Doing Stock Assessment Using ADMB, Stock Synthesis or TMB? A Case Study on the Queensland Saucer Scallop

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My background in doing stock assessment

Start from June 2016 …

Provided by Mark Mclennan (DAF

General background

- The Queensland Government sets "Queensland Sustainable Fisheries Strategy 2017-2027" to reform fisheries management.

- Expect sustainable catch limits based on MEY (about 60%) by 2027.

- Management focuses on evidence-based decisions.

- So, stock assessment plays a crucial role in the strategy.

- There are at lease 28 key species in initial high priorities.

- Need accessible, repeatable and swift stock assessment processes.

- Hence, the Queensland Department of Agriculture and Fisheries (DAF) organized a Stock Synthesis workshop in August 2019.

- One week before that, I attended a TMB workshop hosted by CSIRO.

Team

- Michael F. O'Neill (DAF, Queensland)

- Joanne Wortmann (DAF, Queensland)

- Anthony J. Courtney (DAF, Queensland)

- Matthew J. Campbell (DAF, Queensland)

- George M. Leigh (DAF, Queensland)

- Jerzy A. Filar (CARM, The University of Queensland)

Tasks

- Use Stock Synthesis (i.e., general model) doing stock assessment for Queensland saucer scallop.

- Compare the outputs of ADMB and TMB under the same stock structure.

Outline

- Very briefly introduction to ADMB, TMB and Stock Synthesis.

- General description of the scallop data.

- Fit "the scallop data" to Stock Synthesis.

- Fit the custom stock model to the scallop data using ADMB and TMB.

- Summary

ADMB, TMB and Stock Synthesis

ADMB
- A C++ based template.
- Automatic differentiation (AD).
- Use the Laplace approximation for models with random effects.
- User interface: command-line (cmd or terminal)
- …

Stock Synthesis
- A general model software.
- The current version is based on ADMB.
- User interface: command-line or GUI.
- R package "r4ss" summarises the outputs.
- …

TMB
- An R package.
- A C++ template for AD.
- The Laplace approximation (random effects).
- Provide parallel user templates.
- User interface: R
- …

Flowchart of using ADMB, TMB and Stock Synthesis

ADMB and TMB	Stock Synthesis

Data (fishing, survey, changes of fishery management information, etc.)

Data (fishing, survey, changes of fishery management information, etc.)
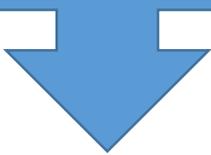
Design models accordingly
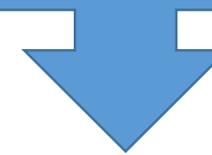
Find models using most of data

Validate and/or finalize the models

Validate and/or finalize the models

Scallop fishery

Fishing history

- Commenced 1950s
- Compulsory logbooks in 1988
- Spatial closures introduced in 1997
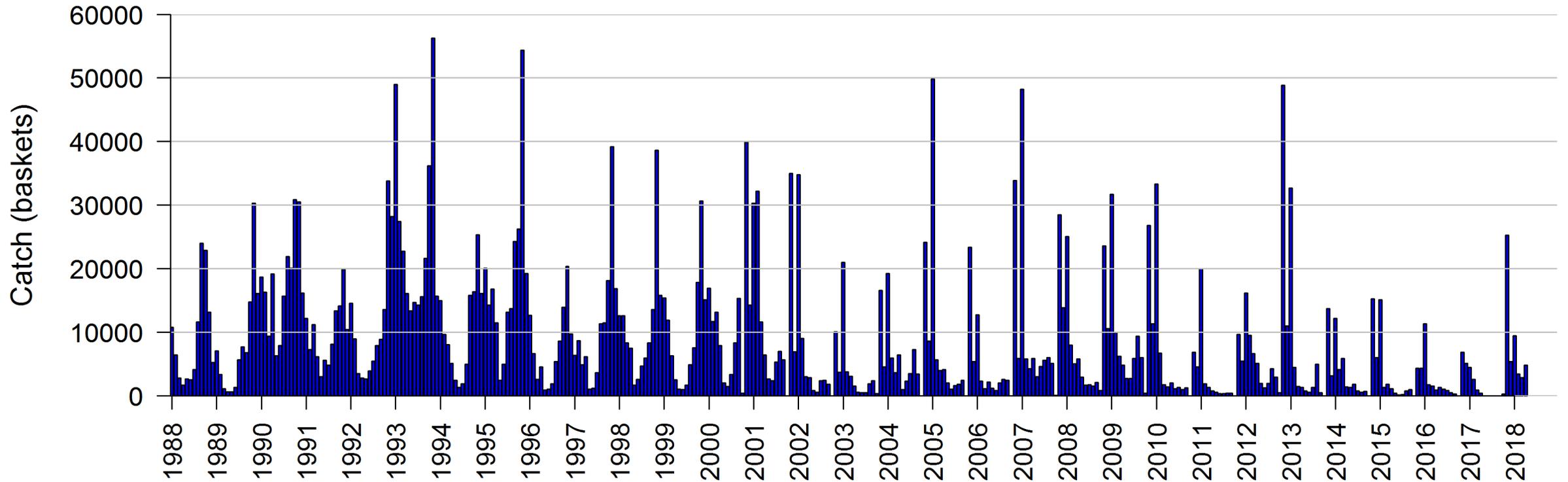- Minimum legal size limits (changes over time)

