Science, Service, Stewardship

The impact of changes in natural mortality on the performance of management strategies for the Gulf of Alaska walleye pollock (*Gadus chalcogrammus*) fishery

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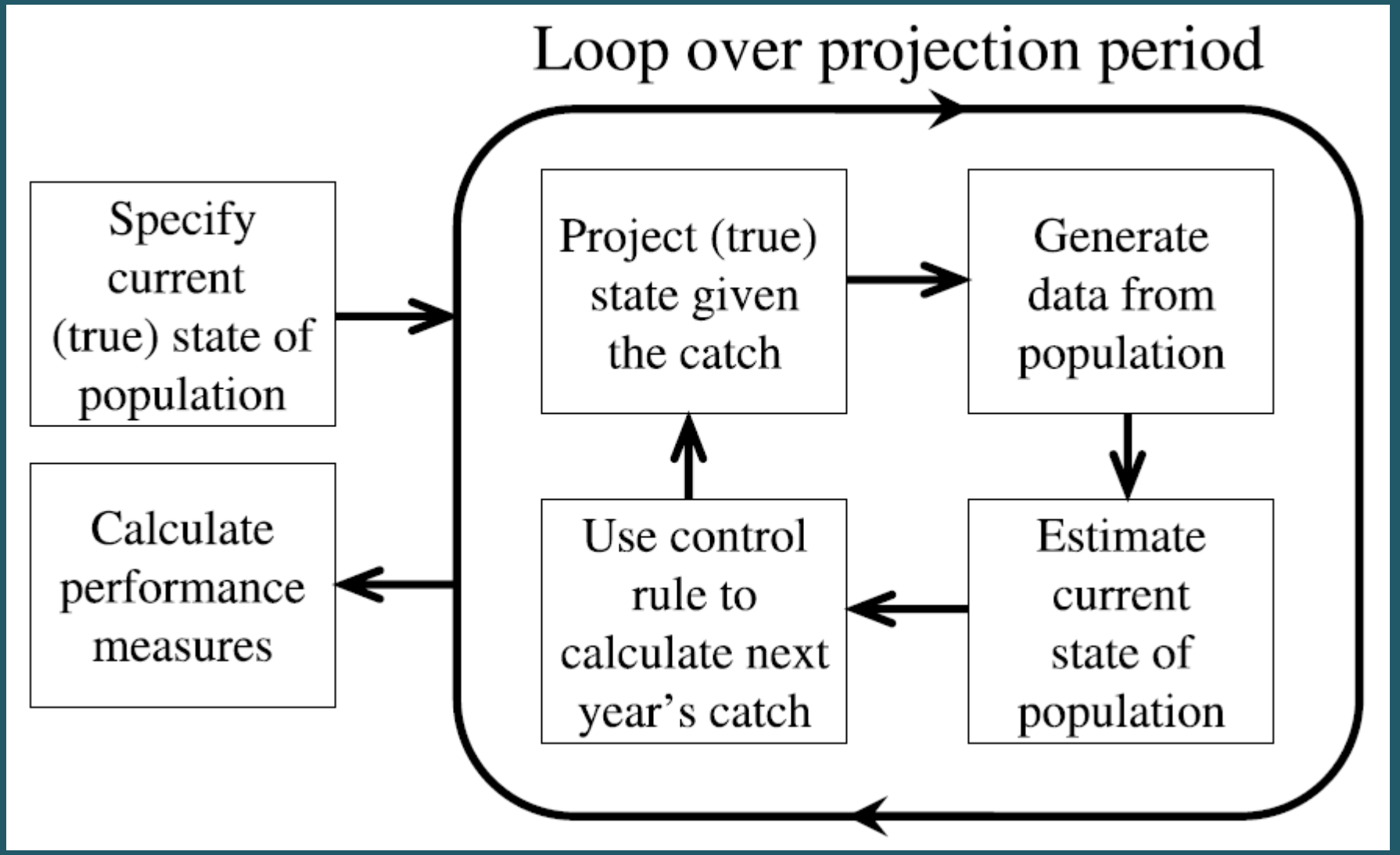
NOAA FISHERIES SERVICE

Management strategy evaluation

- How robust is the harvest control rule to
  - Process and observation error
  - Implementation error
  - Model misspecification
  - Regime shifts
  - Climate variability
  - Ecosystem impacts
  - Other influences


Loop over projection period
Specify current (true) state of population
Calculate performance measures
Project (true) state given the catch
Generate data from population
Use control rule to calculate next year's catch
Estimate current state of population

