Management Strategy Evaluation made operational with Stock Synthesis

Kathryn Doering

Caelum Research Corporation in support of NWFSC, NOAA, Seattle, WA

kathryn.doering@noaa.gov

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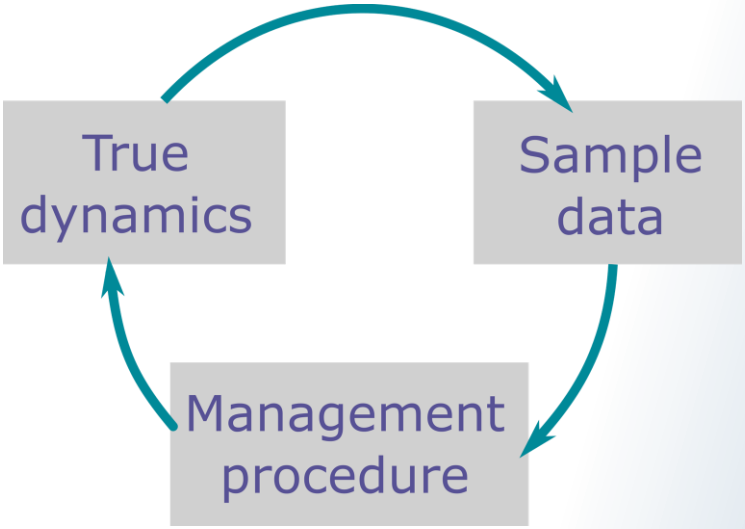
Coauthors -
Nathan Vaughan, John Walter, Richard Methot, Shannon Calay, Nancie Cummings, Nicholas Farmer, Cassidy Peterson, Skyler Sagarese, Matthew Smith, Kelli Johnson, Kristin Marshall, Ian Taylor, and Chantel Wetzel

Thanks also to Matthew Damiano, Allan Hicks, Huihua Lee, Desiree Tommasi, Corrine Bassin, Christine Stawitz

R packages used directly by SSMSE and in this presentation: r4ss, ss3sim, assertive, dplyr, tidyr, ggplot2, ggmap, mapdata, maps, nmfspalette, scales

What is management strategy evaluation (MSE)?

- MSE uses simulation to test the performance of alternative management procedures against pre-specified objectives over a range of uncertainties
- In this case, I will be talking about a tool for **single-species MSE simulations**



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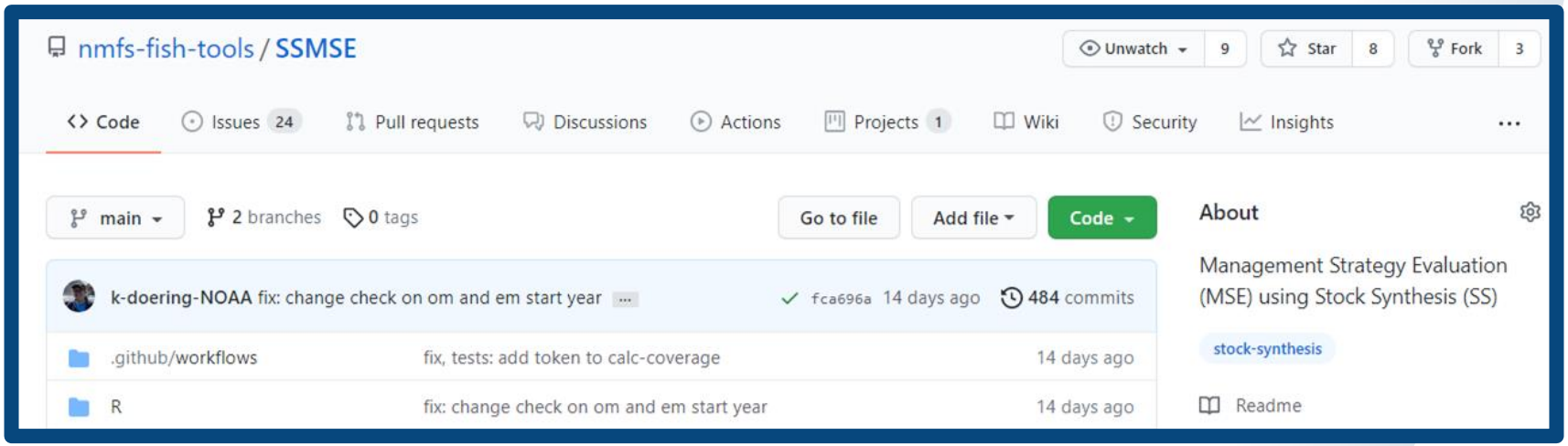
What is SSMSE?

