NOAA FISHERIES

Developing SSMSE, an R package for Management Strategy Evaluation with Stock Synthesis

Think Tank, May 12, 2020

Kathryn Doering

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

NOAA FISHERIES

Coauthors -
Nathan Vaughan, John Walter, Richard Methot
SEFSC/SERO: Shannon Calay, Nancie Cummings, Nicholas Farmer, Cassidy Peterson, Skyler Sagarese, Matthew Smith
NWFSC: 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: assertive, ggplot2, r4ss, ss3sim, stats, tidyr, utils

Feel free to offer feedback and ask questions throughout this presentation!

I especially welcome feedback on audience questions in orange text.

NOAA FISHERIES

What is management strategy evaluation (MSE)?

"Management strategy evaluation (MSE) in the broad sense involves assessing the consequences of a range of management strategies or options and presenting the results in a way which lays bare the tradeoffs in performance across a range of management objectives." Smith (1994)

Use simulation to answer a variety of questions: sampling data, harvest control rules, stock assessment model complexity

NOAA FISHERIES

What is management strategy evaluation (MSE)?

"Management strategy evaluation (MSE) in the broad sense involves assessing the consequences of a range of management strategies or options and presenting the results in a way which lays bare the tradeoffs in performance across a range of management objectives." Smith (1994)

Use simulation to answer a variety of questions: sampling data, harvest control rules, stock assessment model complexity

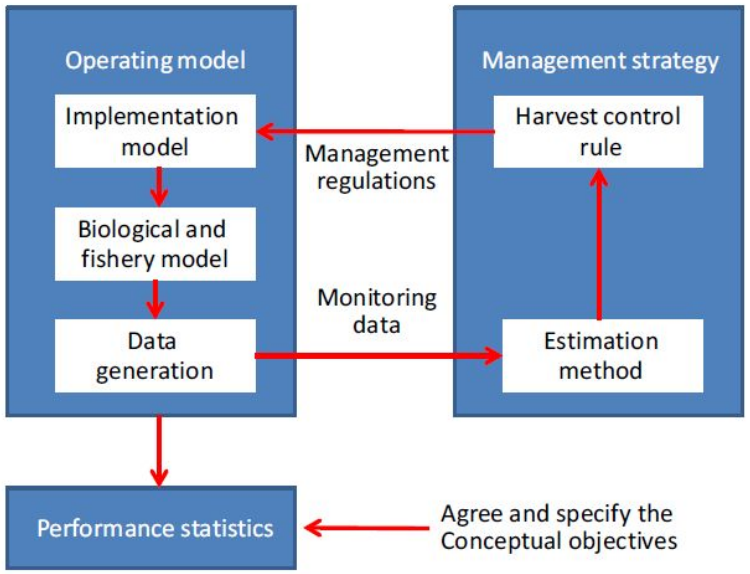


Figure 1 Conceptual overview of the management strategy evaluation modelling process. Punt et al. 2016

Fish and Fisheries, Volume: 17, Issue: 2, Pages: 303-334, First published: 24 November 2014, DOI: (10.1111/faf.12104)

NOAA FISHERIES

Note: Some great options exist for MSE and simulation studies

- For MSE (not with Stock Synthesis (SS), although FLR can convert simple (no discards) SS models structure to simpler version):
  - FLR (flr-project.org/mse/)
  - DLMtool (datalimitedtoolkit.org/) and the associated MSEtool (github.com/tcarruth/MSEtool)

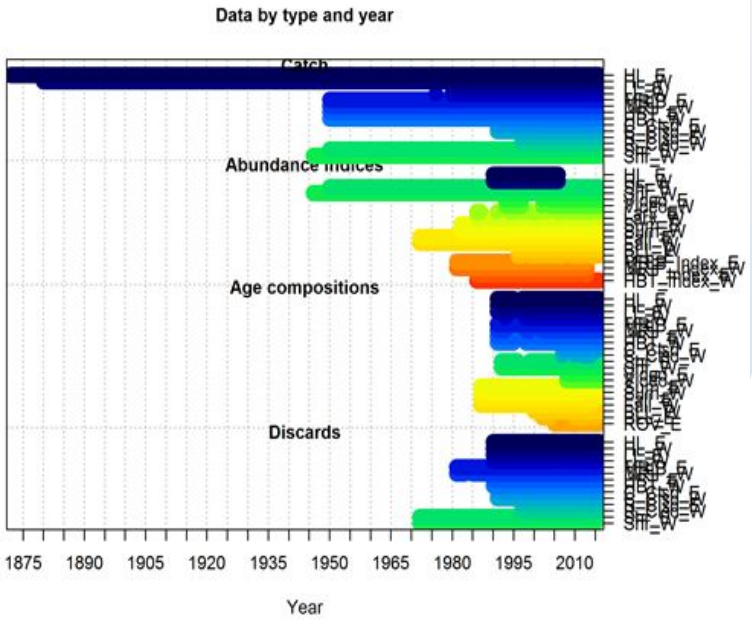
- Simulation studies (no feedback from Estimation Model (EM) to Operating Model (OM)) with SS: ss3sim (github.com/ss3sim/ss3sim)