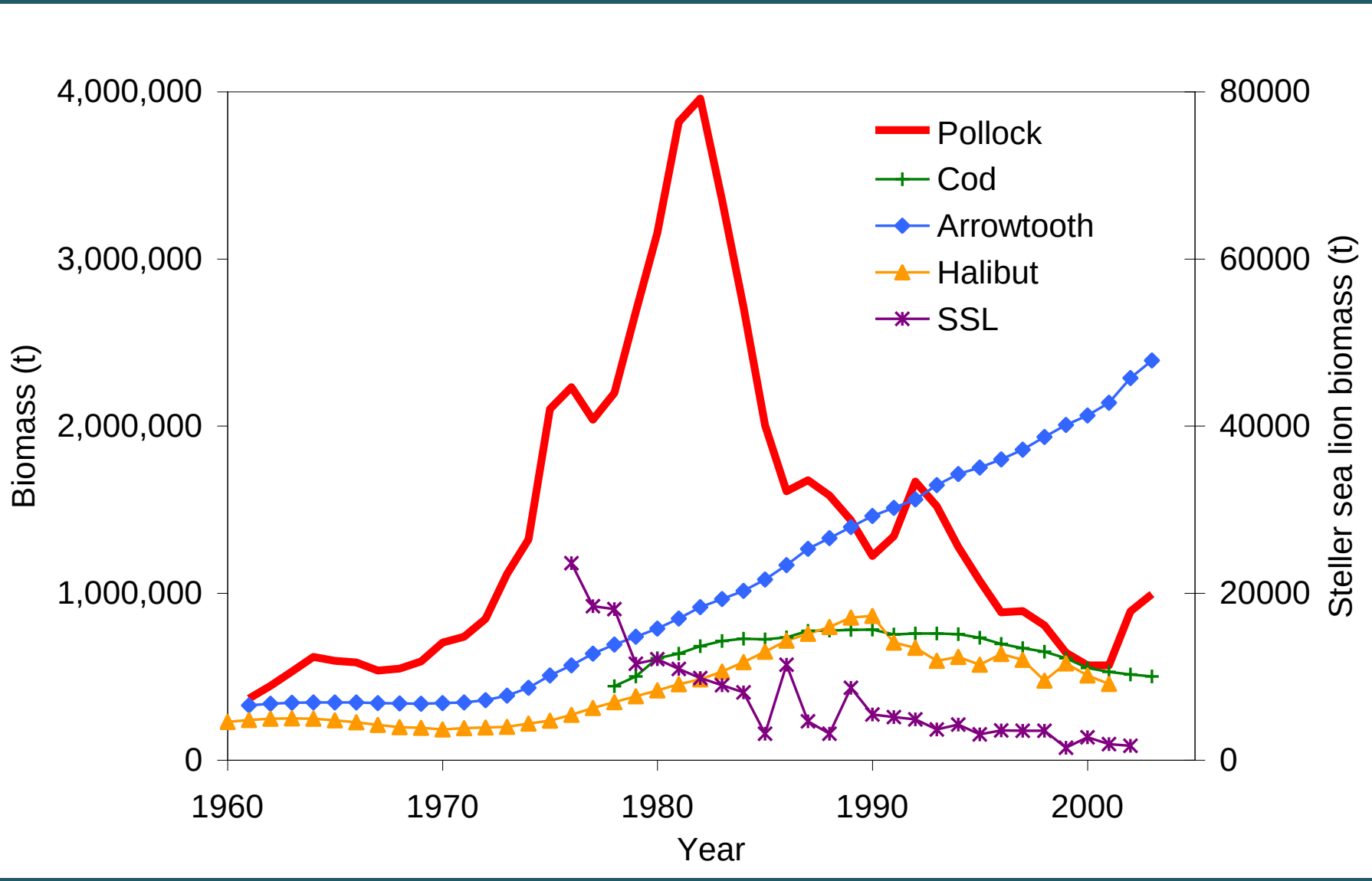
Previous MSE results

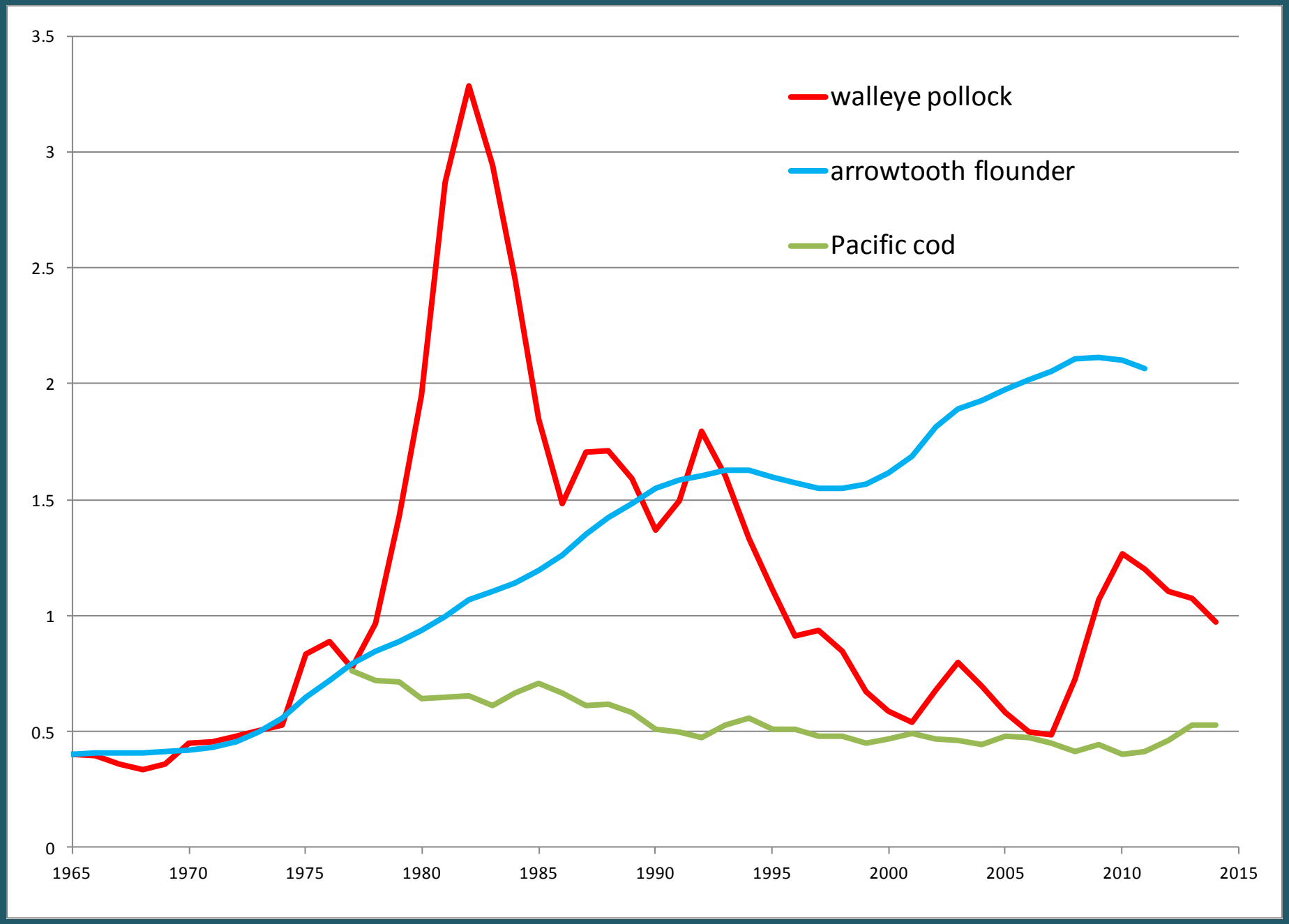
- Median bias of -10% for spawning biomass
- Median bias of 10% for fishing mortality
- Median bias of -10% for ABC

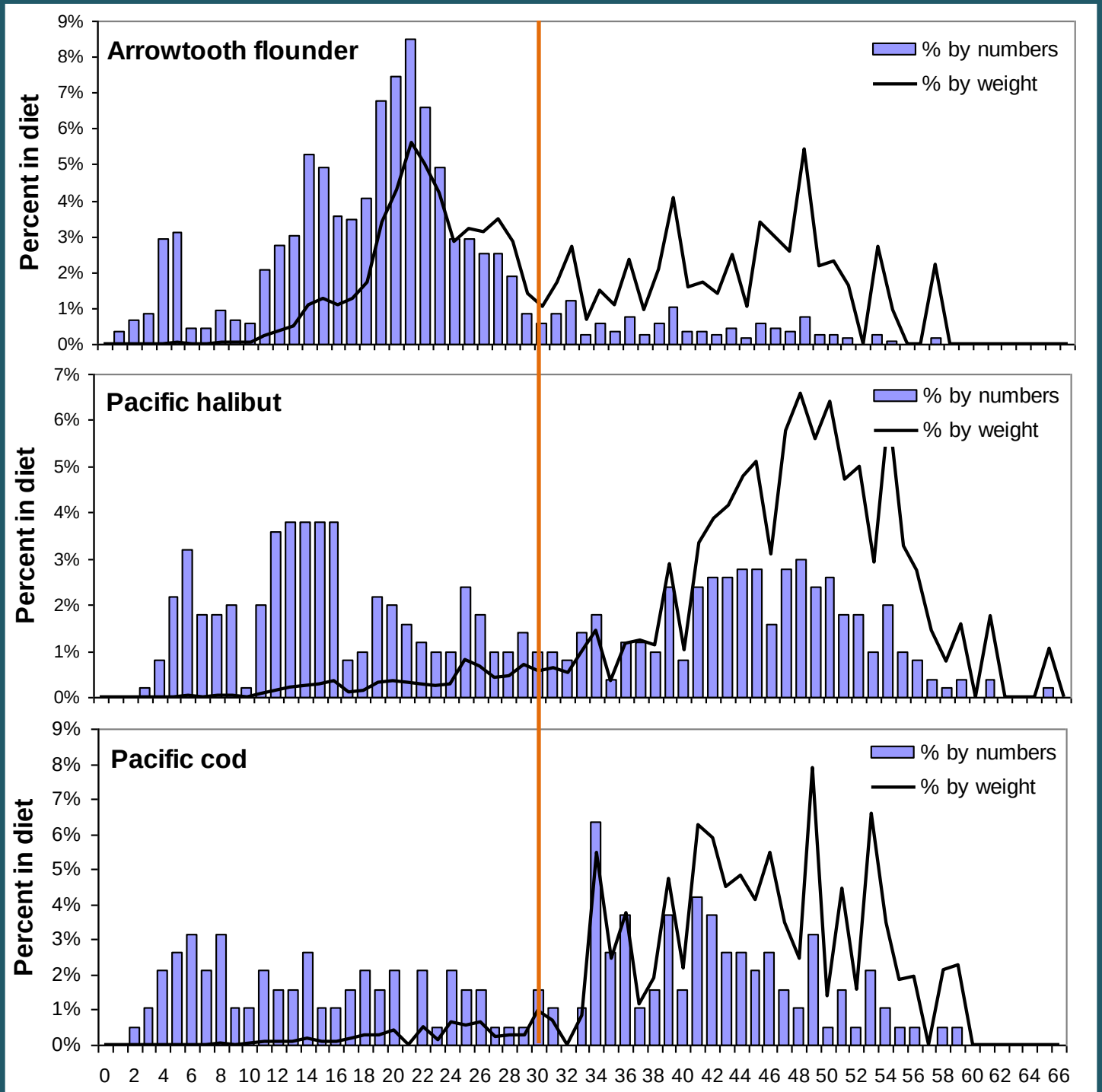
- The current harvest control rule is robust to many sources of error and uncertainty
- But including 3 primary predators as ‘fisheries’ did not work well

Motivation for this work

- Changes to the stock assessment model
  - Age range
  - Independent survey selectivity for age-1 fish
- Arrowtooth flounder are still increasing
- M is assumed to be 0.3 for all ages