github.com/nmfs-fish-tools/SSMSE

Goals

- Create a generalized, standardized tool that directly uses existing SS stock assessments as Operating Models (OMs) in MSE.
- Bundle it into an R package




```
remotes::install_github("nmfs-fish-tools/SSMSE")
```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Why use Stock Synthesis models as OMs?

- Many SS assessment models already exist due to widespread use (e.g., >220 U.S. federal stock assessments used SS from 2010-2020)
- Stock assessment models have already received extensive peer review during the assessment process
- SS offers a rich set of options, allowing nuanced OMs

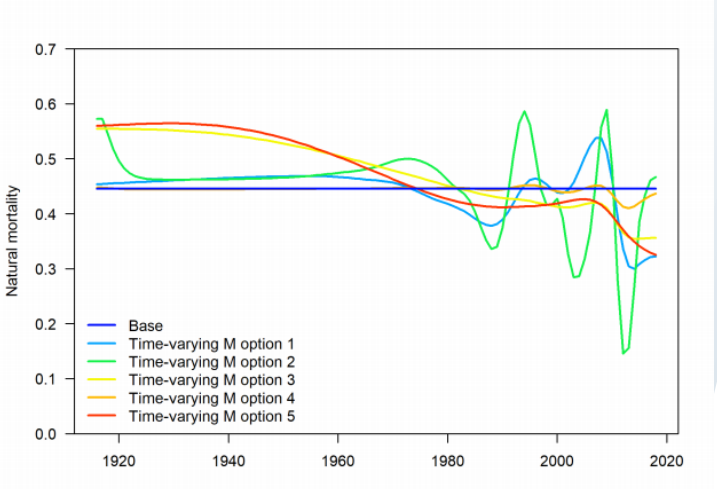


Figure from Taylor et al. (2019) - Status of Big Skate (*Beringraja binoculata*) Off the U.S. Pacific Coast in 2019.

Two main functions

```
# call SSMSE ----
out <- SSMSE::run_SSMSE(out_dir_scen_vec = rep("model_runs", 6), ...

# # look at results ----
summary <- SSMSE::SSMSE_summary_all(dir = "model_runs")
```

For more information on using SSMSE, check out the readme (github.com/nmfs-fish-tools/SSMSE#readme) and user manual (nmfs-fish-tools.github.io/SSMSE/manual/).