Saucer scallop biology

- ½ mature at 11 months age
- All mature at 18 month age
- ¾ mature at 90 mm shell height
- Spawn April to Oct
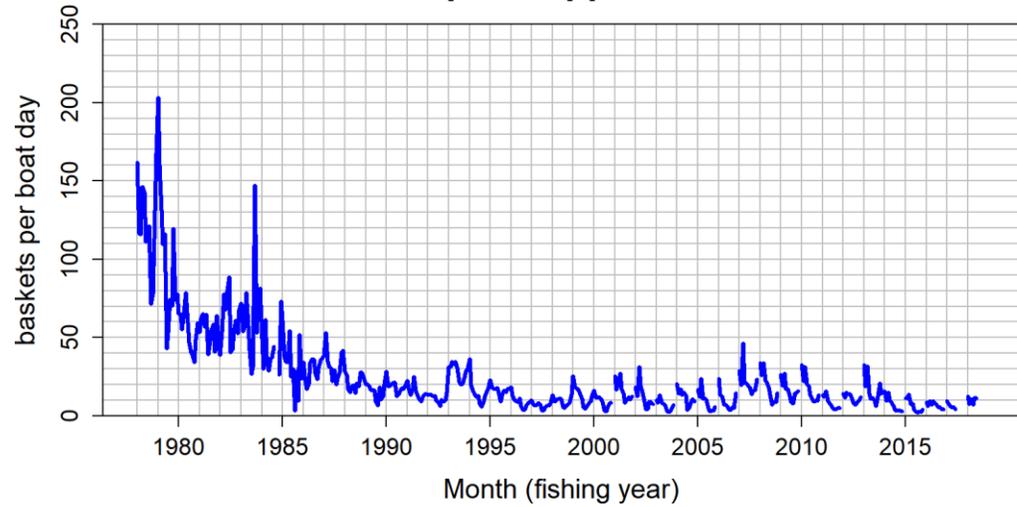- Can live for 4+ years
- Can grow up to 120 mm
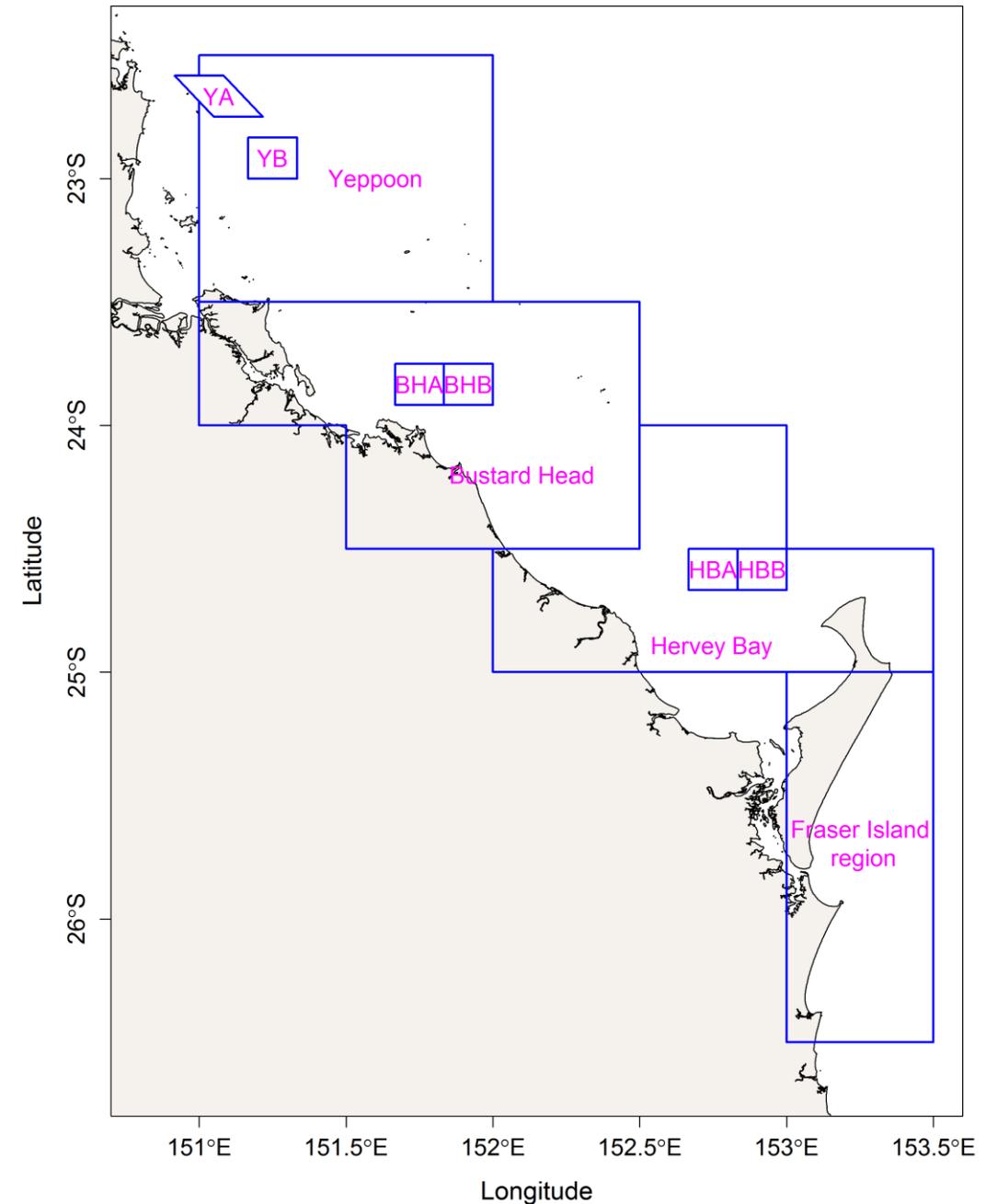
Harvest (logbooks)
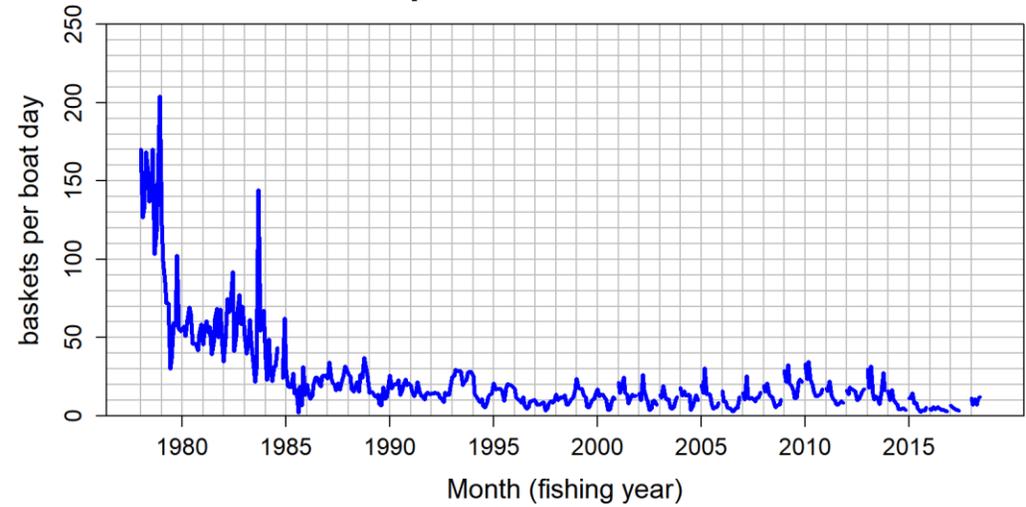