Problem 1: SS is widely used in custom MSEs, but there is no generalized MSE package capable of directly using SS OMs

- SS has been used in many custom MSE analyses (e.g., Pacific Halibut, North Pacific Albacore, Atlantic sharks, Pacific Hake, US West Coast rockfish, and US West Coast flatfish)
- Analysts write custom code (often specific to the OM and EM being used) that is time consuming to create and is difficult to reuse
- custom code = more potential errors?

Problem 2: US Southeast stocks have dynamics that are difficult to capture in other MSE R packages.

- Federal stock assessments in the US Southeast often include:
  - Discards and bycatch
  - Fleet allocations
  - Large recreational component for some stocks
- FLR models don't work well for these complex stocks and fleets.



SEDAR52, Gulf of Mexico Red Snapper

Need ability to create more complex OMs

NOAA FISHERIES

What is the SSMSE project?

- The Stock Synthesis management strategy evaluation (SSMSE) project is a joint collaboration between SEFSC, SERO, and NWFSC
- Our goal is to create a generalized tool that enables MSE to be performed more directly using SS OMs and (if desired) SS EMs.
- SS assessment models can easily be turned into OMs with less custom code
- Address (but not limited by) needs of U.S. southeast

NOAA FISHERIES

We chose to develop this tool to use SS within an R package

- The target users are assessment scientists who are already familiar with SS and likely comfortable writing R code (and perhaps prefer it to using a GUI)
- We can use existing R code (depend on r4ss, ss3sim)

We chose to develop this tool to use SS within an R package

- The target users are assessment scientists who are already familiar with SS and likely comfortable writing R code (and perhaps prefer it to using a GUI)
- We can use existing R code (depend on r4ss, ss3sim)

Questions to Think Tank participants:

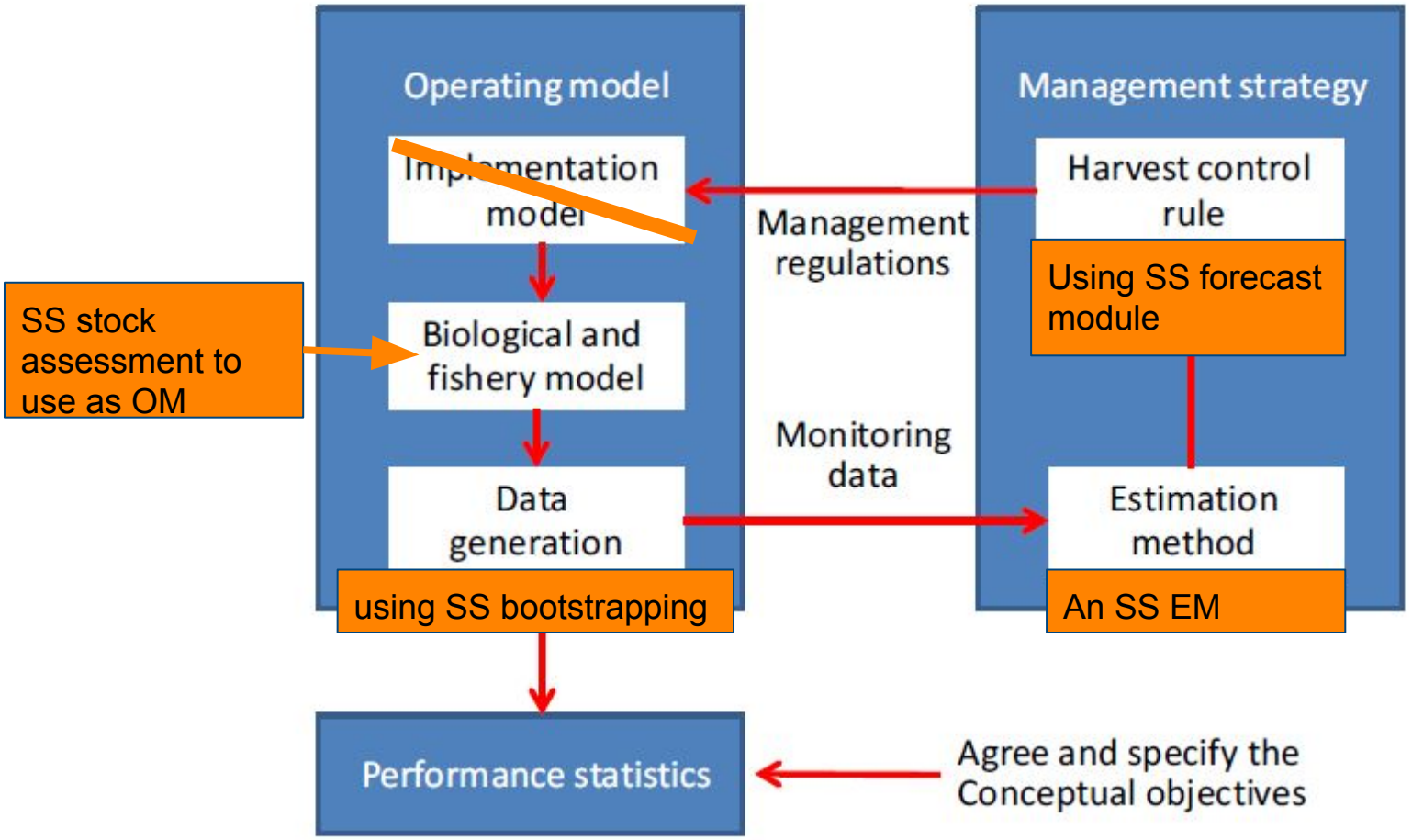
- Are there any downsides to developing this as an R package that we should consider? Or additional reasons why an R package is a good choice for this type of tool?