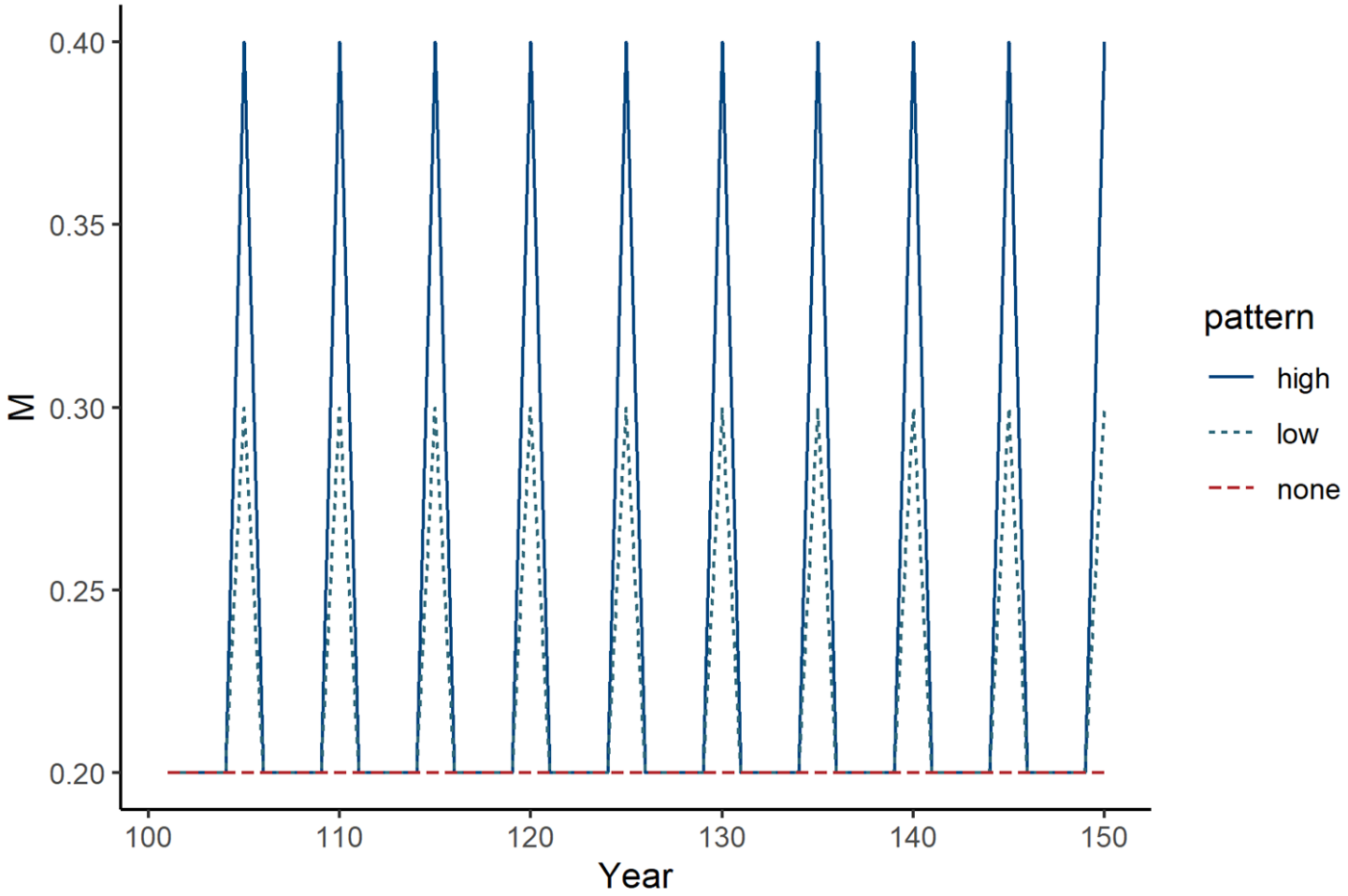
An SSMSE example

What happens if we don't account for natural mortality (M) events in stock assessments?

- Project forward 50 years (years 101-150), with a stock assessment every 5 years
- cod-like species, 1 fishing fleet and 1 survey
- Three operating model scenarios (different M patterns), two management procedures, for a total of 6 scenarios