4,000,000
3,000,000
2,000,000
1,000,000
0
Biomass (t)
80000
60000
40000
20000
0
Steller sea lion biomass (t)
1960
1970
1980
1990
2000
Year
Pollock
Cod
Arrowtooth
Halibut
SSL


walleye pollock
arrowtooth flounder
Pacific cod
3.5
3
2.5
2
1.5
1
0.5
0
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015


Arrowtooth flounder
% by numbers
% by weight
Percent in diet
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
Pacific halibut
% by numbers
% by weight
Percent in diet
7%
6%
5%
4%
3%
2%
1%
0%
Pacific cod
% by numbers
% by weight
Percent in diet
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66

Scenarios

- 30-year projection period, 2014 – 2043
- Maximum value of M-at-age
  - Age-1 M of 0.7
  - Age-1 M of 1.0
  - Age-1 M of 1.0, age-2 M of 0.7
  - Age-1 M of 1.0, age-2 M of 0.7, age-3 M of 0.5
- 3 patterns in changing M-at-age
  - Increase linearly to max from year 1 through 30
  - Increase linearly to max from year 11 through 20
  - Step increase to max in year 16
- 2 ways of generating future recruits

Performance measures

- 'True' spawning biomass
- Percent relative error in
  - Spawning biomass
  - Fishing mortality
  - ABC
  - % relative error = 100 * (est – 'true') / 'true'
- Percent when 'true' F > 'true' F_{OFL} (overfishing)

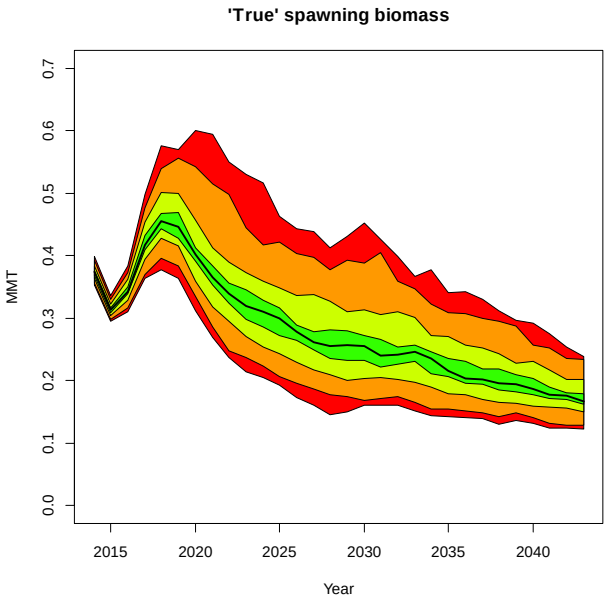
Results for simpler scenarios

Performance measure	Base scenarios	Max age-1 M of 0.7	Max age-1 M of 1.0
Median bias in spawning biomass	-10% to -15%	Increases from -15% to -10%	Increases from -15% to -5%
Median bias in fishing mortality	10% to 15%	Decreases from 10% to almost 0%	Decreases from 10% to less than 0%
Median bias in ABC	-10% to -15%	Increases from -20% to -10%	Increases from -20% to almost 0%
Overfishing	Maximum of less than 5%	Maximum of less than 5%	Maximum of less than 10%
Rec 1977 on vs. Rec 1980 on	No significant differences	No significant differences	No significant differences
		No differences among the scenarios	Slight differences among the scenarios

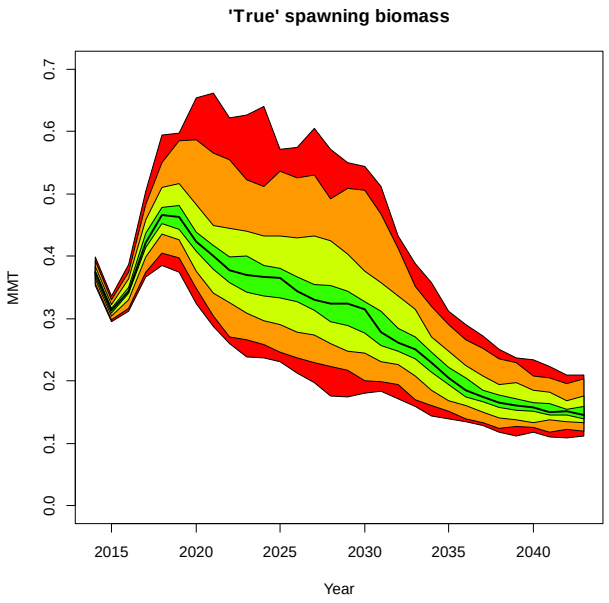
Max age-1 M of 1.0 and age-2 M of 0.7

- More significant differences between increasing M linearly over the 30-year projection period and increasing M more rapidly
- No significant differences in bias with the 2 ways of generating future recruits