What is available so far?

https://github.com/nmfs-fish-tools/SSMSE

NOAA FISHERIES

MSE process for 1 iteration



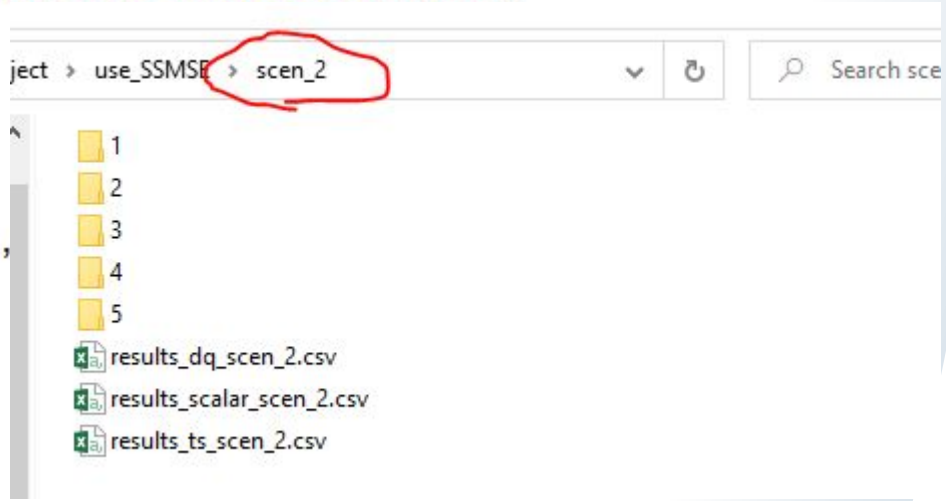
NOAA FISHERIES

Run 5 iterations

```
# load packages ----
library(SSMSE) # remotes::install_github("nmfs-fish-tools/SSMSE")

# define data ----
dat_str <- list(
  catch = data.frame(year = 101:106,
                     seas = 1,
                     fleet = 1),
  CPUE = data.frame(year = c(102, 105),
                    seas = 7,
                    index = 2)
)

dat_str_list <- list(dat_str)

# run the MSE loop ----
run_SSMSE(scen_name_vec = "scen_2",
          iter_list = list(1:5),
          OM_name_vec = "cod",
          EM_name_vec = "cod",
          MS_vec = "EM",
          use_SS_boot_vec = TRUE,
          nyrs_vec = 6,
          nyrs_assess_vec = 3,
          rec_dev_pattern = "none",
          impl_error_pattern = "none",
          dat_str_list = dat_str_list)

# summarize results ----
summary_scen <- SSMSE_summary_scen("scen_2")
```

