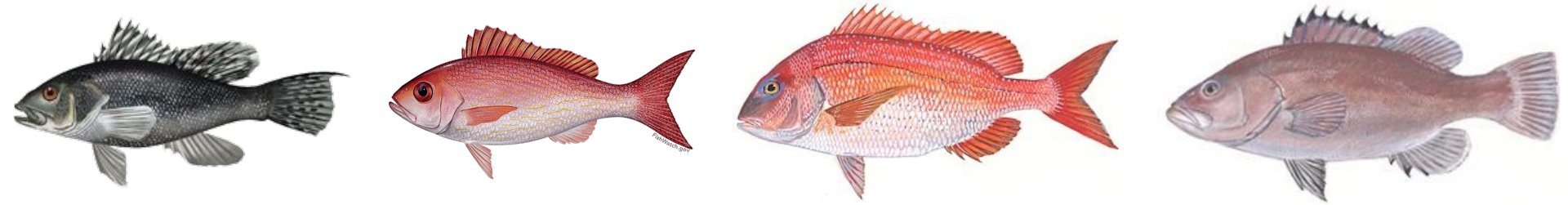

Evaluating procedures for updating catch advice of reef fishes between stock assessments, with management strategy evaluation

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Kyle Shertzer, Matt Vincent, and Erik Williams

2023 May, GMFMC SSC Meeting

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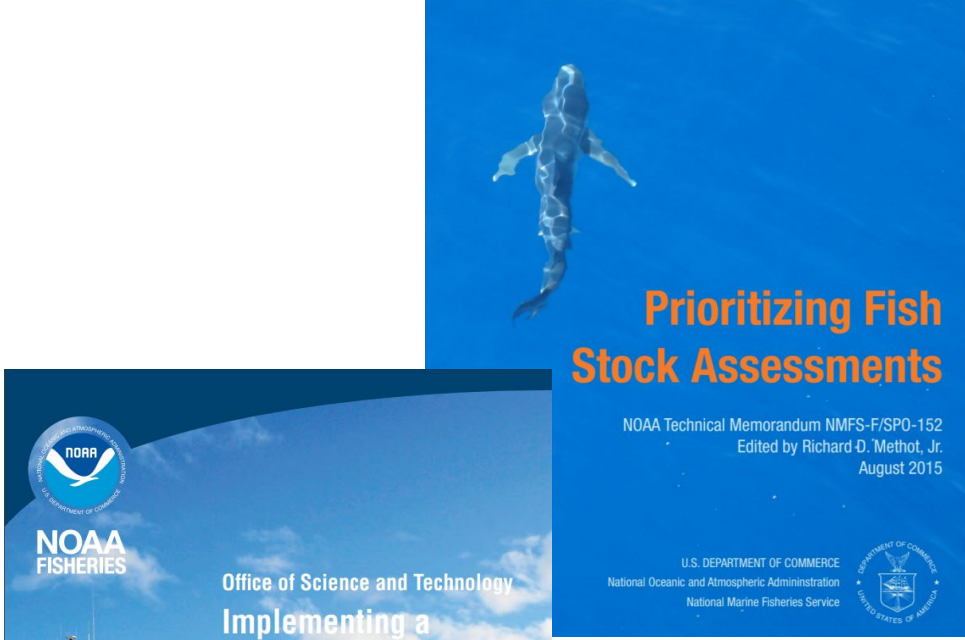
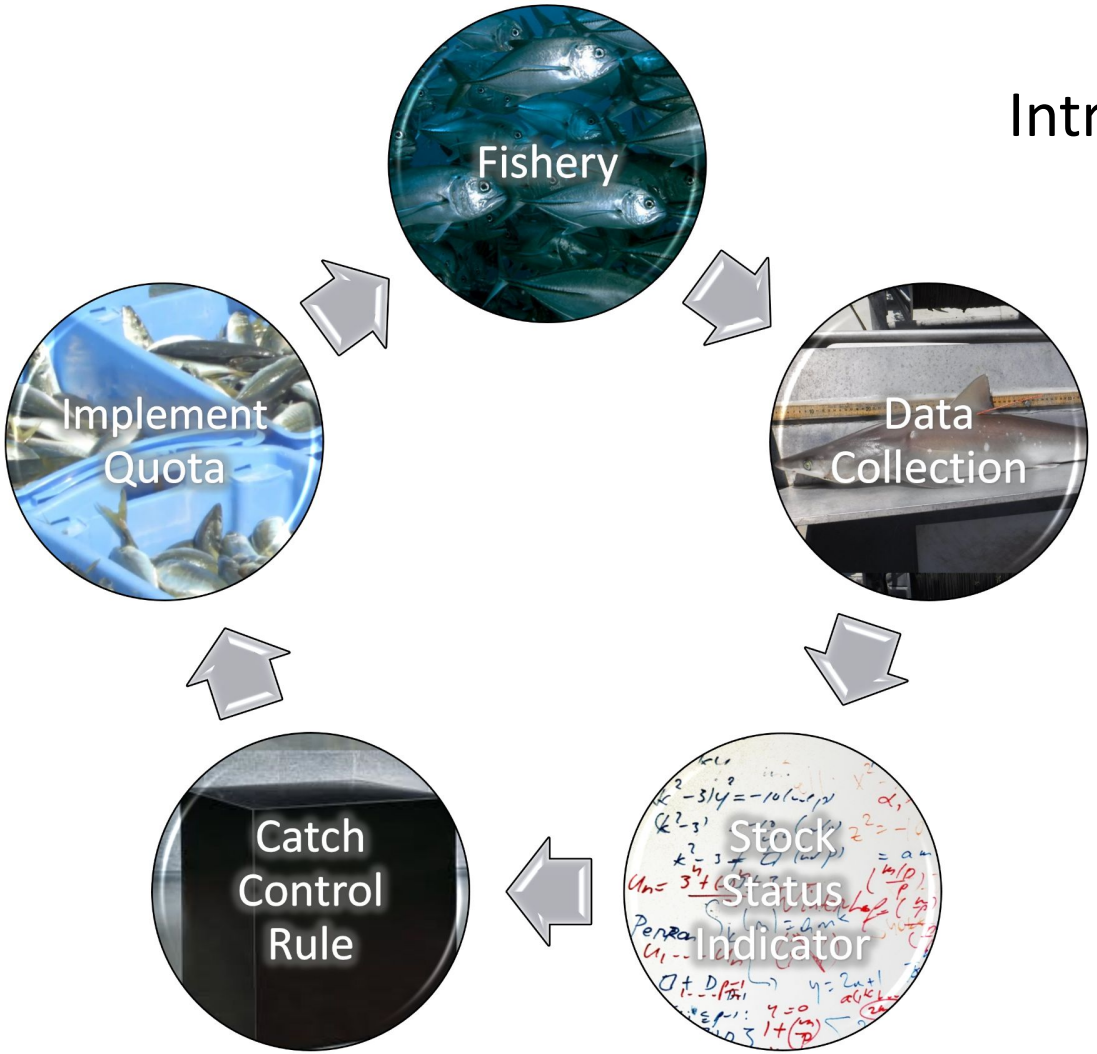
Motivation

- Recent NMFS guidance prioritizes efficiency in the stock assessment enterprise
- Interim assessment approach (Huynh et al. 2020)

Are interim assessment approaches appropriate for stocks in the South Atlantic?