https://github.com/k-doering-NOAA/ssmse-wfc

OM natural mortality



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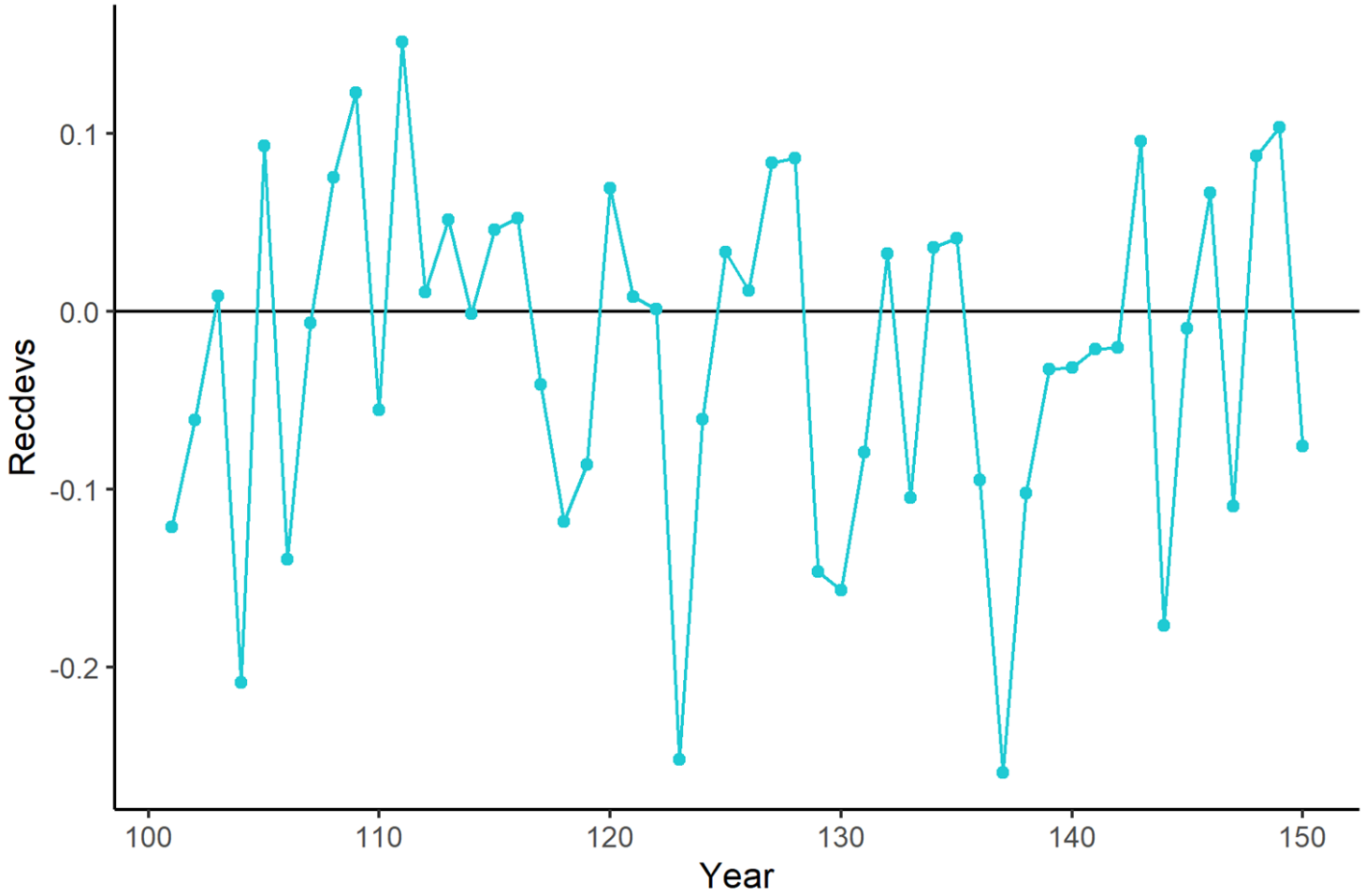
OM recruitment deviations