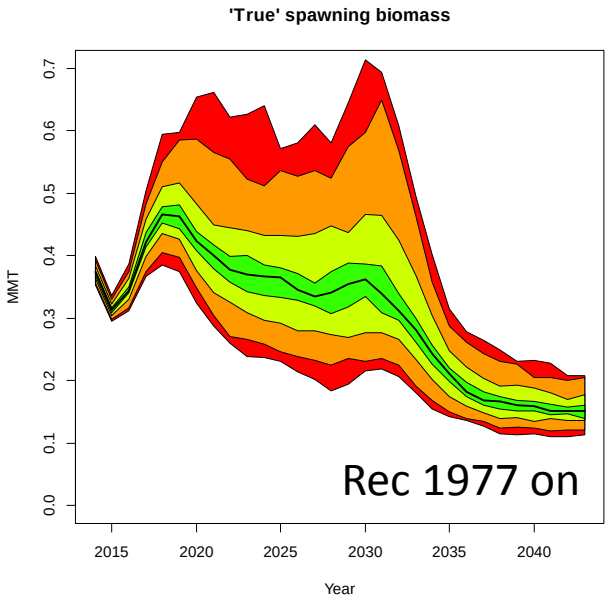
01 – 30 linear ramp up

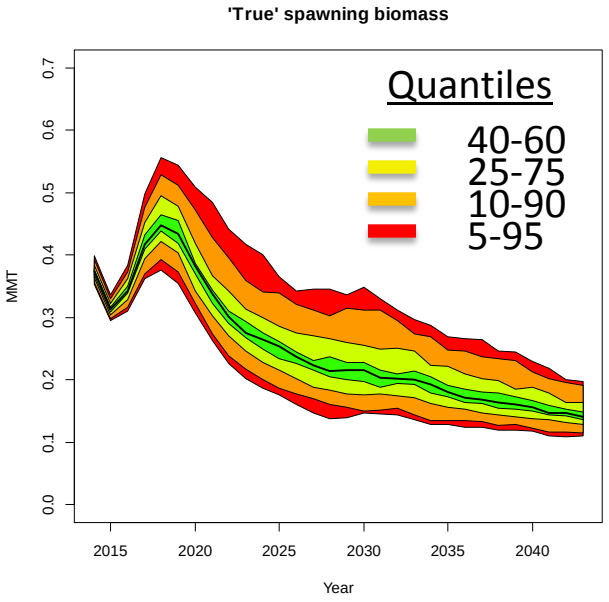


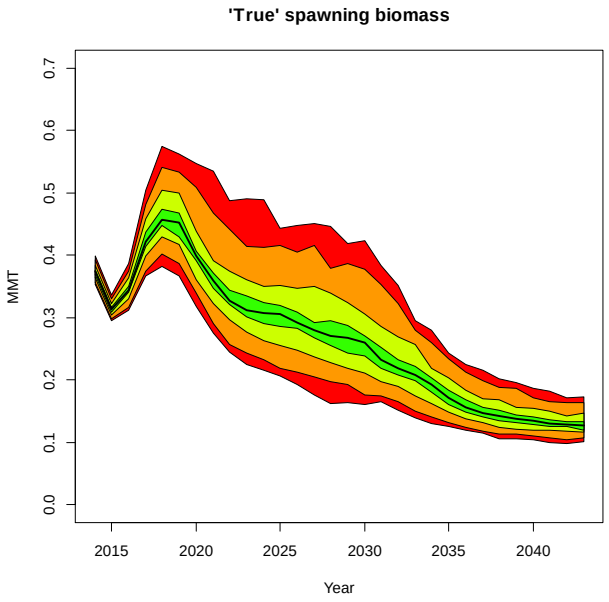
11 – 20 linear ramp up

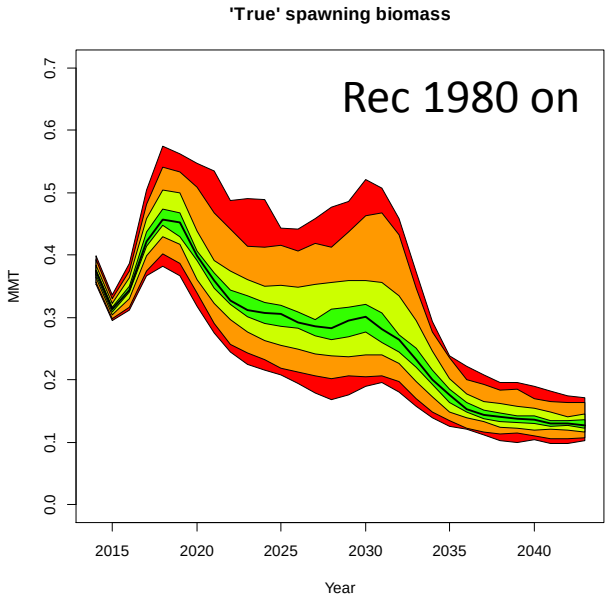


16 step increase





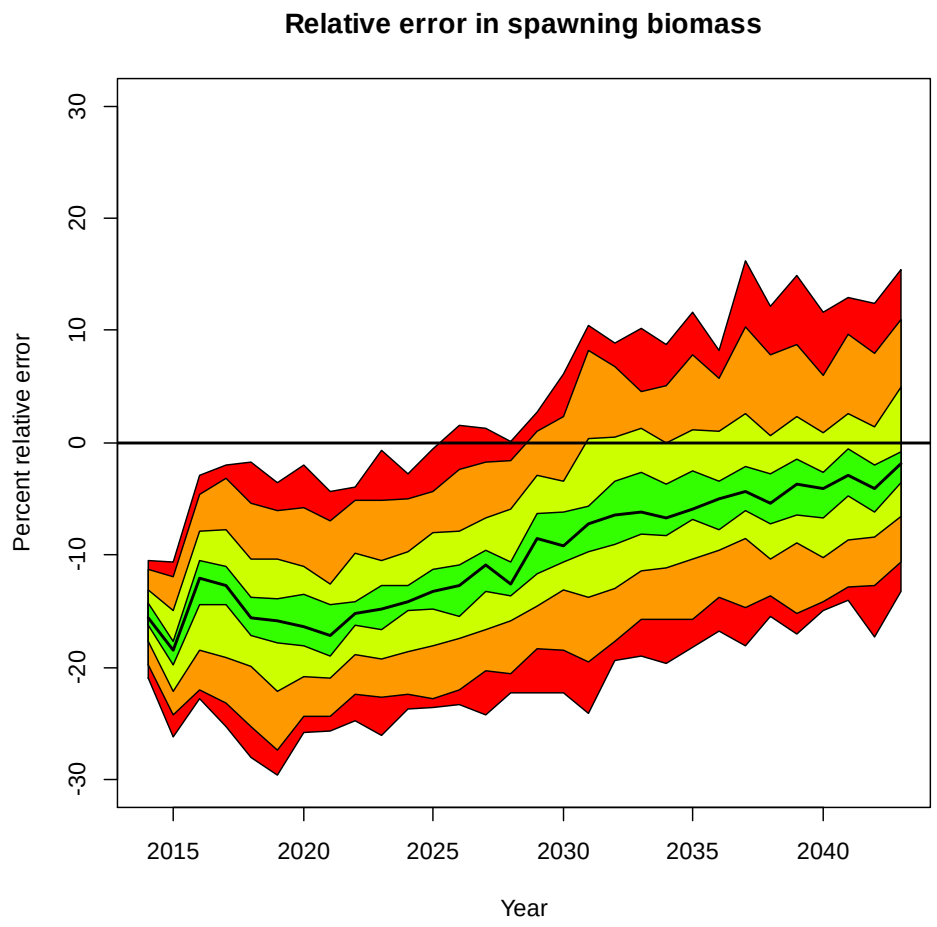


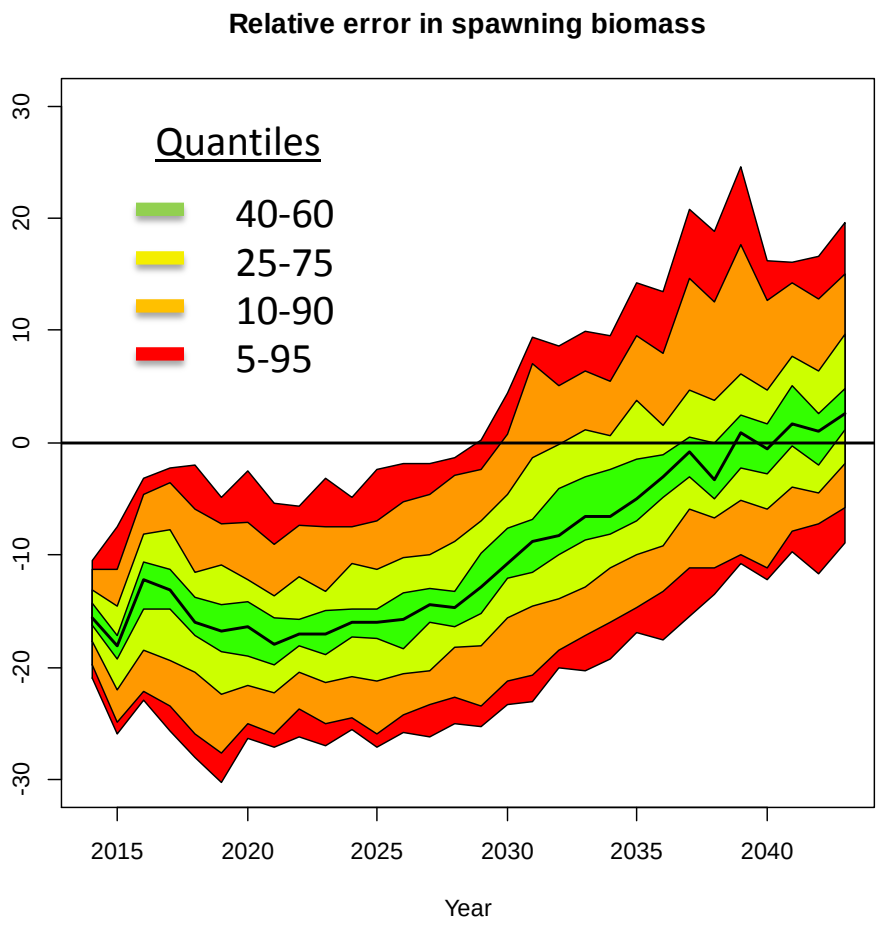


Relative error in spawning biomass