Introduction: Management Procedures

Management procedure: formal rule that defines how fisheries are managed

- Data collection process
- Estimating model
- Catch control rule
- Implementation rule

Introduction:
Management Strategy Evaluation

Management strategy evaluation: framework to build and test candidate management procedures across a range of uncertainties using closed-loop simulation

To measure performance, we develop **performance metrics**, which should reflect stakeholder-informed management goals of the fishery

Management objectives often conflict, such that MSE is useful for clarifying **trade-offs** inherent in fisheries management.

Multiple OMs are built to reflect **uncertainties**. By testing MPs across a suite of OMs, we ensure that the MP is robust to the uncertainties inherent in the system.

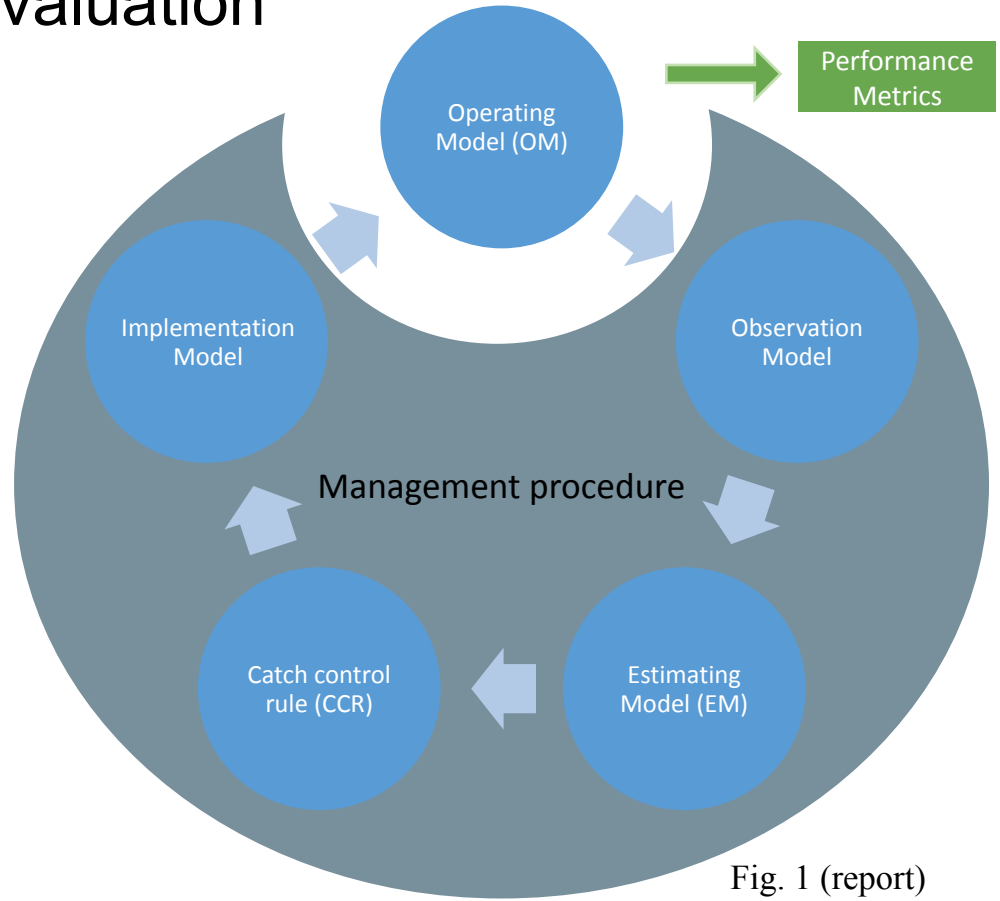
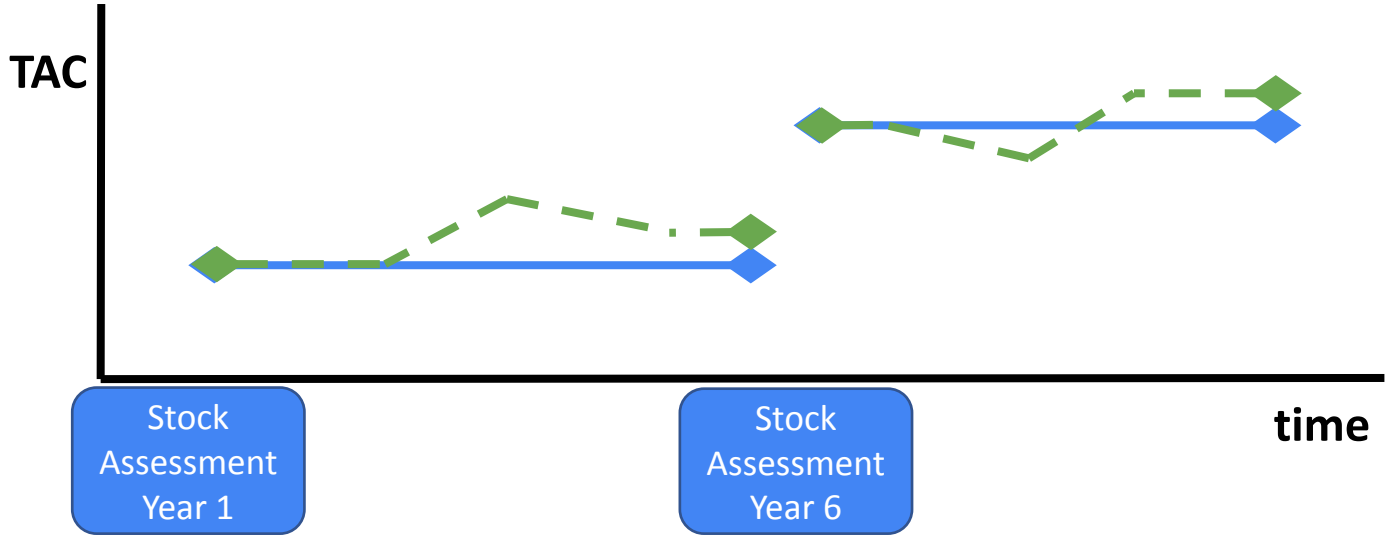


Fig. 1 (report)

Introduction: Interim Assessment Approach

- Index of abundance: CPUE $\propto$ B



- Huynh et al. 2020

Purpose

We applied the Huynh et al. (2020) approach it to South Atlantic fishes to explore whether interim assessment approaches are suitable for South Atlantic species