Logbook scallop monthly landing (22-28° S)
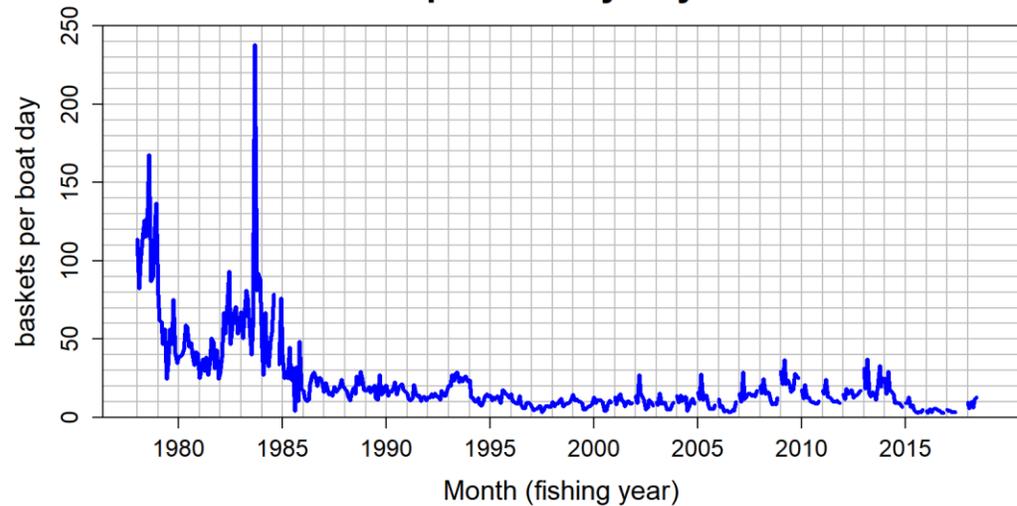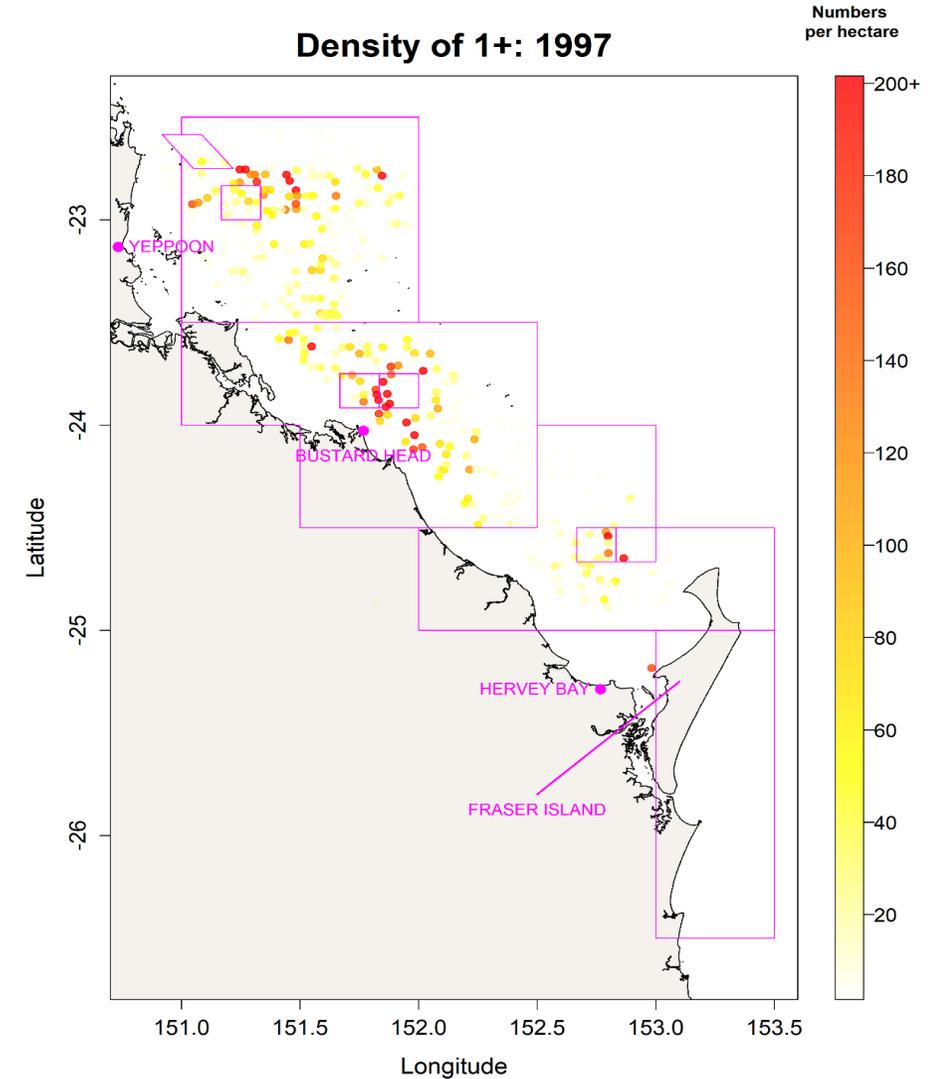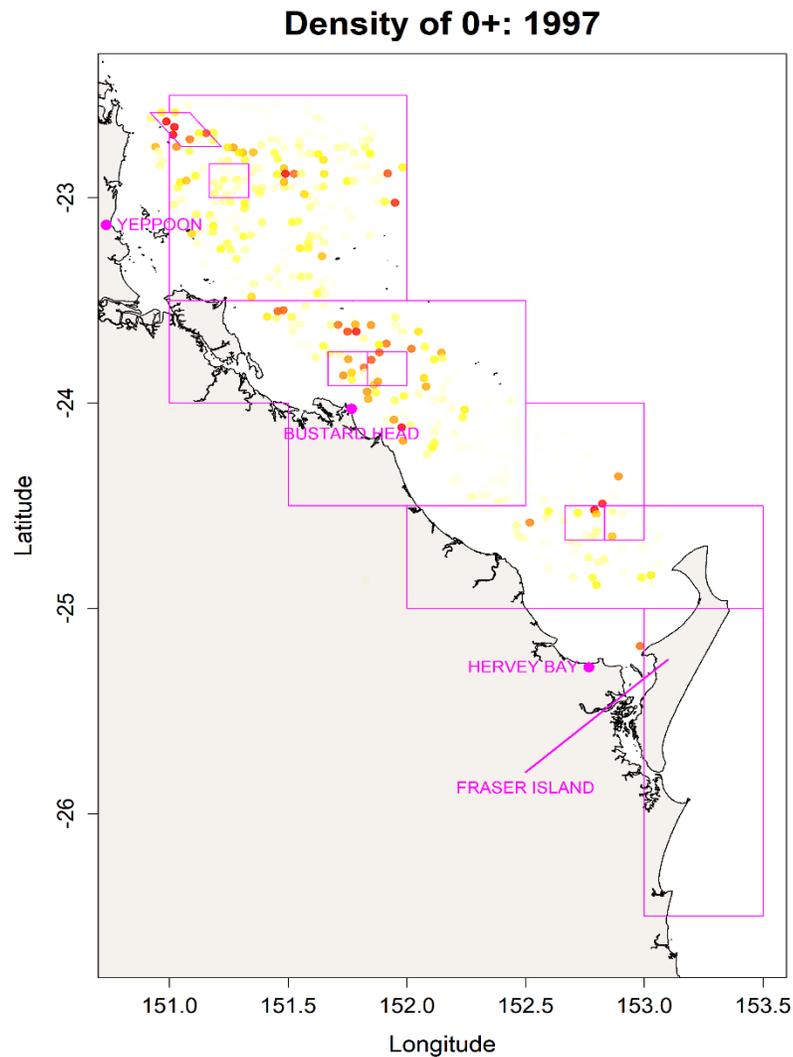