Run 5 iterations

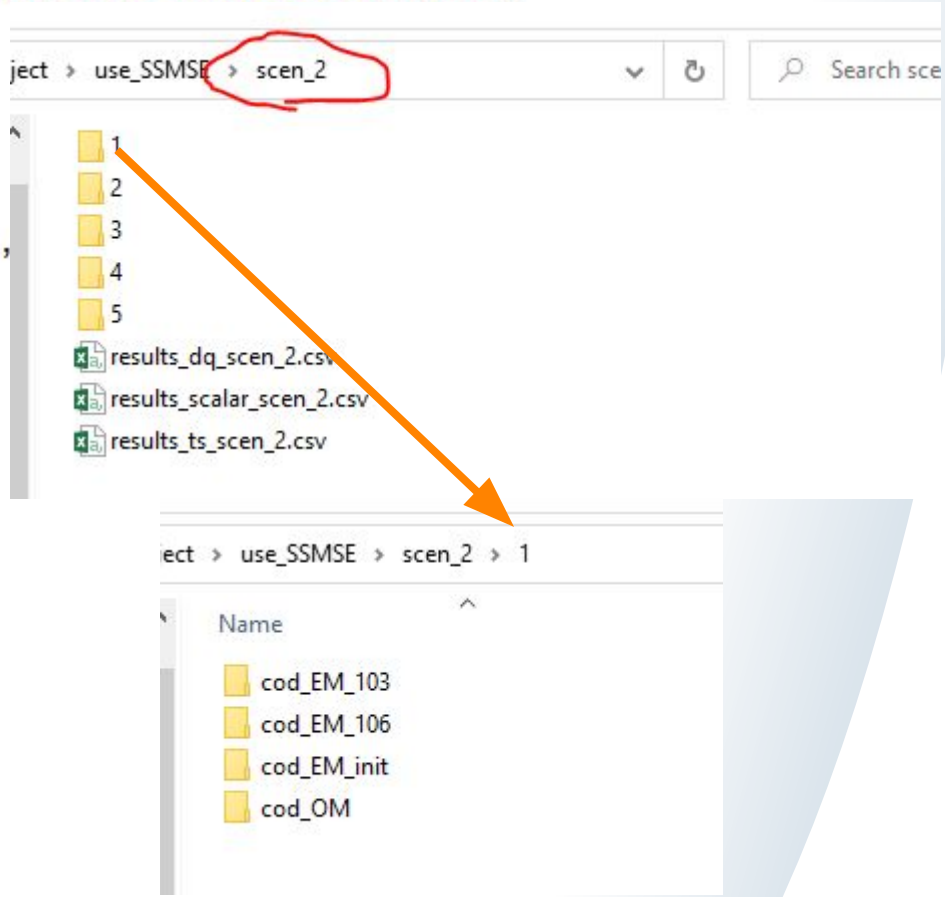
```r
# load packages ----
library(SSMSE) # remotes::install_github("nmfs-fish-tools/SSMSE")

# define data ----
dat_str <- list(
  catch = data.frame(year = 101:106,
                     seas = 1,
                     fleet = 1),
  CPUE = data.frame(year = c(102, 105),
                    seas = 7,
                    index = 2)
)

dat_str_list <- list(dat_str)

# run the MSE loop ----
run_SSMSE(scen_name_vec = "scen_2",
          iter_list = list(1:5),
          OM_name_vec = "cod",
          EM_name_vec = "cod",
          MS_vec = "EM",
          use_SS_boot_vec = TRUE,
          nyrs_vec = 6,
          nyrs_assess_vec = 3,
          rec_dev_pattern = "none",
          impl_error_pattern = "none",
          dat_str_list = dat_str_list)

# summarize results ----
summary_scen <- SSMSE_summary_scen("scen_2")
```