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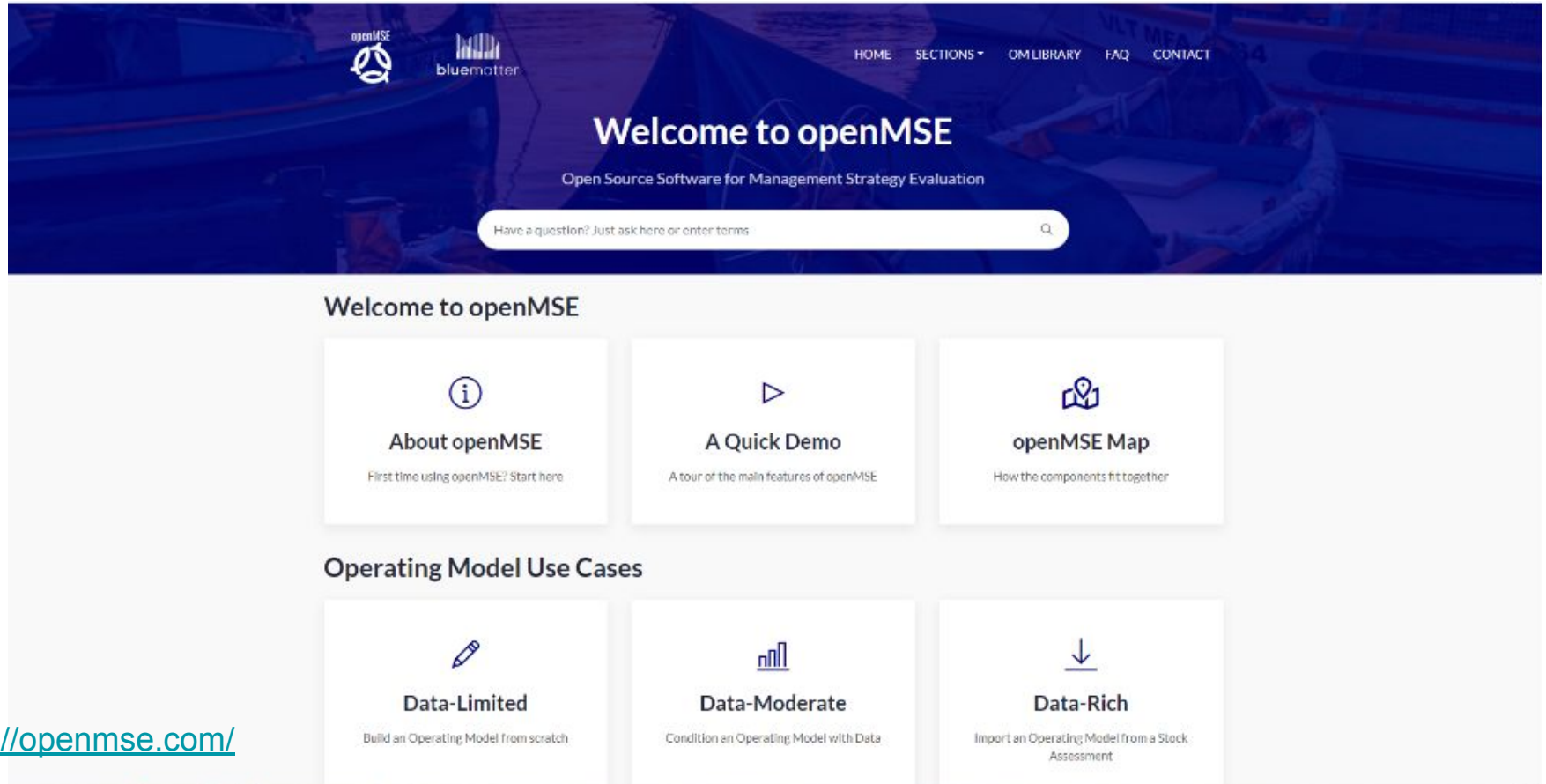
ORIGINAL ARTICLE

FISH and FISHERIES WILEY

The interim management procedure approach for assessed stocks: Responsive management advice and lower assessment frequency

Quang C. Huynh[1] | Adrian R. Hordyk[1] | Robyn E. Forrest[2] | Clay E. Porch[3] | Sean C. Anderson[2] | Thomas R. Carruthers[1]

Methods: MSE software



https://openmse.com/

Methods: MSE software

openMSE consists of several packages

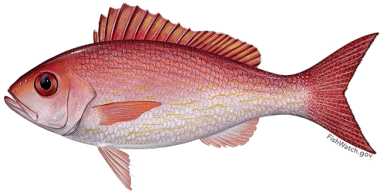
- DLMtool - Data Limited Methods toolkit
- MSEtool - Management Strategy Evaluation Toolkit
- SAMtool - Stock Assessment Methods Toolkit

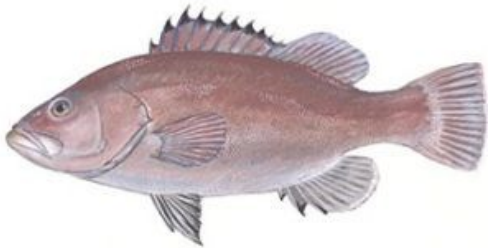
Provides an efficient framework for conducting MSE with extensive flexibility to customize operating models, selecting and modifying management procedures, running MSE, computing performance metrics, and plotting results.

Methods: Operating models

Four base operating models configured from recent BAM stock assessments

- SA Red Porgy (SEDAR 60)
- SA Black Sea Bass (SEDAR 56)
- SA Snowy Grouper (SEDAR 36 Update 2021)
- SA Vermilion Snapper (SEDAR 55)



Methods: Operating models

Sub-objects of operating models (OM objects)

1. Stock - biology, life history, and other stock-level information
2. Fleet - information about catch and fisheries
3. Obs(ervation) - sample sizes and observation error information
4. Imp(lementation) - parameters that specify how effectively management is applied
5. Cpars - custom parameters, allowing great flexibility in adding parameters and time and age variation
    a. Data
        i. Additional indices of abundance
        ii. Additional indices of abundance CVs
        iii. Additional indices of abundance selectivities
    b. Other (e.g. life history parameters, recruitment residuals)

Methods: Operating models

Two new R packages

bamExtras - A miscellany of functions and data sets used in support of stock assessments using the Beaufort Assessment Model (BAM).

(https://github.com/nikolaifish/bamExtras)

bamMSE - A set of functions used to convert data and assessment outputs from the Beaufort Assessment Model (BAM) to inputs used by the openMSE packages (DLMtool, MSEtool, and SAMtool).

(https://github.com/nikolaifish/bamMSE)

Methods: Operating models

- Initial operating models built using MSEtool::Assess2OM function from BAM output
  - Inputs from BAM rdat objects to Assess2OM
    - N, F, M, weight, length, and maturity, at-age matrices
    - Beverton-Holt steepness and R0
  - Additional information added to OMs
    - Values of various parameters at age-0
    - Von Bertalanffy growth parameters (Linf, K, t0)
    - Additional indices of abundance
      - Only included indices available in the terminal year of the BAM assessment
      - Most OM therefore included a single index
  - Observation sub-object constructed based on sample sizes and CVs from BAM data
  - Implementation sub-object assumes perfect management (e.g. no overages or underages)