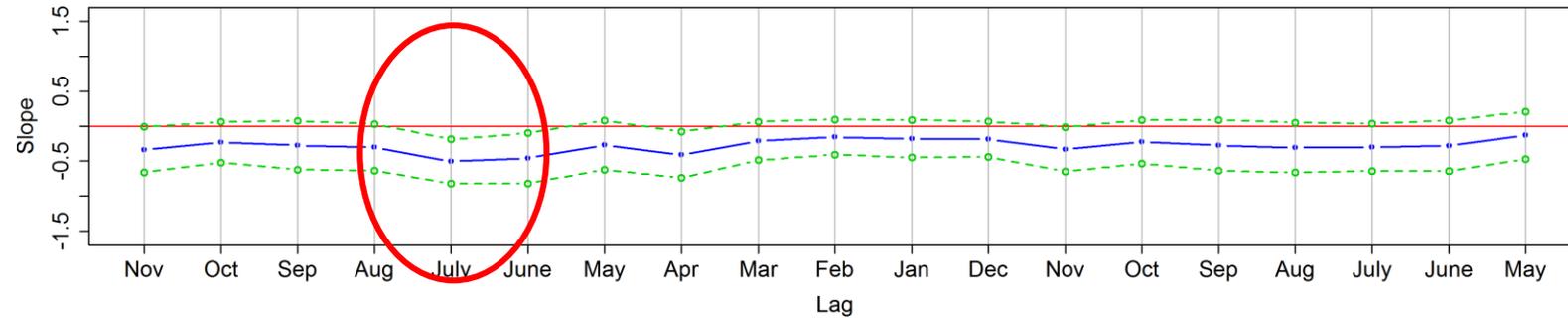# Standardised catch rates (1978-2018)
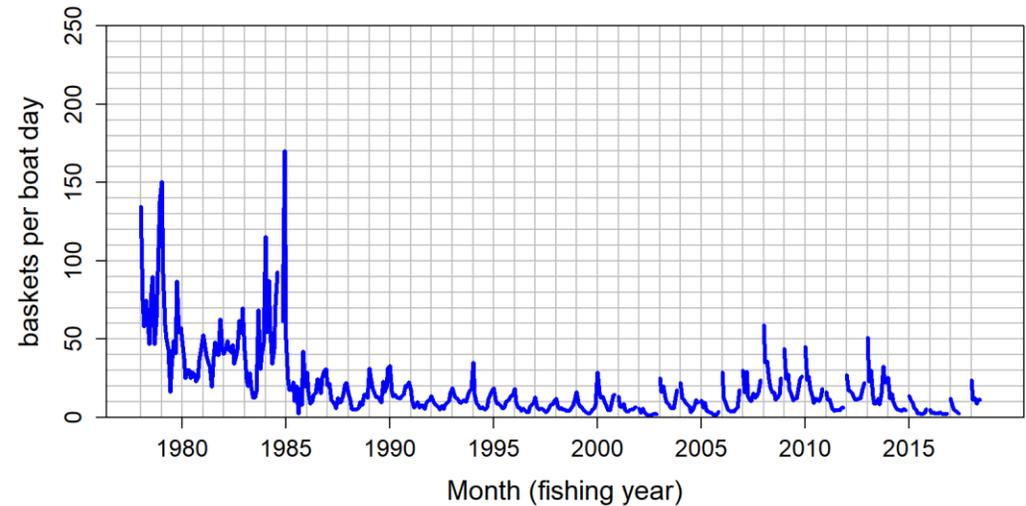
Scallop Density Data