01 – 30 linear ramp up

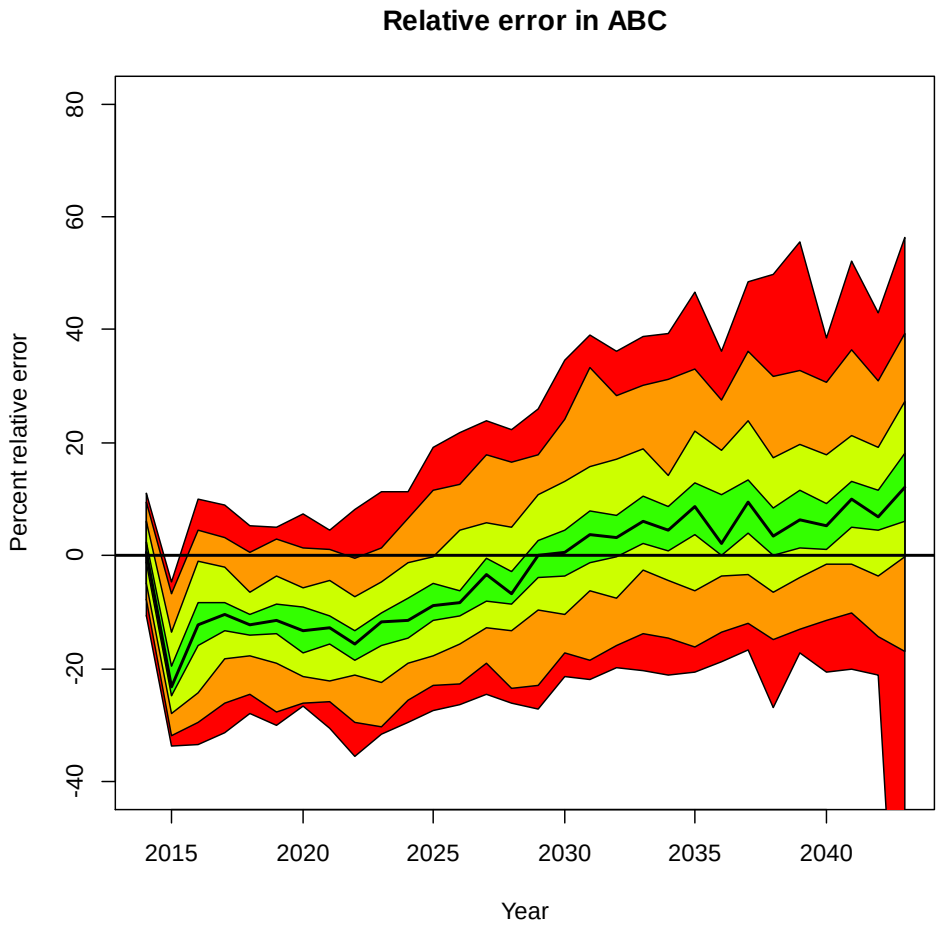
11 – 20 linear ramp up



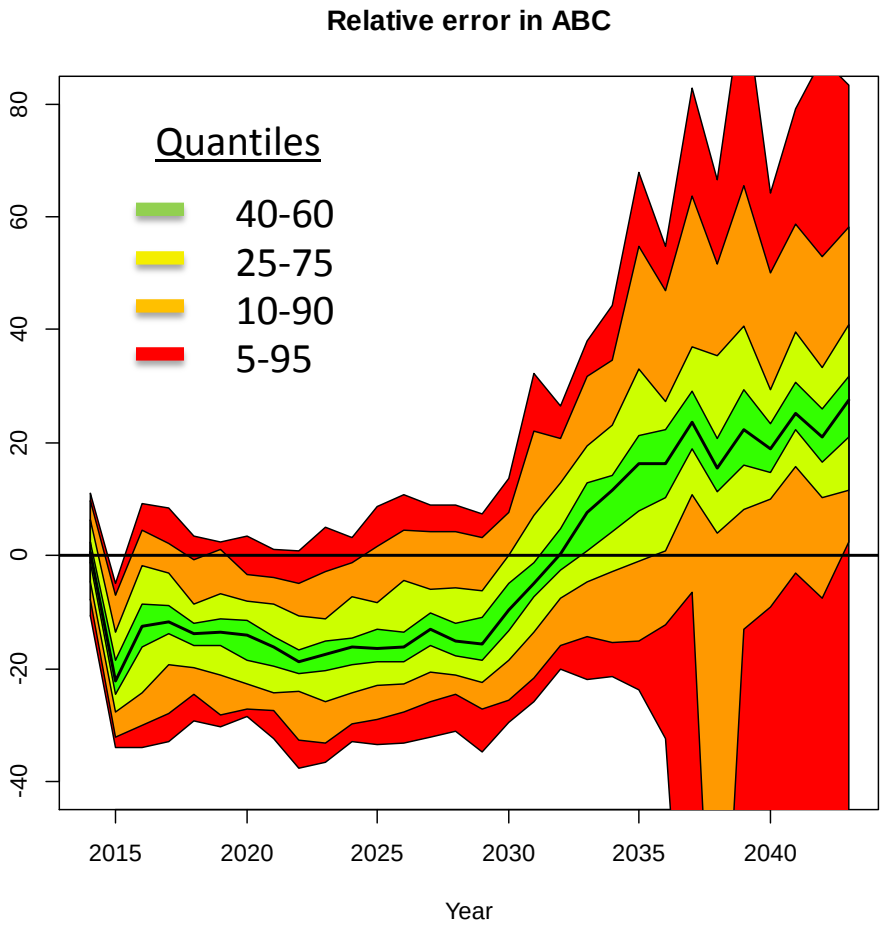


Relative error in ABC

01 – 30 linear ramp up

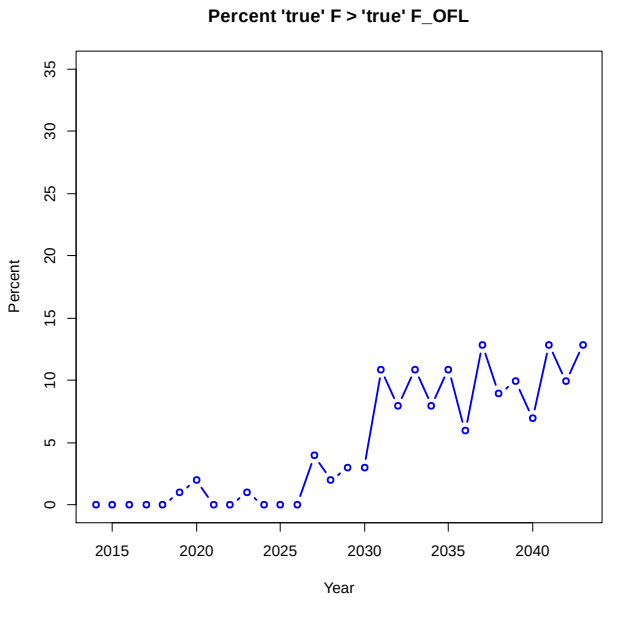


16 step increase

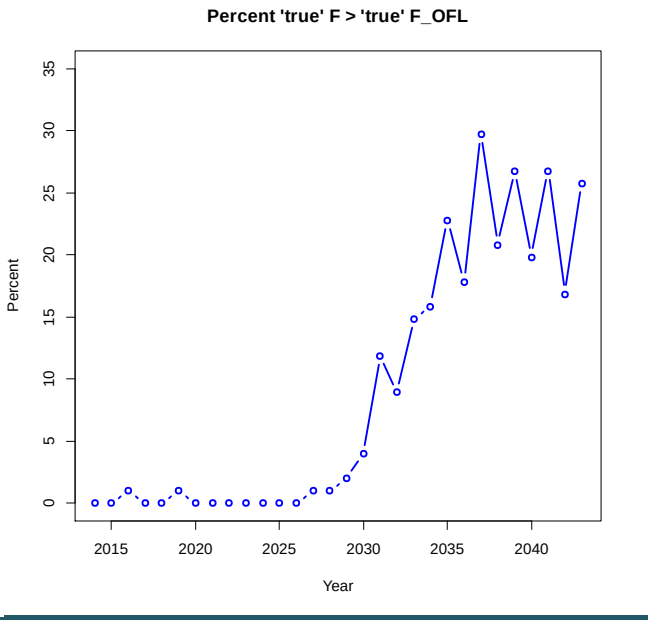


Overfishing

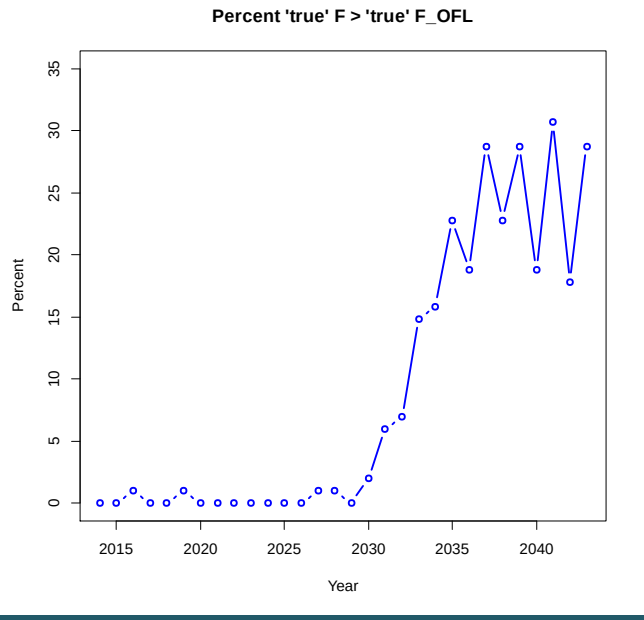
01 – 30 linear ramp up



11 – 20 linear ramp up