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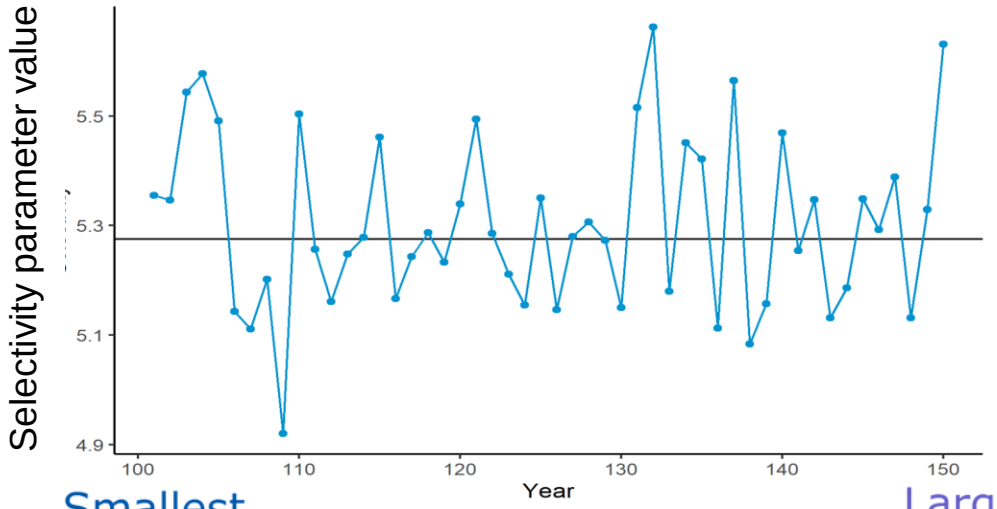
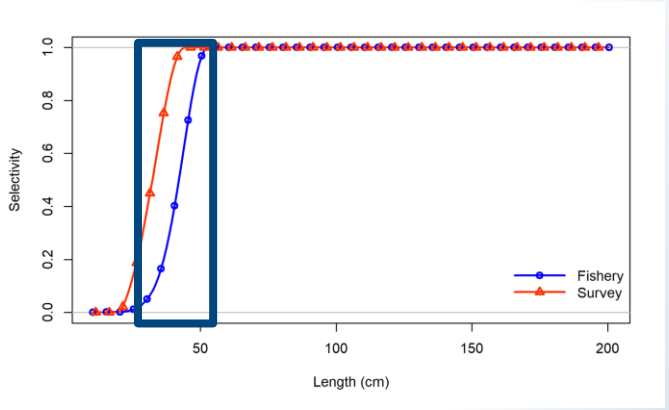
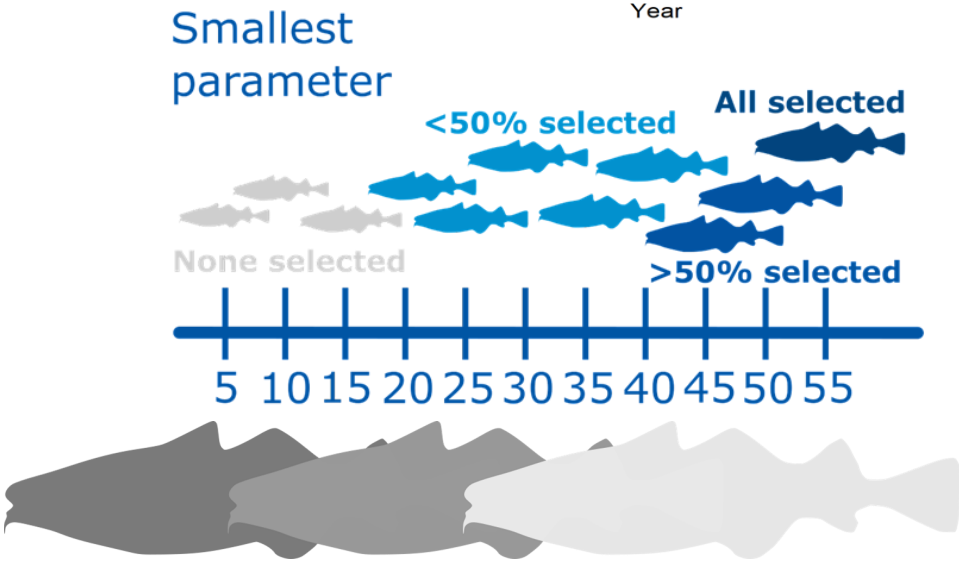
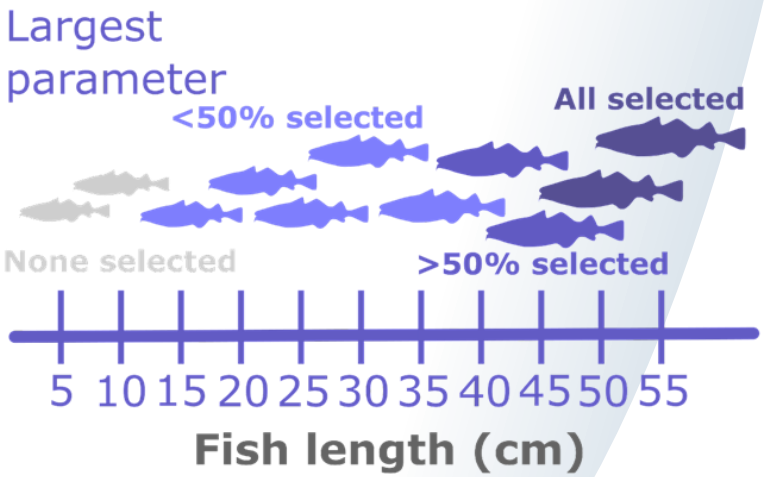
OM fishery ascending length selectivity parameter