- Scallop survey:
  - Month: October
  - Years: 1997-2006, 2017-2018

- 2001-2006 on SRAs

- Fraser Island: 2017-2018

- Two classes:
  - 0+ (<78 mm shell height)
  - 1+ (≥78 mm shell height)
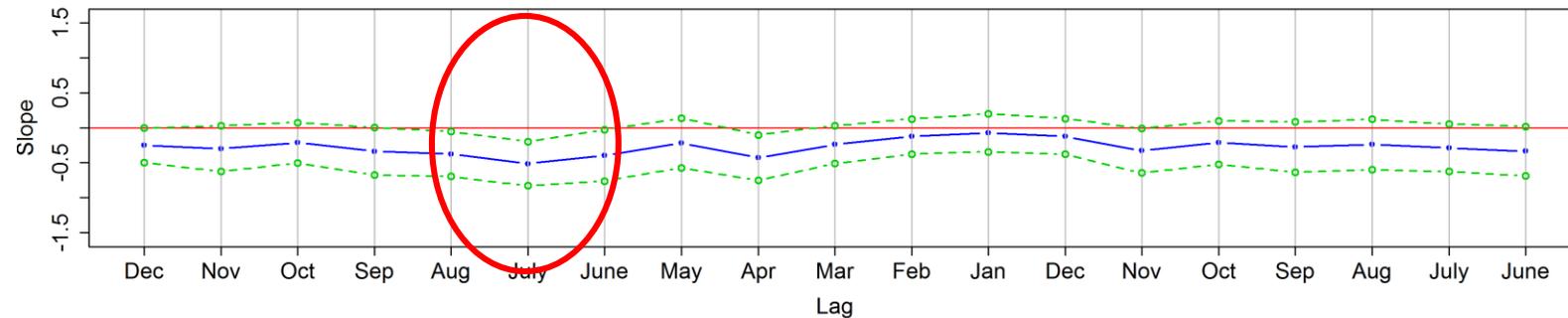
Standardised catch rate and SST
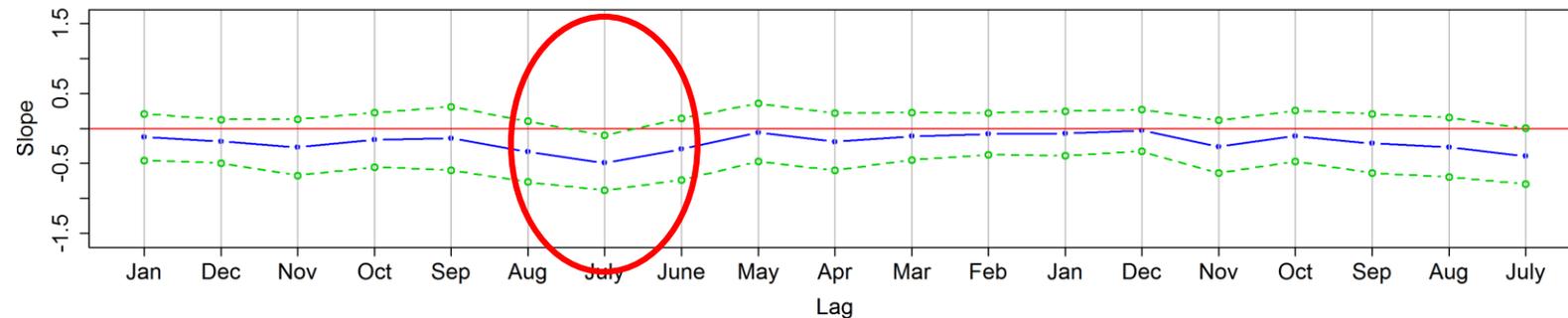
- Slope represents relationship between standardised catch rates and SST.