Methods: Operating models

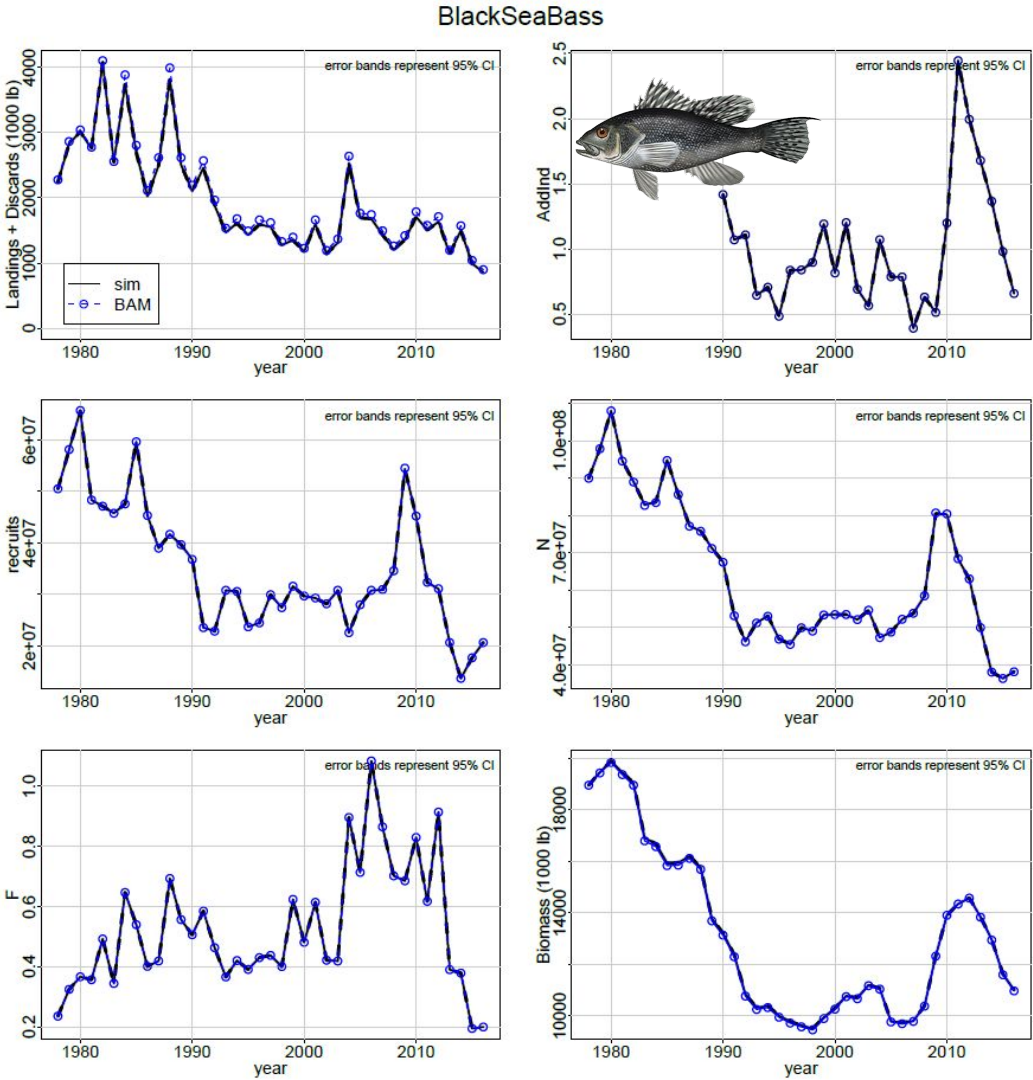
MSEs run using MSEtool::runMSE

- Fleet structure simplified from BAM using a single time series of removals and corresponding selectivity based on BAM total removals (landings + dead discards)

Methods: Operating models

- MSEtool::Assess2OM effectively matches inputs from BAM
- The simulated time series are stored in the operating model to represent the **historical period**, which become part of the data used to run stock assessments during the **projection period**
- Historical time series were essentially fixed in the analyses

Simulated = black
BAM = blue



Methods: Management procedures

All management procedures ran statistical catch-at-age (SCA) stock assessment models with the **SAMtool::SCA function**

- Years - historical period and projection years, up to two years (lag) before simulated assessment year
- Ages - age-0 to max age modeled in BAM assessment
- Life history
  - Length-weight equation (fixed)
  - Von Bertalanffy growth model (fixed)
  - Age-varying M
- Data
  - Catch - single time series of catch and CVs.
  - Indices of abundance - multiple time series
  - Age compositions (CAA) - single time series, associated with catch. Multinomial distribution.
- Selectivity
  - Logistic selectivity for catch (estimated)
  - Selectivity function for each index (fixed)
- Recruitment
  - Beverton-Holt stock-recruit function (steepness fixed)
  - Standard deviation of the recruitment deviations (rec sigma) is fixed
  - Recruitment deviations estimated from one generation prior to CAA data to number of early ages less than half modal catch (i.e. half age at full selection)
- Baranov catch equation
- Equilibrium *F* fixed
- MSY-based reference points

Methods: Management procedures

All management procedures ran statistical catch-at-age (SCA) stock assessment models at intervals of 1, 5, or 10 years

In assessment years TAC = MSY, computed as Baranov function of Fmsy, M, and catch selectivity

Between assessments TAC set in different ways

Methods: Management procedures

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
9	Bfr I (10)	10	adjusted by recent index buffered by SD of index

Methods: Management procedures

- Data lag
  - Two year data lag incorporated into SCA
    - Terminal year of data = y - 2
    - Assessment year = y
    - Management year = y + 1
  - No data lag when applying interim adjustments to catch advice
    - Terminal year of index = y
    - Interim adjustment year = y
    - Management year = y + 1

Methods: Scenarios

Base - described above

Alternative*

1. Index high CV (ucvhi): Uncertainty (coefficient of variation; CV) in primary index of abundance of abundance is twice the CV of the base scenario
2. Index low CV (ucvlo): Uncertainty (CV) in primary index of abundance of abundance is half the CV of the base scenario
3. Index is biased (ubias): Primary index of abundance increasingly underestimates population size (i.e. decreasing catchability)
4. High TAC (tachi): TAC = 1.25 X MSY (*F*target = 1.25 X *F*msy in HCR)
5. Low TAC (taclo): TAC = 0.75 X MSY (*F*target = 0.75 X *F*msy in HCR)

*We ran at least 15 other alternative scenarios, but focused on these five in the report