NOAA FISHERIES

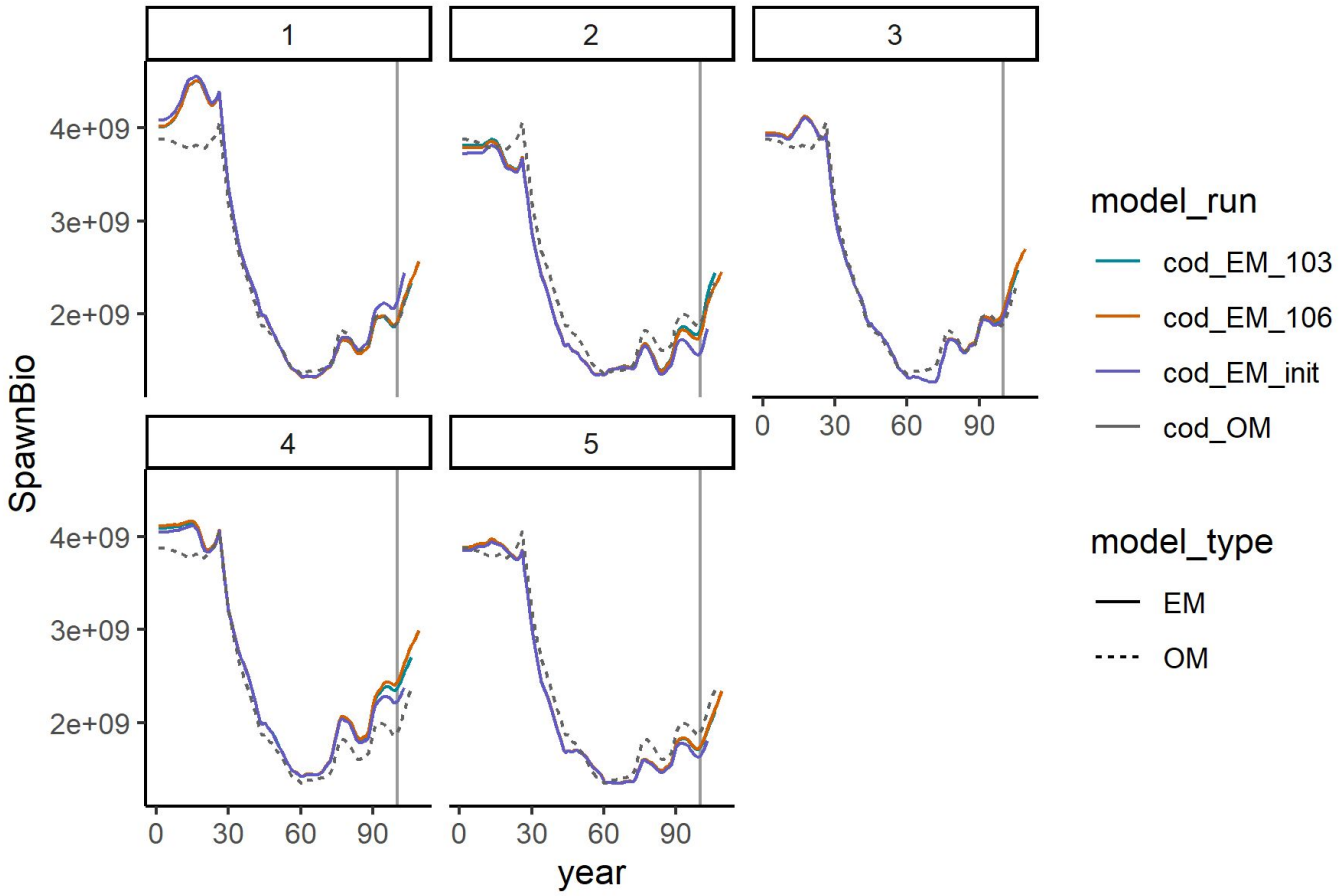
Run 5 iterations

```r
# load packages ----
library(SSMSE) # remotes::install_github("nmfs-fish-tools/SSMSE")

# define data ----
dat_str <- list(
  catch = data.frame(year = 101:106,
                     seas = 1,
                     fleet = 1),
  CPUE = data.frame(year = c(102, 105),
                    seas = 7,
                    index = 2)
)

dat_str_list <- list(dat_str)

# run the MSE loop ----
run_SSMSE(scen_name_vec = "scen_2",
          iter_list = list(1:5),
          OM_name_vec = "cod",
          EM_name_vec = "cod",
          MS_vec = "EM",
          use_SS_boot_vec = TRUE,
          nyrs_vec = 6,
          nyrs_assess_vec = 3,
          rec_dev_pattern = "none",
          impl_error_pattern = "none",
          dat_str_list = dat_str_list)

# summarize results ----
summary_scen <- SSMSE_summary_scen("scen_2")
```