- Estimates of slope represent in blue.

- 95% confidences interval represent in green.

- All estimates of slope are negative values.

- Indicate SST influences standardised catch rate negatively.

- Specifically, SST of June, July and August.
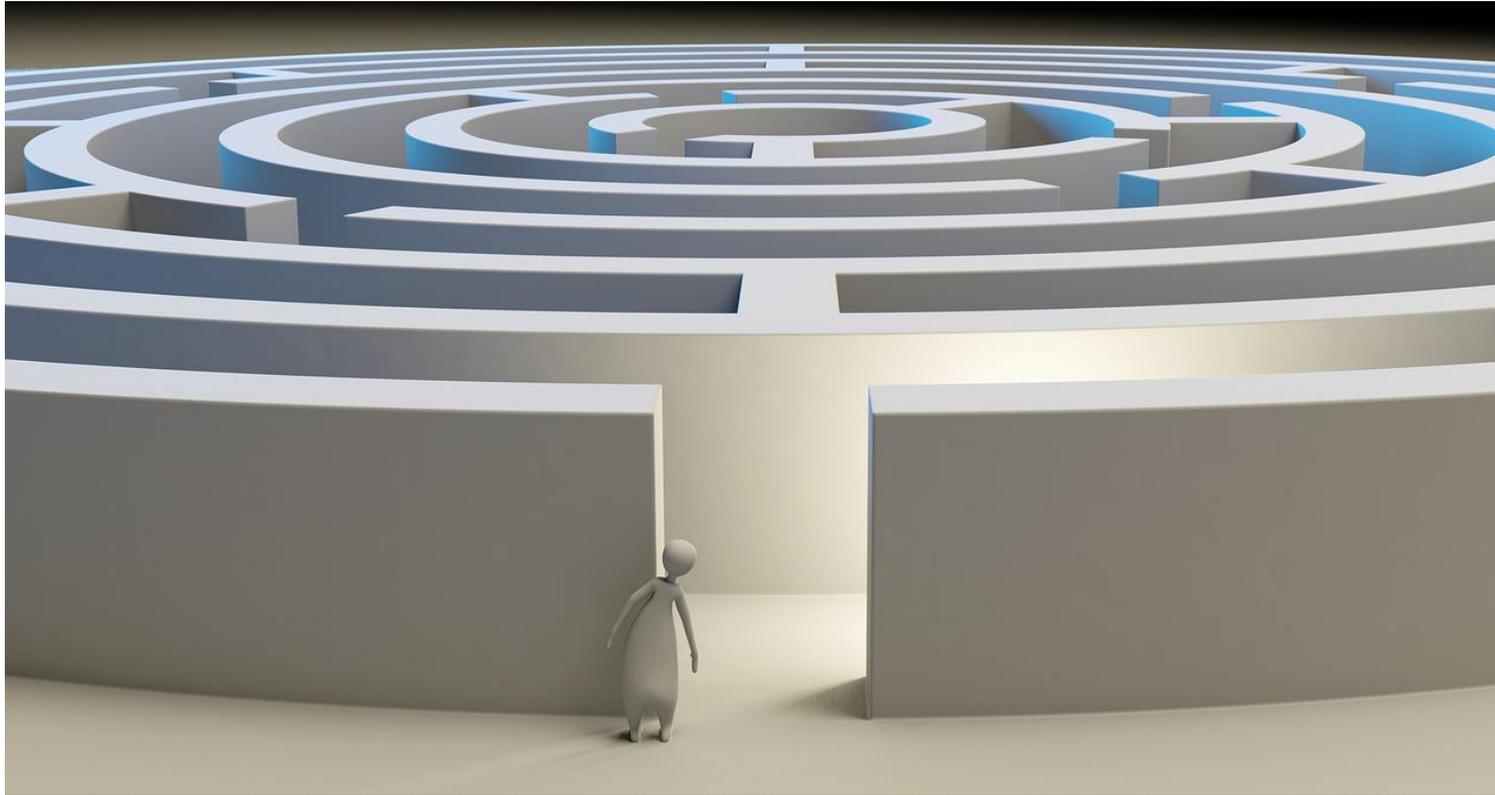
Let's use Stock Synthesis.