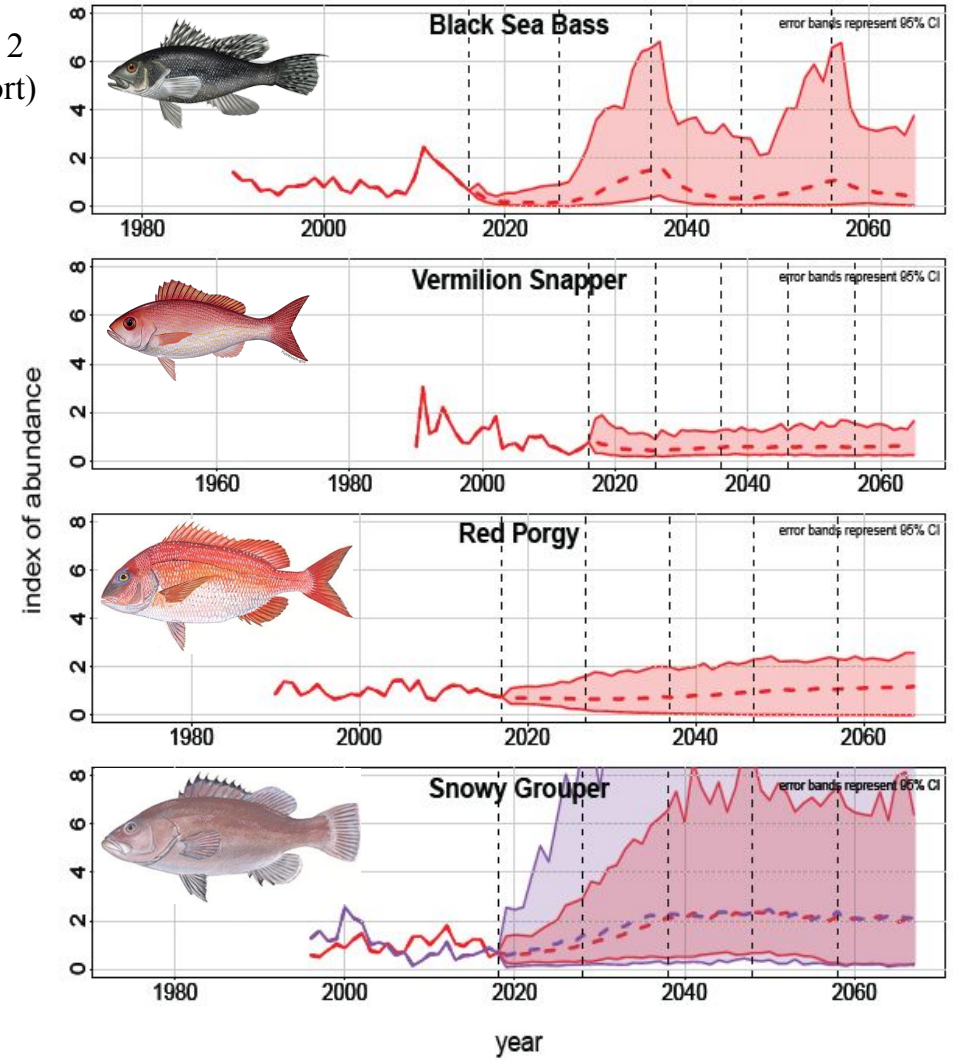
Methods: Performance

- Reference points
  - total catch
  - relative catch (C/MSY)
  - stock status (SSB/SSBmsy)
  - fishery status (F/FMSY)
  - average annual variability in yield (AAVY)
- Performance metrics
  - average long term yield
  - probability [P()] of healthy stock status P(SSB > SSBmsy)
  - probability of not overfishing P(F < FMSY)
  - probability of stable yield P(AAVY < 20%)

Results: Base

- Simulated indices of abundance
  - Base scenario
  - SCA (10) MP
  - Red indices were used in interim procedures
    - SERFS chevron trap/video for Black Sea Bass, Vermilion Snapper, and Red Porgy
    - SERFS chevron trap for Snowy Grouper
  - Purple index is MARMAP vertical longline survey
  - Vertical dashed lines indicate assessment years

Fig. 2 (report)



Results: Base

SSB/SSBmsy

-each set of three boxplots represent three consecutive time periods during projection period (~17 yr)

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
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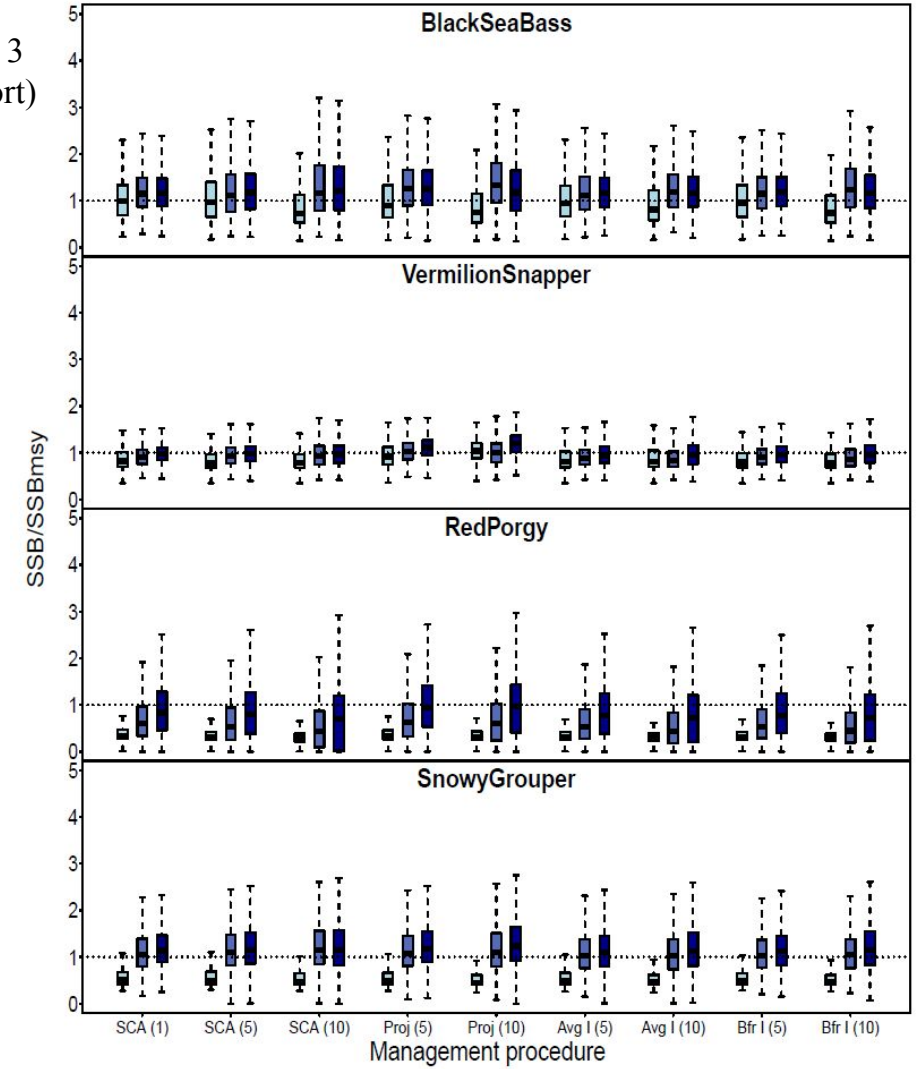
Fig. 3 (report)



Results: Base

F/Fmsy

-each set of three boxplots represent three consecutive time periods during projection period (~17 yr)

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
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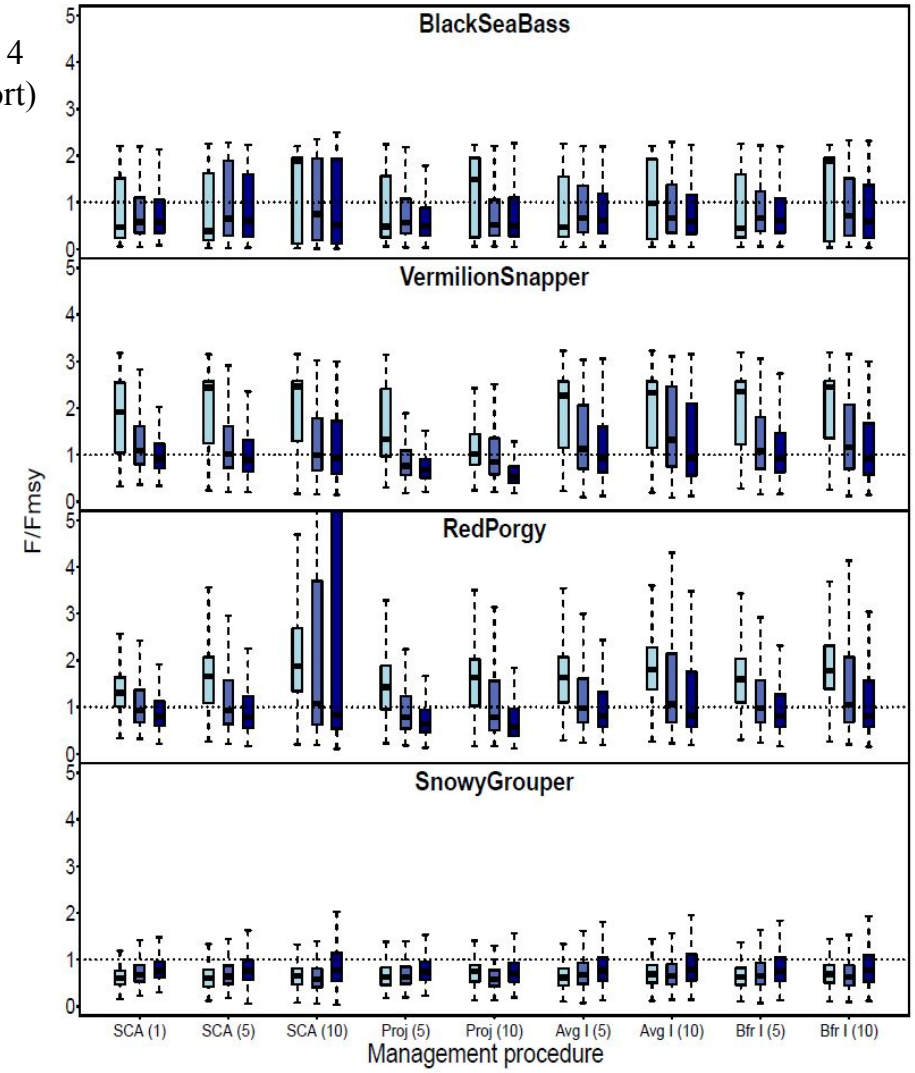
Fig. 4 (report)