16 step increase



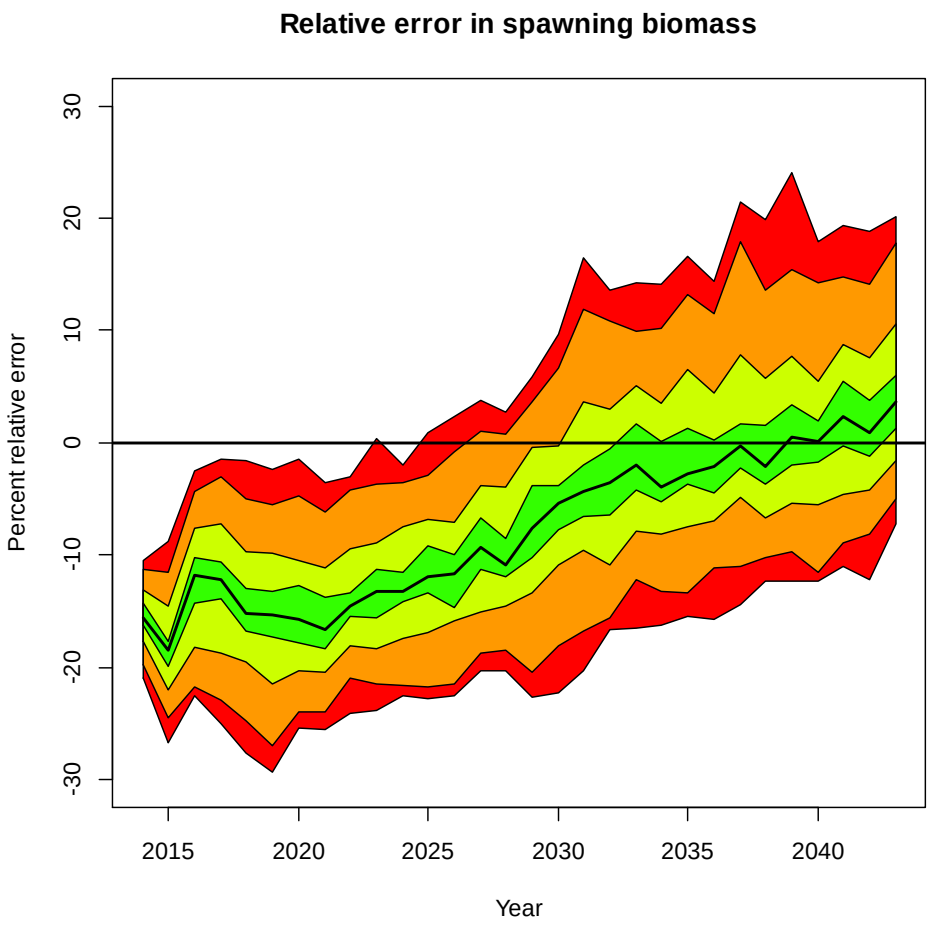
Max age-1 M of 1.0, age-2 M of 0.7, age-3 M of 0.5

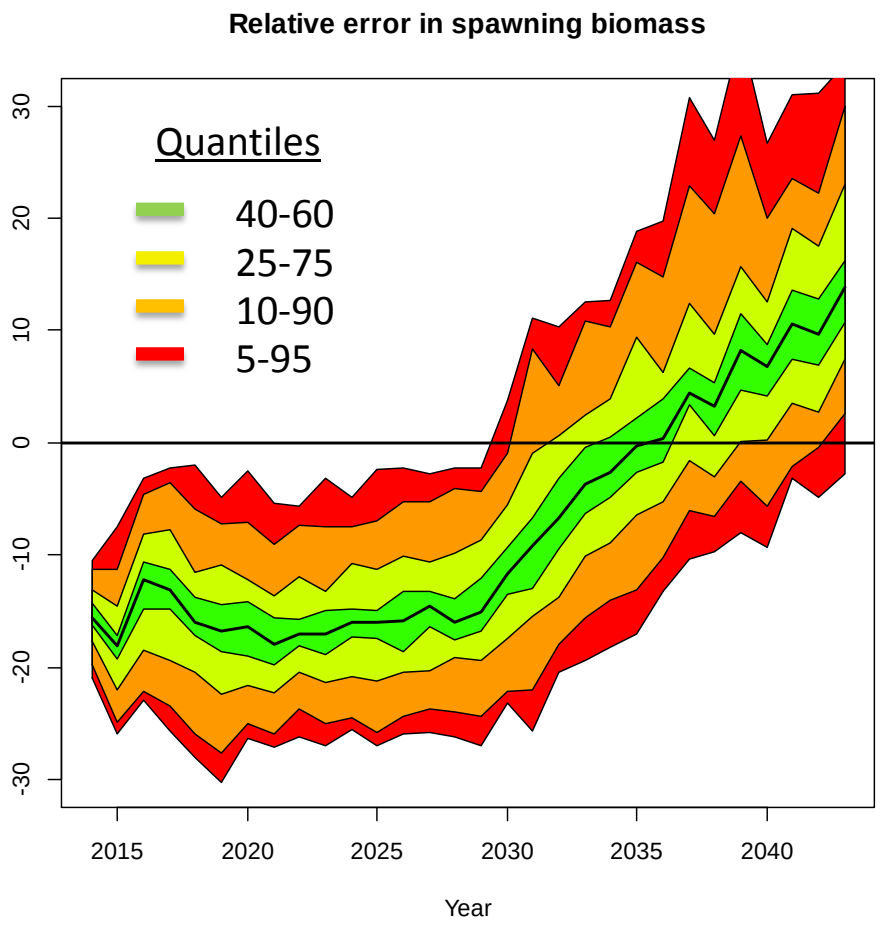
- Significant differences between increasing M linearly over the 30-year projection period and increasing M more rapidly
- No significant differences in bias with the 2 ways of generating future recruits