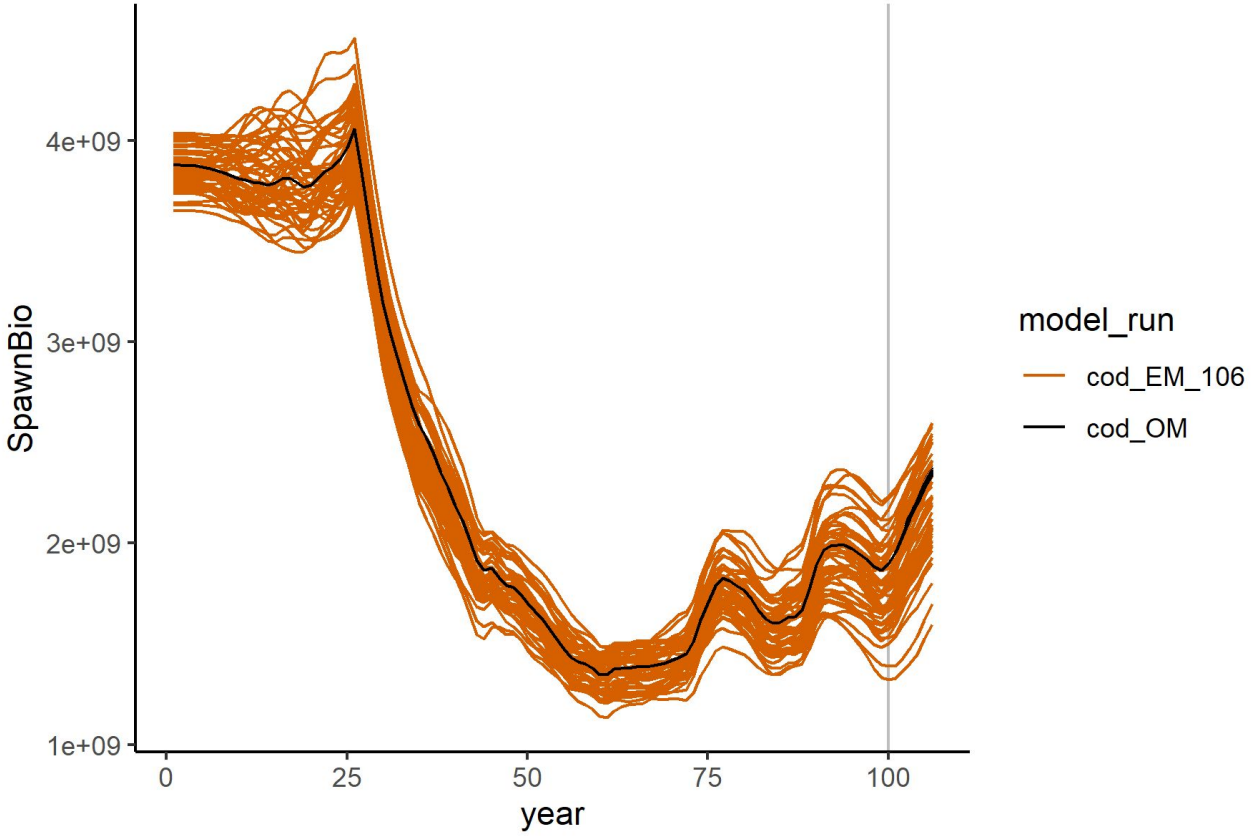
NOAA FISHERIES

EM runs track OM SSB



NOAA FISHERIES

Running 50 iterations shows EM SSB tracks OM



Makes sense given OM and EM are same model with only observation error added

NOAA FISHERIES

Other values summarized

```
# summarize results ----
summary_scen <- SSMSE_summary_scen("scen_2")
```

Time series quantities:

SpawnBio	Recruit_0	F	SPRratio	dev	raw_dev	year	model_run	iteration	scenario
4014310000	149431000	0	0	0.0609357	0.0609357	1	cod_EM_103	1	scen_2
4014310000	150093000	0	0	0.0682381	0.0682381	2	cod_EM_103	1	scen_2
4016820000	150981000	0	0	0.0769295	0.0769295	3	cod_EM_103	1	scen_2
4026120000	152199000	0	0	0.0875334	0.0875334	4	cod_EM_103	1	scen_2
4041640000	153942000	0	0	0.101285	0.101285	5	cod_EM_103	1	scen_2
4062680000	176675000	0	0	0.241209	0.241209	6	cod_EM_103	1	scen_2

Scalar quantities (only showing some):