Results: Base

Total catch (1000 lb)

-each set of three boxplots represent three consecutive time periods during projection period (~17 yr)

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
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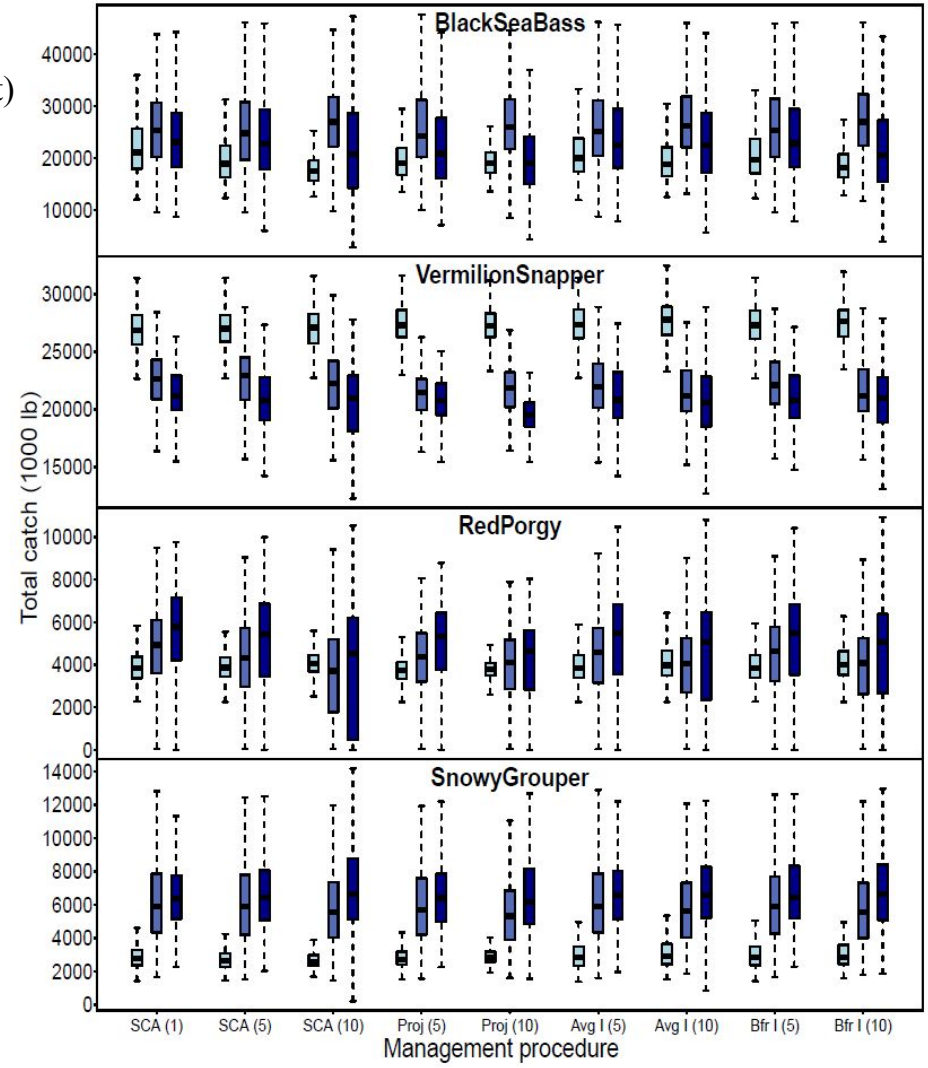
Fig. 5 (report)



Results: Base

Average annual variability in yield (catch; AAVY)

-each set of three boxplots represent three consecutive time periods during projection period (~17 yr)

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
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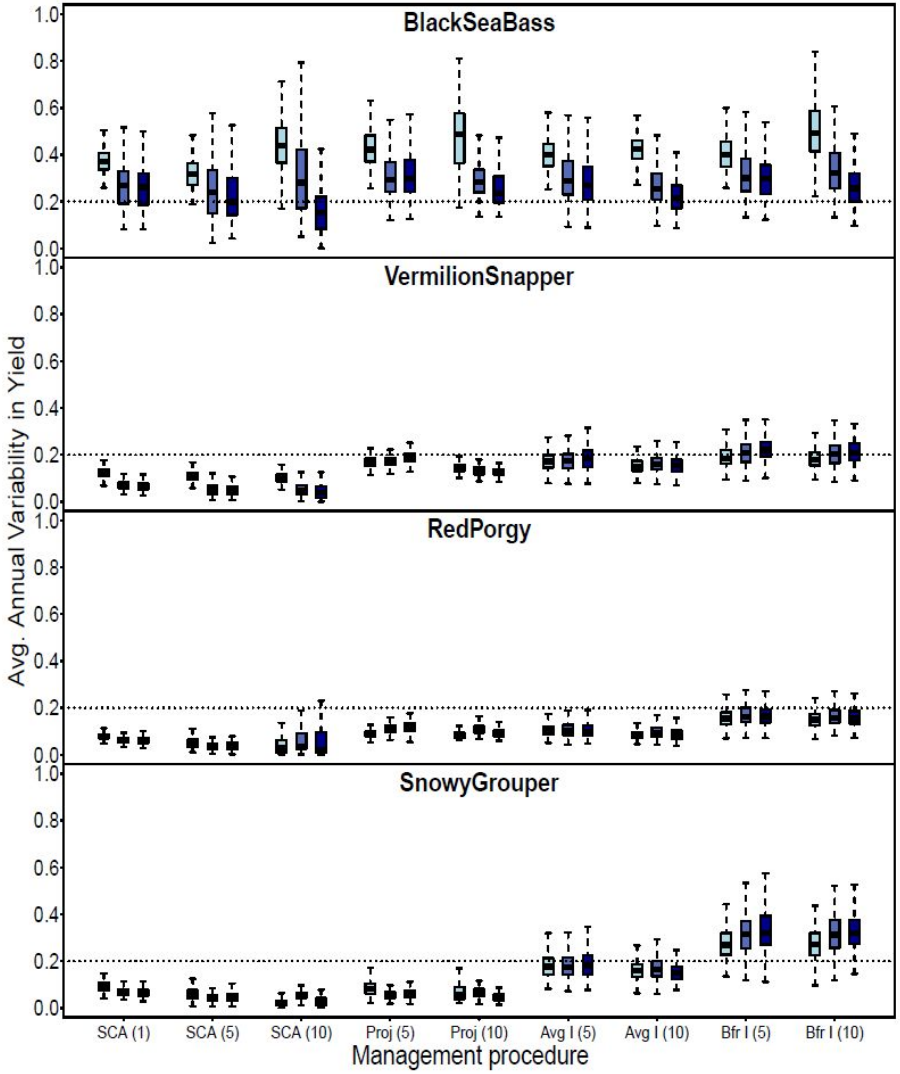
Fig. 6 (report)