Relative error in spawning biomass

01 – 30 linear ramp up

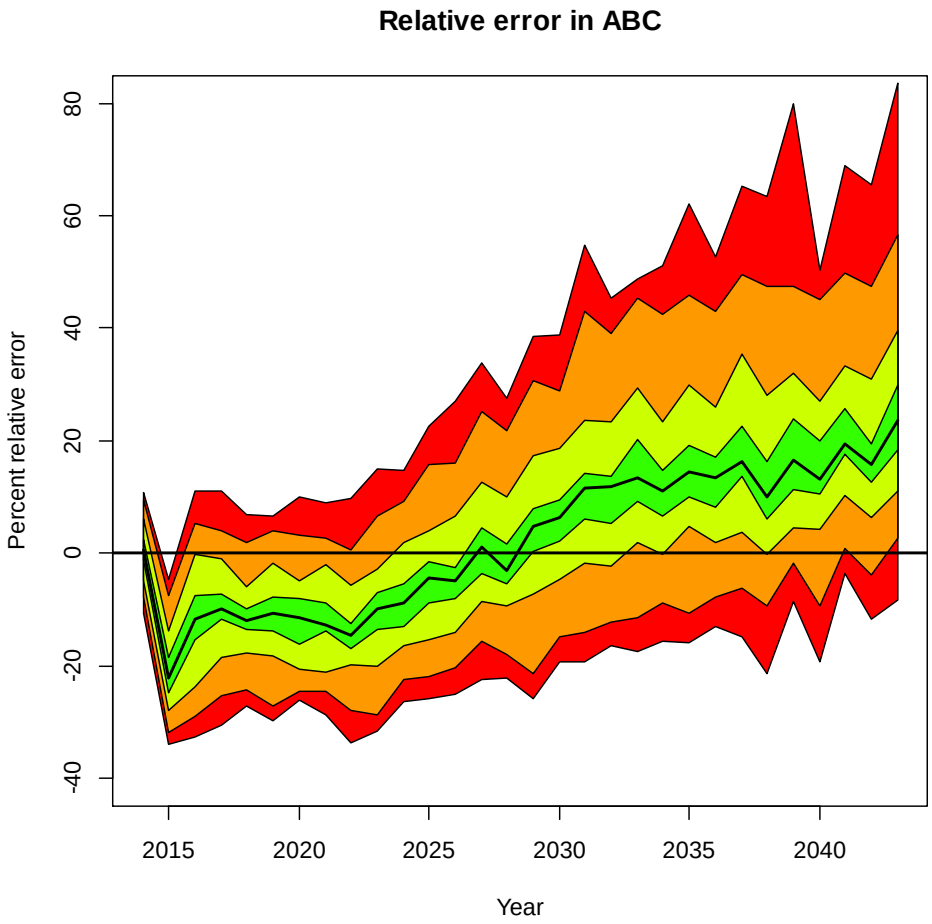
16 step increase



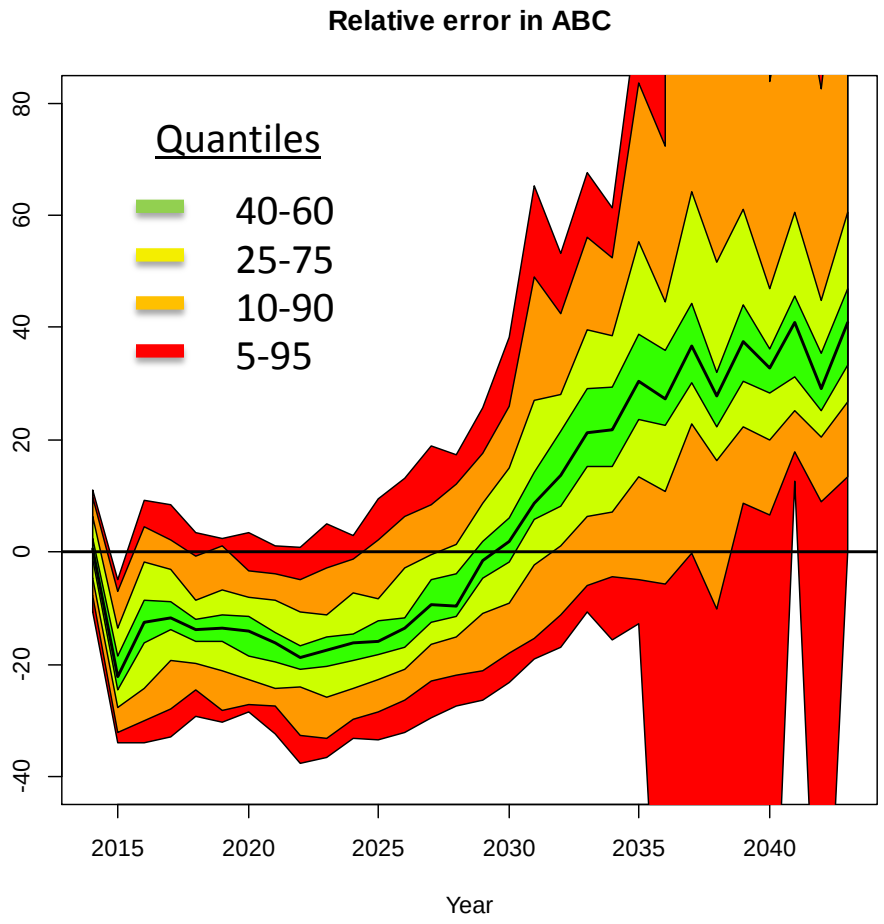


Relative error in ABC

01 – 30 linear ramp up

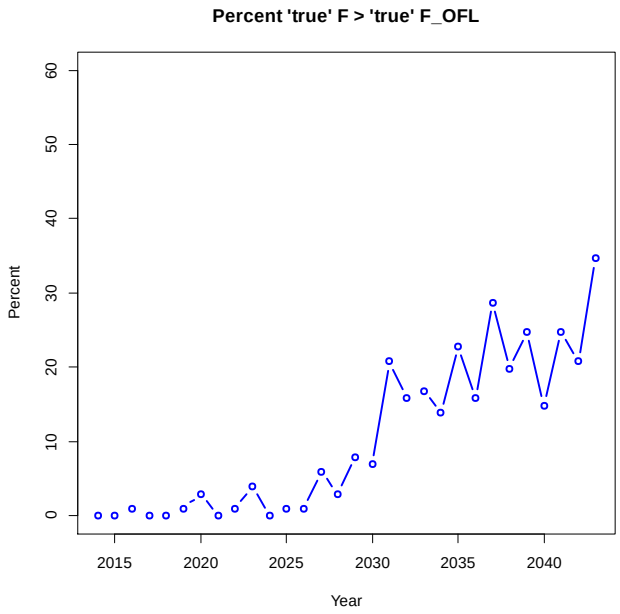


11 – 20 linear ramp up

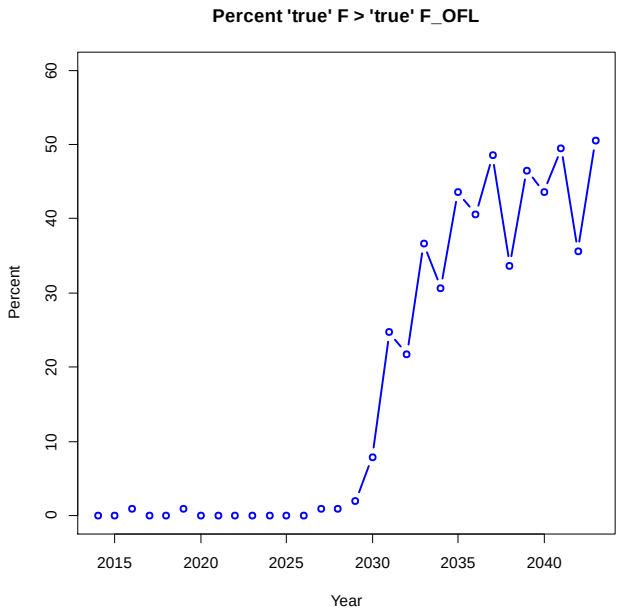


Overfishing

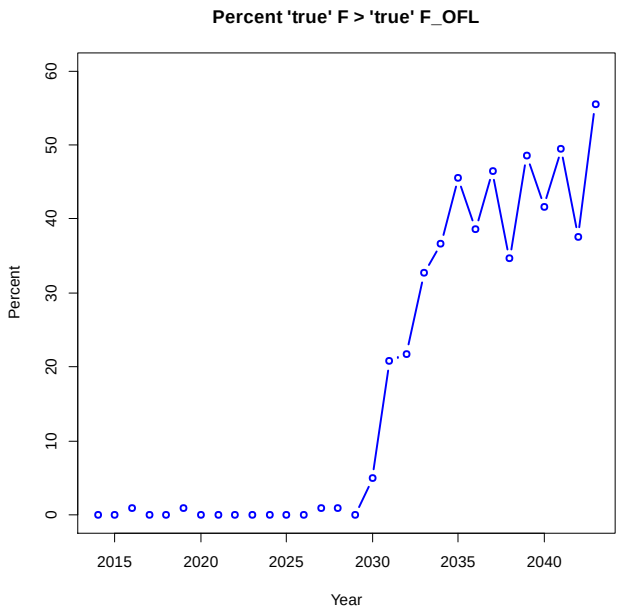
01 – 30 linear ramp up



11 – 20 linear ramp up



16 step increase

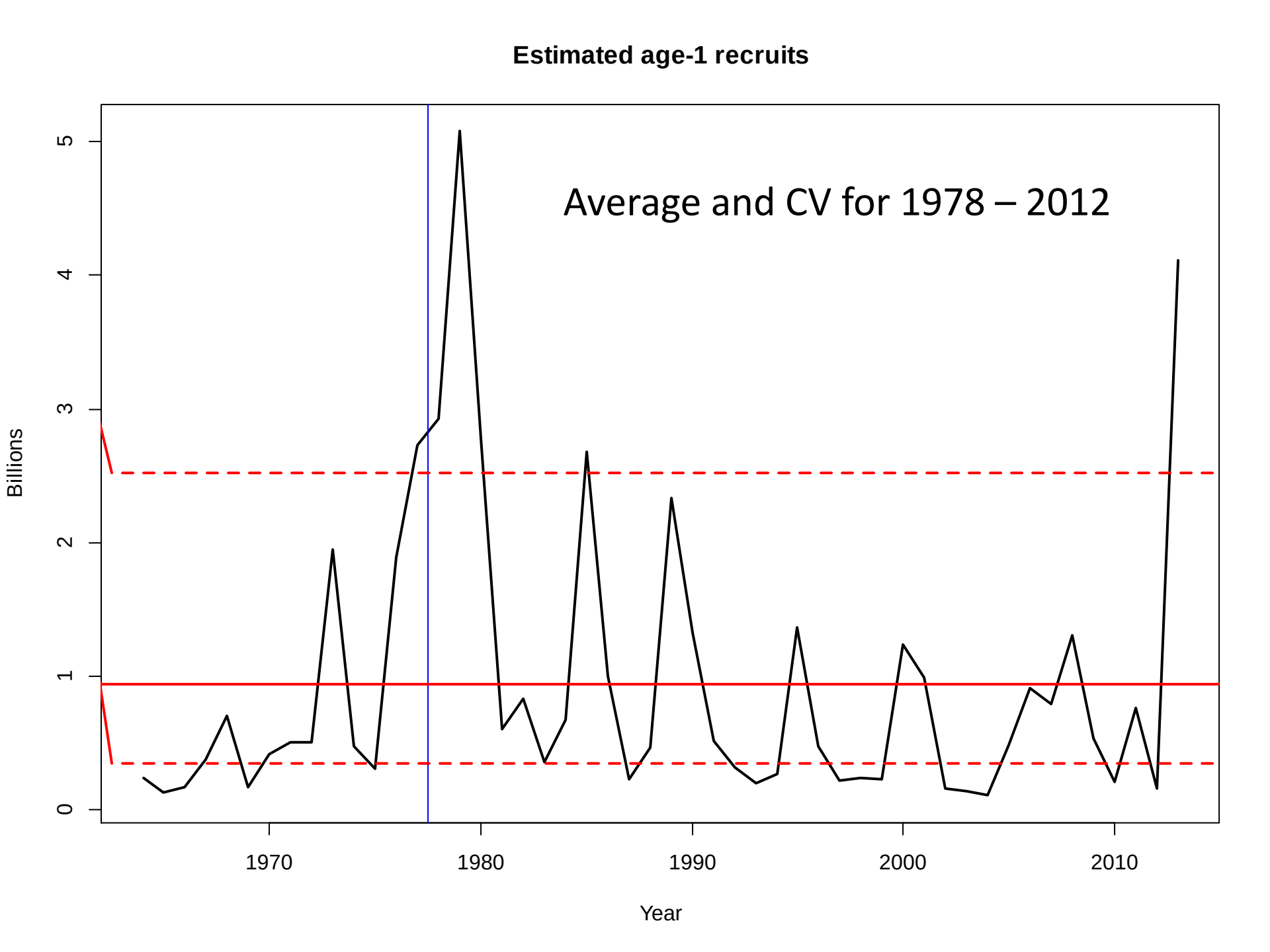


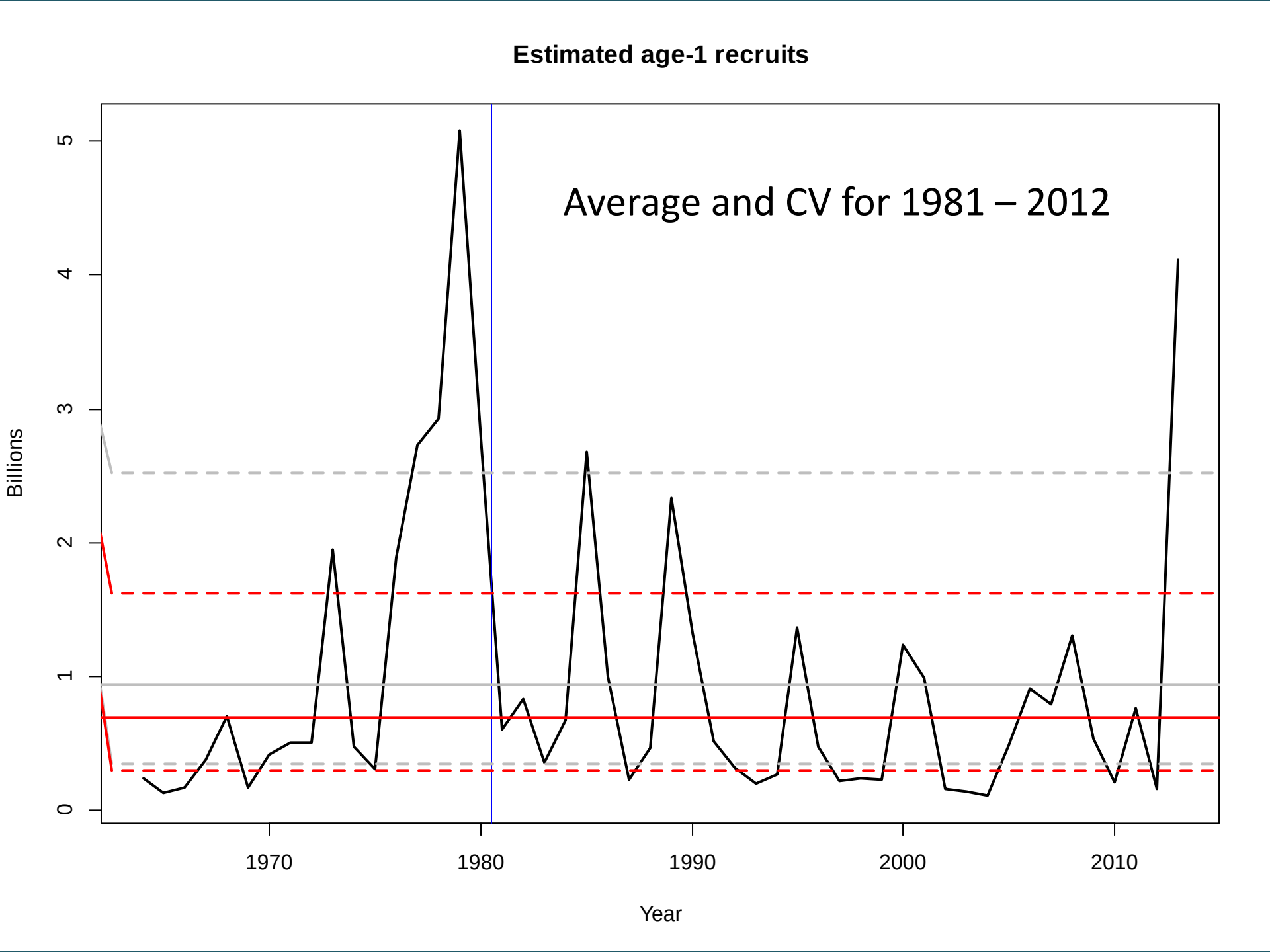
Next steps

- Developing other changing M-at-age scenarios
- Evaluating other harvest control rules
- Addressing changing M-at-age for young fish in the stock assessment model

Age-1 recruitment

- Future recruits generated randomly using average and CV of historical recruitment
- If generated recruit value is larger than the maximum of historical values then the recruit value is set to the maximum
- Average recruitment and CV of recruitment are calculated using the estimated historical recruitment values for 1977 – 2012 (status quo) **or** 1980 – 2012


Estimated age-1 recruits
Average and CV for 1978 – 2012
Billions
0
1
2
3
4
5
1970
1980
1990
2000
2010
Year


Estimated age-1 recruits
Average and CV for 1981 – 2012
Billions
0
1
2
3
4
5
1970
1980
1990
2000
2010
Year

Results for base scenarios

- Median bias of -10% to -15% in spawning biomass
- Median bias of 10% to 15% in fishing mortality
- Median bias of -10% to -15% in ABC
- The ‘true’ F exceeds the ‘true’ F_{OFL} less than 5% of the time
- No significant differences in bias with the 2 ways of generating future recruits

Results for max age-1 M of 0.7

- Median bias in spawning biomass increases from -15% to -10%
- Median bias in F decreases from 10% to almost 0%
- Median bias in ABC increases from -20% to -10%
- The 'true' F exceeds the 'true' F_{OFL} less than 5% of the time
- No significant differences in bias with the 2 ways of generating future recruits

Results for max age-1 M of 1.0

- Slight differences between increasing M linearly over the 30-year projection period and increasing M more rapidly
- Median bias in spawning biomass increases from -15% to -5%
- Median bias in F decreases from 10% to less than 0%
- Median bias in ABC increases from -20% to almost 0%
- The ‘true’ F exceeds the ‘true’ F_{OFL} less than 10% of the time
- No significant differences in bias with the 2 ways of generating future recruits