(source: https://pixabay.com)

Preparing input files: Stock Synthesis

- Major four input files:
  - starter.ss
  - data.ss (structure is complicated.)

```
C:\D\research\scallop\Wen-Hsi02\population_model\codes\StockSynthesis\case01\ss_
Error trying to open data input file ss.dat
 reading from STARTER.SS
 reading from data file
Data read sucessful 999

 reading forecast file
 reading from control file
If you see 999, we got to the end of the control file successfully! 999
 end of parameter section
Error: param_init_bounded_number_vector was not allocated.
terminate called after throwing an instance of 'std::bad_alloc'
  what():  std::bad_alloc
```
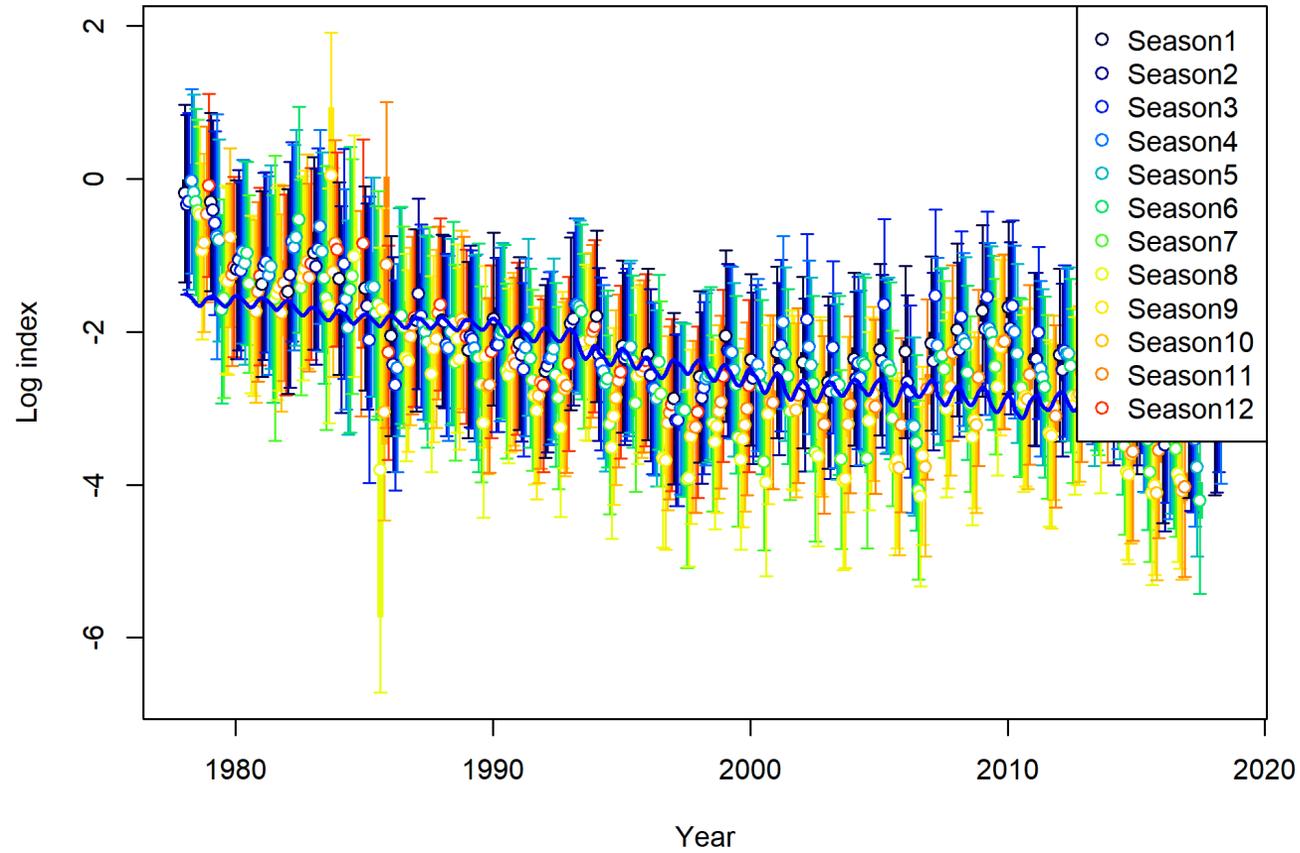
(source: http://drlorraine.net)

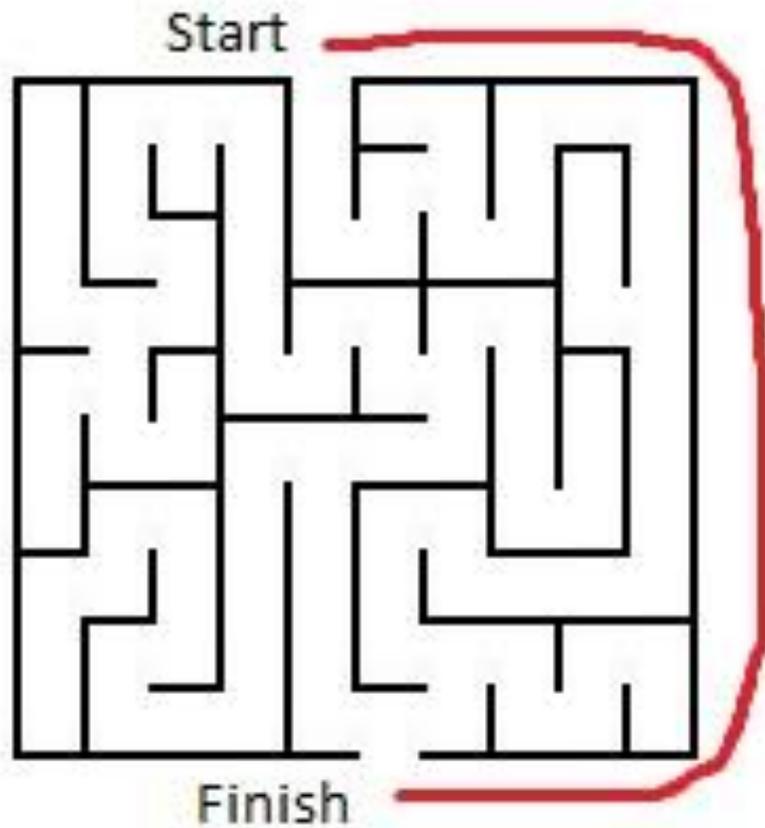- What can I do and use?
  - Monthly, 48 months and spatial analysis.
  - Units: baskets to meat weight, density (numbers per hectare).
  - 0+ and 1+ age class density data.
  - Various minimum legal size managements.
  - Implement the Winter SST.