SSB_MSY	TotYield_MSY	SSB_Unfished	model_run	hessian	iteration	scenario
1389370000	165362000	4014310000	cod_EM_103	FALSE	1	scen_2
1391870000	165661000	4021550000	cod_EM_106	FALSE	1	scen_2
1415400000	168486000	4089610000	cod_EM_init	FALSE	1	scen_2
1342470000	158398000	3878510000	cod_OM	FALSE	1	scen_2
1.32E+09	157333000	3812490000	cod_EM_103	FALSE	2	scen_2
1311790000	156338000	3788730000	cod_EM_106	FALSE	2	scen_2
1290470000	153724000	3726990000	cod_EM_init	FALSE	2	scen_2
1342470000	158398000	3878510000	cod_OM	FALSE	2	scen_2

Thoughts on improving user interaction?

```r
# load packages ----
library(SSMSE) # remotes::install_github("nmfs-fish-tools/SSMSE")

# define data ----
dat_str <- list(
  catch = data.frame(year = 101:106,
                     seas = 1,
                     fleet = 1),
  CPUE = data.frame(year = c(102, 105),
                    seas = 7,
                    index = 2)
)

dat_str_list <- list(dat_str)

# run the MSE loop ----
run_SSMSE(scen_name_vec = "scen_2",
          iter_list = list(1:5),
          OM_name_vec = "cod",
          EM_name_vec = "cod",
          MS_vec = "EM",
          use_SS_boot_vec = TRUE,
          nyrs_vec = 6,
          nyrs_assess_vec = 3,
          rec_dev_pattern = "none",
          impl_error_pattern = "none",
          dat_str_list = dat_str_list)

# summarize results ----
summary_scen <- SSMSE_summary_scen("scen_2")
```


NOAA FISHERIES

R packages and MSE software - what is useful?

1. Are there features you have found helpful when using R packages?
    a. E.g., available on CRAN, ways of interacting with inputs/outputs, ability to make plots?
2. What makes you NOT want to use an R package?
3. What are the biggest struggles you have when conducting MSE analyses? Could these be overcome with better tool features?

We have a limited amount of development time, so which options should be prioritized?

- Creating better sampling from OMs?
- More options for adding uncertainty to OMs?
- Adding more customized management strategy options?
- Summarizing and plotting capabilities?
- Something else?

NOAA FISHERIES

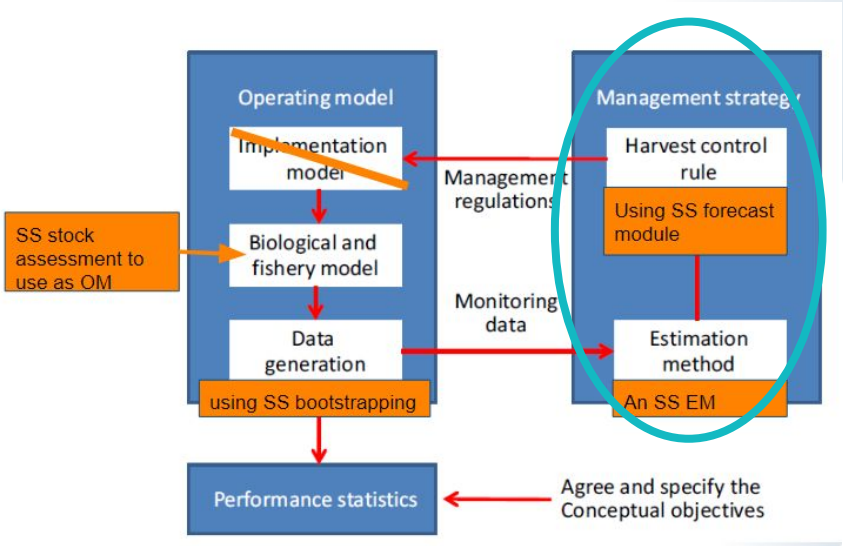
How do we make the output general enough to be useful by many, but specific enough for MSE applications?

- Many different MSE questions (e.g., form and parameterization of harvest control rule, amount/type of data to collect, stock assessment model complexity)
- E.g., performance metrics tend to be numerous and specific
  - Deal with this by making summaries that users can manipulate to calculate their own performance metrics and provide examples in documentation?

NOAA FISHERIES

Management strategy options

- Not all users will want SS as the estimation method or to use SS forecast module.
- Potential solution: provide a generic framework to allow users to program their own estimation method/HCR and plug it into the SSMSE framework.