Results: Base

Median (catch/MSY)

10 yr assessment interval

- vertical dashed lines indicate 10 yr assessments
- note that SCA (1) was conducted every year

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
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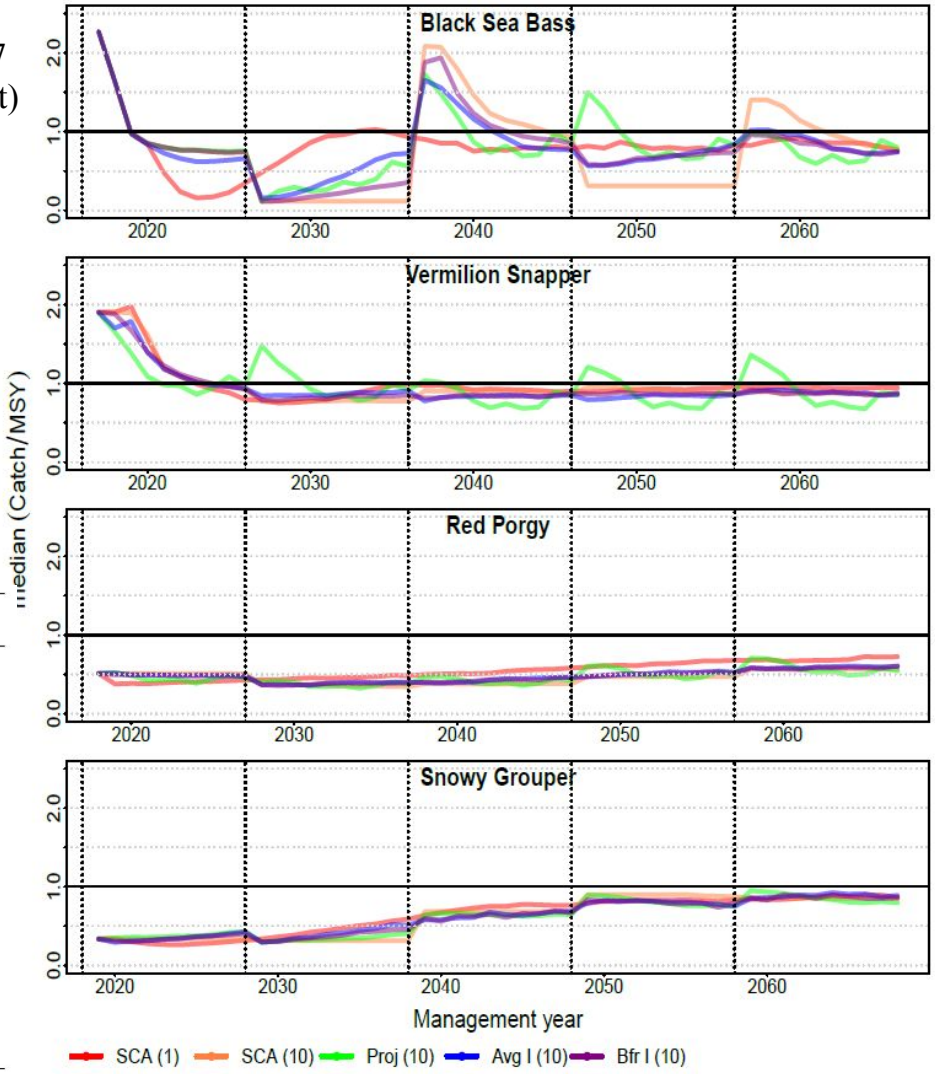
9	Bfr I (10)	10	adjusted by recent index buffered by SD of index

Fig. 7 (report)



Results: Base

Median (catch/MSY)

5 yr assessment interval

- vertical dashed lines indicate 5 yr assessments
- note that SCA (1) was conducted every year

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
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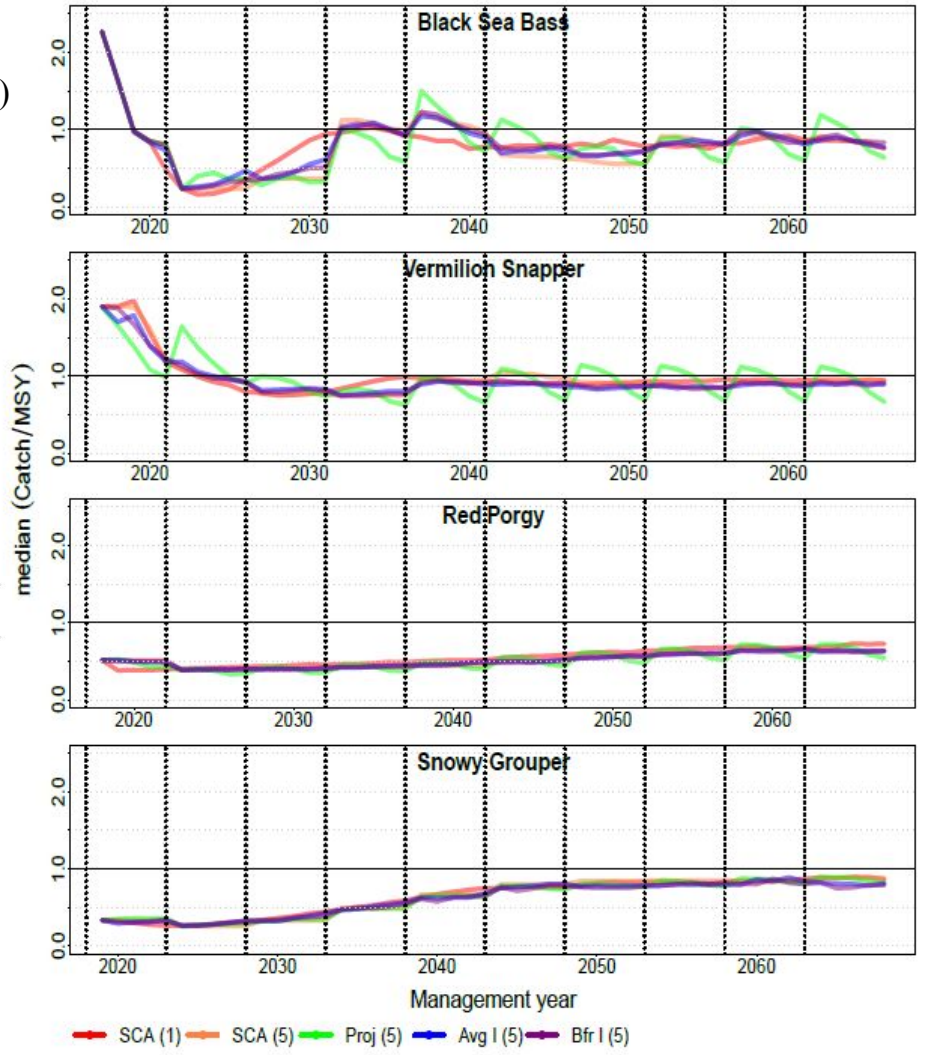
Fig. 8 (report)