R package "r4ss"

"R4ss"
is
fantastic!

Let's use ADMB and TMB.

(source: https://bestandworstever.blogspot.com/2013/01/worst-maze-cheating-ever.html)

Preparing input files: ADMB and TMB

- Need to write codes of the designed stock models fit to the data (Different from the use of Stock Synthesis).

- Input files

ADMB	TPL (model's C++ code), DAT and PIN files
TMB	An CPP (model's C++ code) file and R scrips. Importantly, R package "TMB" installed.

- In my experience, if you have an ADMB code, you can translate it to TMB easily.

- Of course, there are some subtle differences. In TMB, for example, the index of vector or matrix starts from 0.

- I also prepare an R script of the model to make sure ADMB and TMB do what I want to do.

Comparison

- No R4ss! You summarise the output by yourself.

- TMB deals with "random effects" more efficiently and economically.

- Parameter estimates
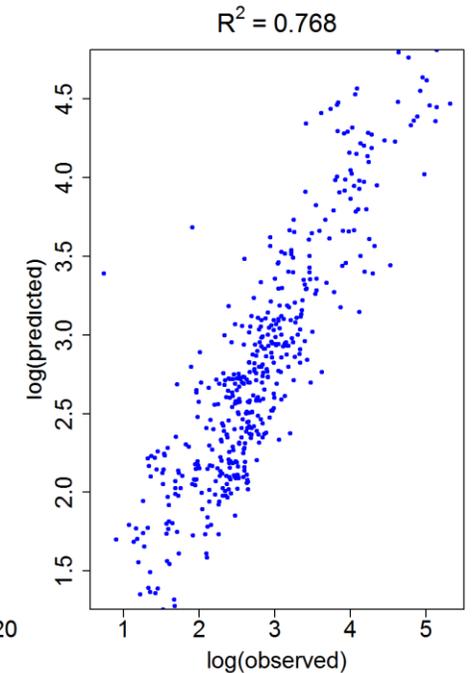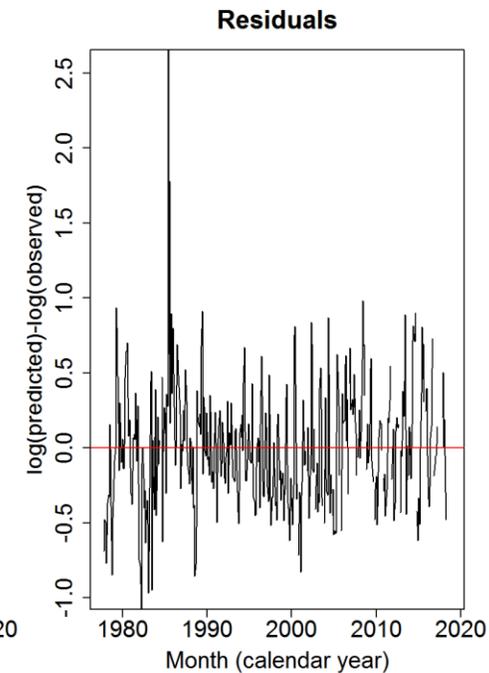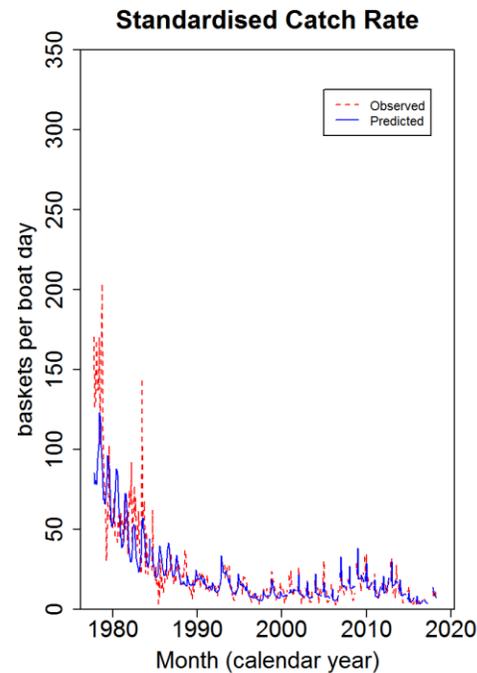
	ADMB	TMB	TMB (random)
h (steepness)	0.22 (lower bound)	0.51 (0.31)	0.49 (0.30)
SST effects	-0.60 (0.02)	-0.38 (0.07)	-0.37 (0.07)

- More investigation is needed (for myself)!

Summary

- Should the next generation model be coded by stock assessment scientists or professionally trained computer programmers?

- How can we ensure that with all the desired features included the code remain computationally efficient for models that don't use the more computationally demanding features?

- Is there a coding standard that is appropriate for the development of the next generation model?

- Is there a way to easily allow the addition of new features?

Thank you.

References

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