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Management procedures

- Run SS estimation model as the stock assessment
- EM assumes M is fixed at 0.2 in all scenarios (i.e., does not account for the mortality events)
- Catches determined by alternative harvest rates (SPR_{30} or SPR_{45})
- Catches projected between assessments using forecast module of SS
- Note more realistic management procedures (empirical or model based) are possible with the SSMSE tool

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Performance metrics

- Punt et al. 2016 recommends, at a minimum, using metrics for catch, variability in catch, and population size
- Average annual catch
- Catch variability (i.e., CV)
- Average annual SSB
- Summarized over the last 25 years (of 50 total years, years 126-150) of simulation to get long-term averages

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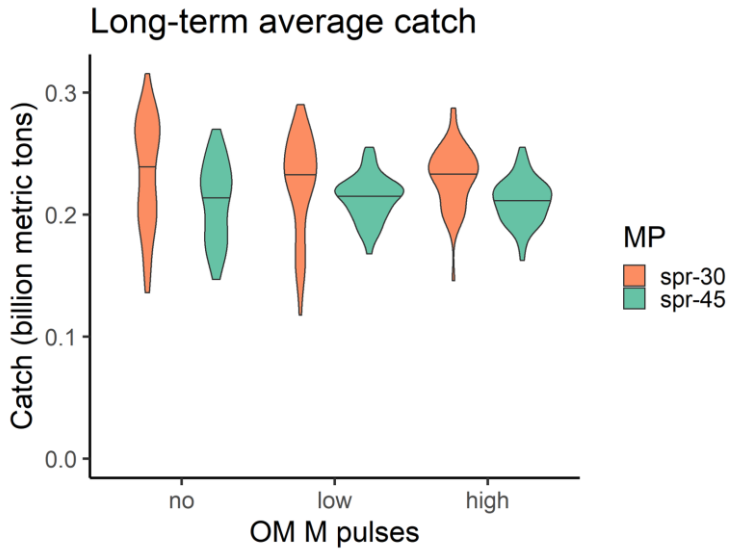
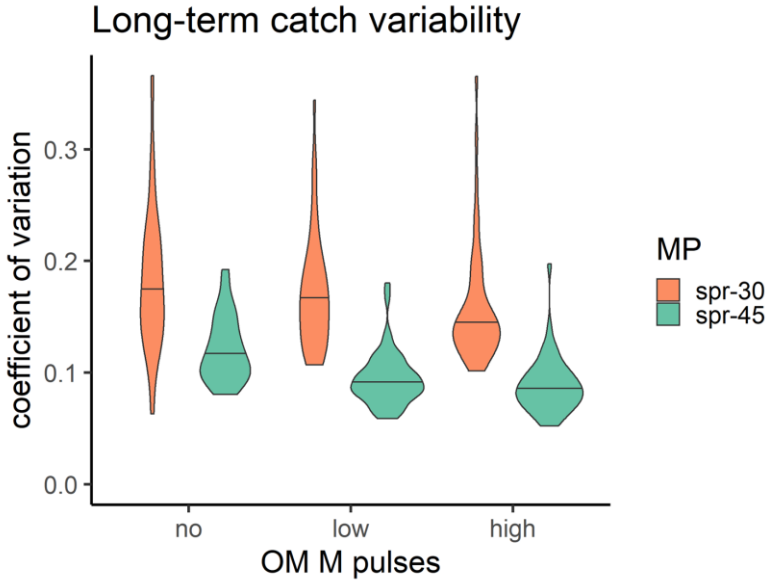
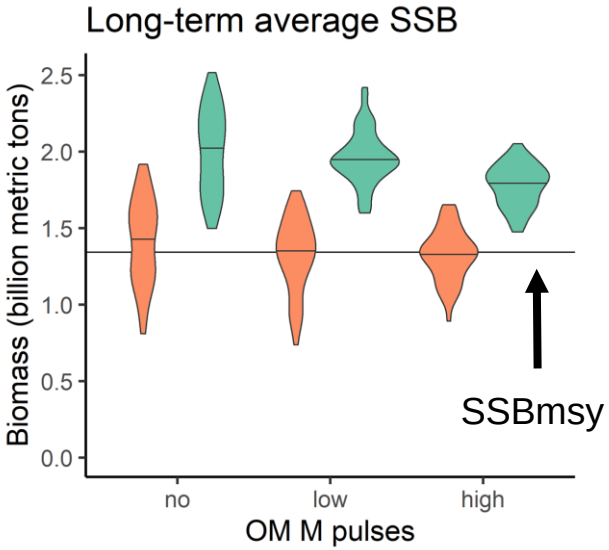
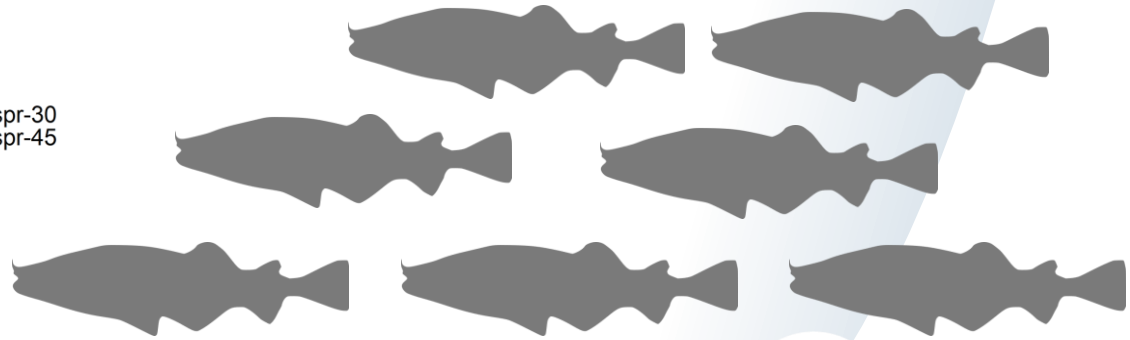
Performance metrics plots







Examples of how SSMSE output can be summarized



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Some key SSMSE features

- Turn an SS model into an OM for use in MSE
- User-specified adjustments to operating model parameters
- User-specified data sampling
- Use an SS estimation model or create your own custom management procedure
- Summarize simulation output

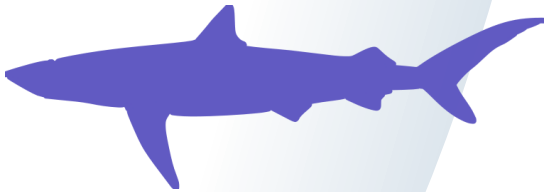
...all through R code

Potential upcoming applications of SSMSE

- Management procedure performance under climate change scenarios for Pacific Sardine, West Coast, US
- Stocks affected by red tide in the Gulf of Mexico, US
- Evaluating performance of data-limited assessment methods for blue shark

Pacific Ocean

Gulf of Mexico



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Interested in learning more, contributing to, or using SSMSE?

- Via our github repository: github.com/nmfs-fish-tools/SSMSE
- The Stock Synthesis email: nmfs.stock.synthesis@noaa.gov
- My email: kathryn.doering@noaa.gov