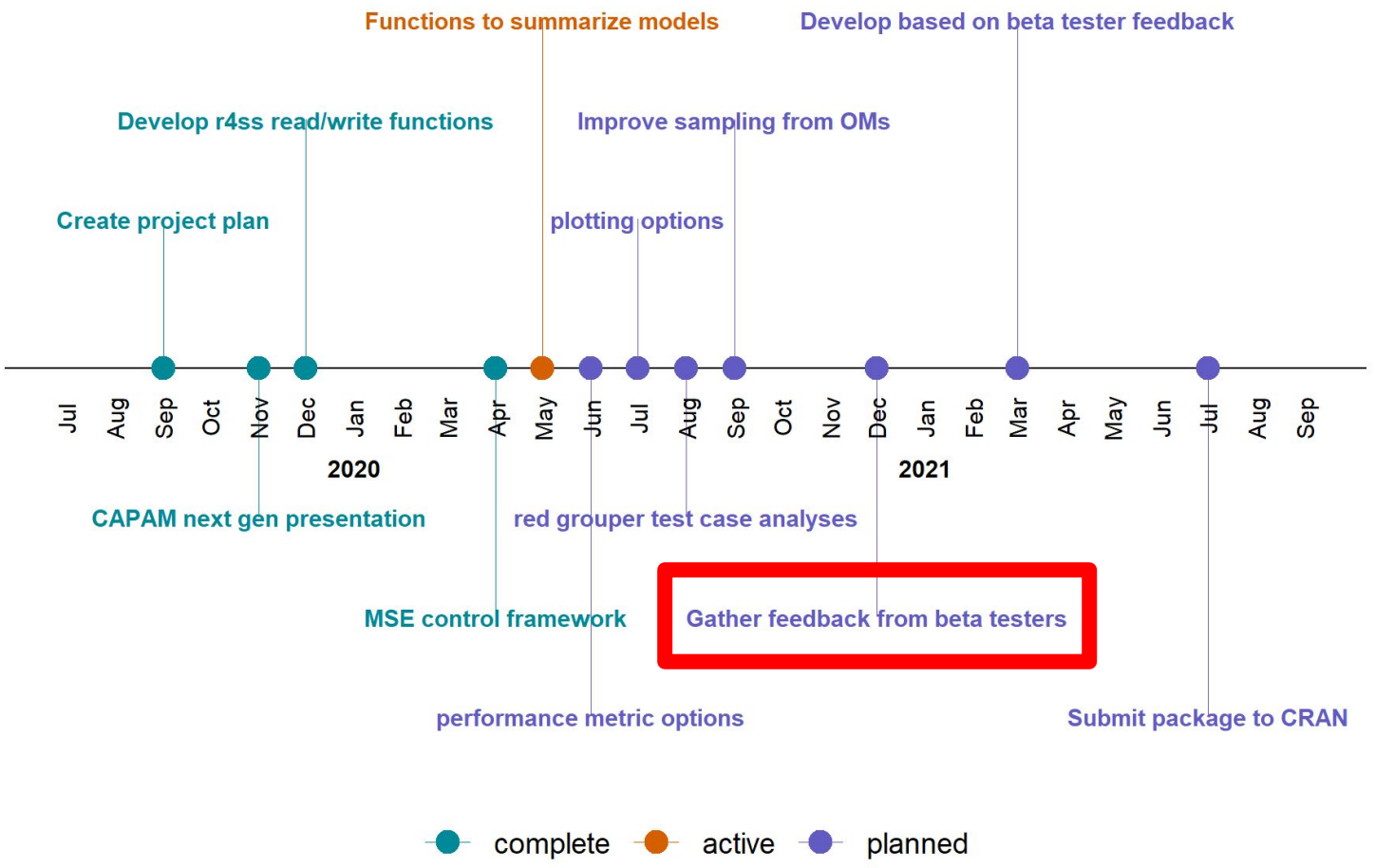


NOAA FISHERIES

Thoughts?

- We have a limited amount of development time, so which options should be prioritized?
- How do we make the output general enough to be useful by many, but specific enough for MSE applications?
- Which management strategy options?

SSMSE next steps



Interested in learning more, contributing to, or using SSMSE? Contact us!

- Via our github repository: github.com/nmfs-fish-tools/SSMSE
- My email: kathryn.doering@noaa.gov
- The Stock Synthesis email address: nmfs.stock.synthesis@noaa.gov
- The Stock Synthesis Forums (now public!): vlab.ncep.noaa.gov/web/stock-synthesis/public-forums

NOAA FISHERIES