_1
5	BH	2	Limiting	BH_2
6	BH	4	Masking	BH_4

Analysis & Results

Analyses

1. Convergence of the estimating models

2. Model identifiability of an underlying stock recruitment model and/or an underlying relationship between environmental covariate

3. ΔAIC and model probability

4. Assessment error (recruitment, spawning stock biomass, and Fbar)

5. Bias of estimated parameters

6. Mohn's ρ

7. Projection performance relative to assumptions about the environmental covariate

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• Results will be shown for β unstandardized case, because β standardization had no appreciable effect

Crashes

- ~3.3-3.5% crashes, typically for Ecov=Masking ("BH_4") and σ_R=0.1
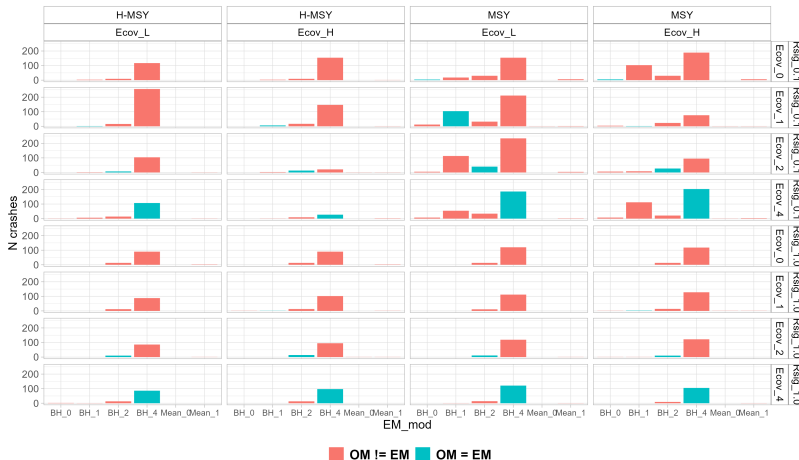
Convergence Criteria

1. the optimization routine (stats::nlminb) completed without error
2. the stats::nlminb convergence flag $= 0$ indicated successful convergence
3. the maximum absolute value of the gradient of the log-likelihood is $< $ 1e-6
4. TMB::sdreport provided non-NA values for all fixed effects standard errors
5. TMB::sdreport provided all standard errors < 100

- Models not satisfying all of these conditions were dropped from Results summaries

Background
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Inputs
OOO

OM
OOOOO

EM
OO

Analysis & Results
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Conclusions
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Future Work
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Unconverged Models (from EM having'best' EM per OM-Simulation)

Unconverged Models (considering all EMs per OM-Simulation)

Unconverged Model - The Offending Parameters

Unconverged Model - Even More Offending Parameters

Model Identifiability

ΔAIC and model probability

Assessment error (recruitment, spawning stock biomass, and Fbar)

Background
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Inputs
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OM
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EM
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Analysis & Results
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Conclusions
oo

Future Work
ooo

Bias of estimated parameters

Mohn's ρ

Projection performance relative to assumptions about the environmental covariate

Background
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Inputs
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OM
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EM
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Analysis & Results
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Conclusions
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Future Work
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Conclusions

Take-aways

- These are the take-aways (copy from WP)

Future Work

Recommendations for further analyses

- This is what we suggest for follow-up
- Note that WP1-Appendix looked at σ_R=0.5 and found no difference from results in WP1

Acknowledgements

- This work could not have been completed without the use of Azure computing (NOAA) and MIT (. . . greg to fill in)
- We thank other members of the SSRTWG for thoughtful comments during earlier discussions and presentations of this work