Results: Base

Median (F/Fmsy)

10 yr assessment interval

- vertical dashed lines indicate 10 yr assessments
- note that SCA (1) was conducted every year

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
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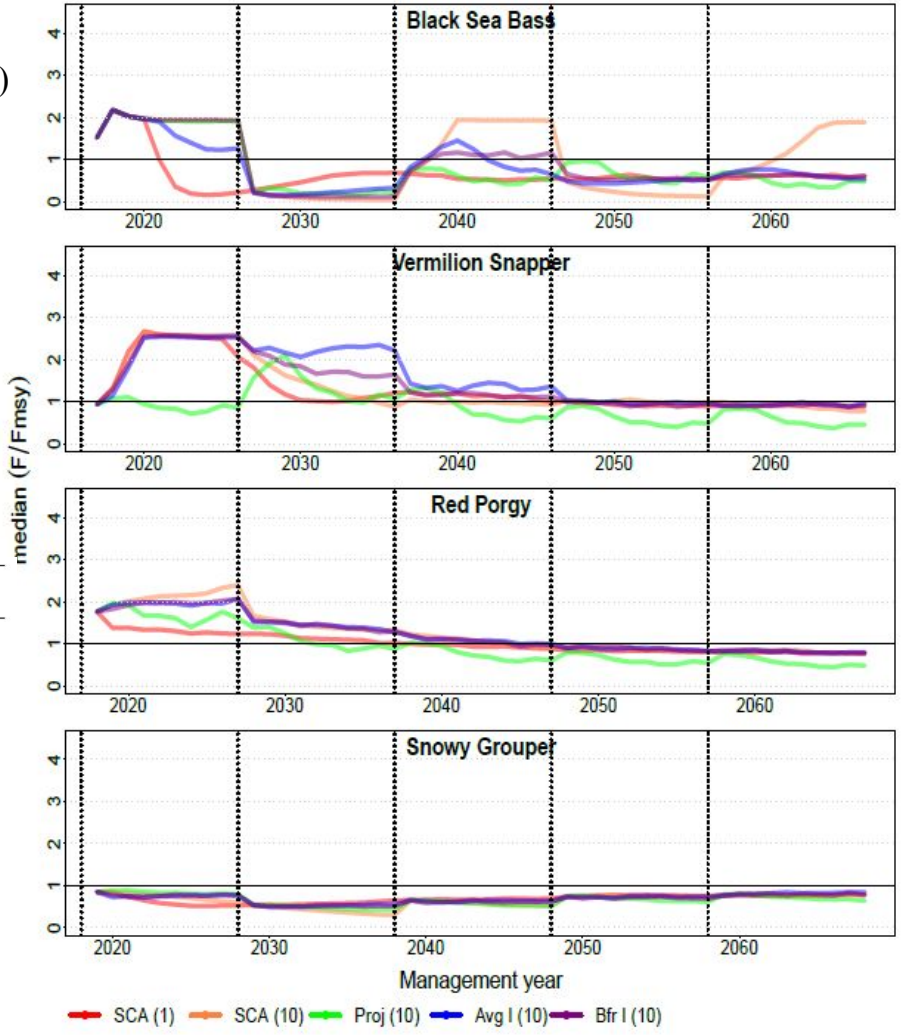
9	Bfr I (10)	10	adjusted by recent index buffered by SD of index

Fig. 9 (report)



Results: Base

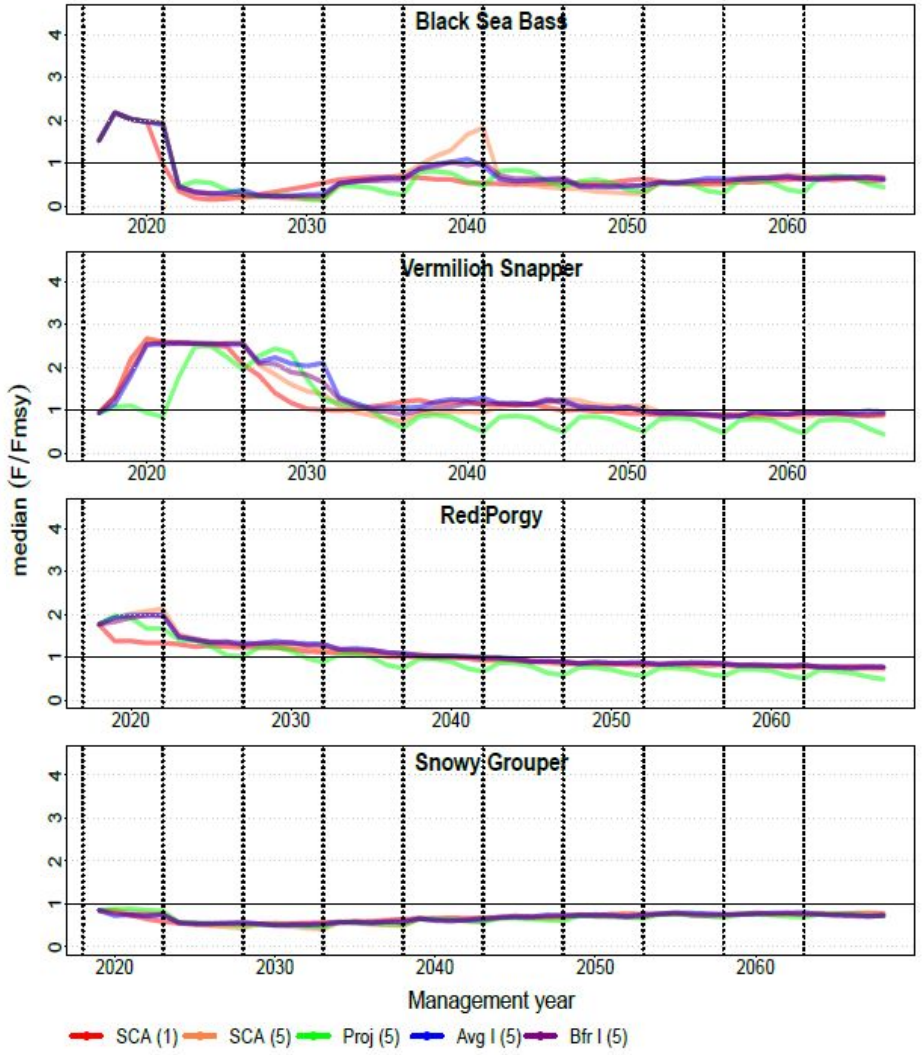
Median (F/Fmsy)

5 yr assessment interval

- vertical dashed lines indicate 5 yr assessments
- note that SCA (1) was conducted every year

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
9	Bfr I (10)	10	adjusted by recent index buffered by SD of index

Fig. 10 (report)



Results: Base

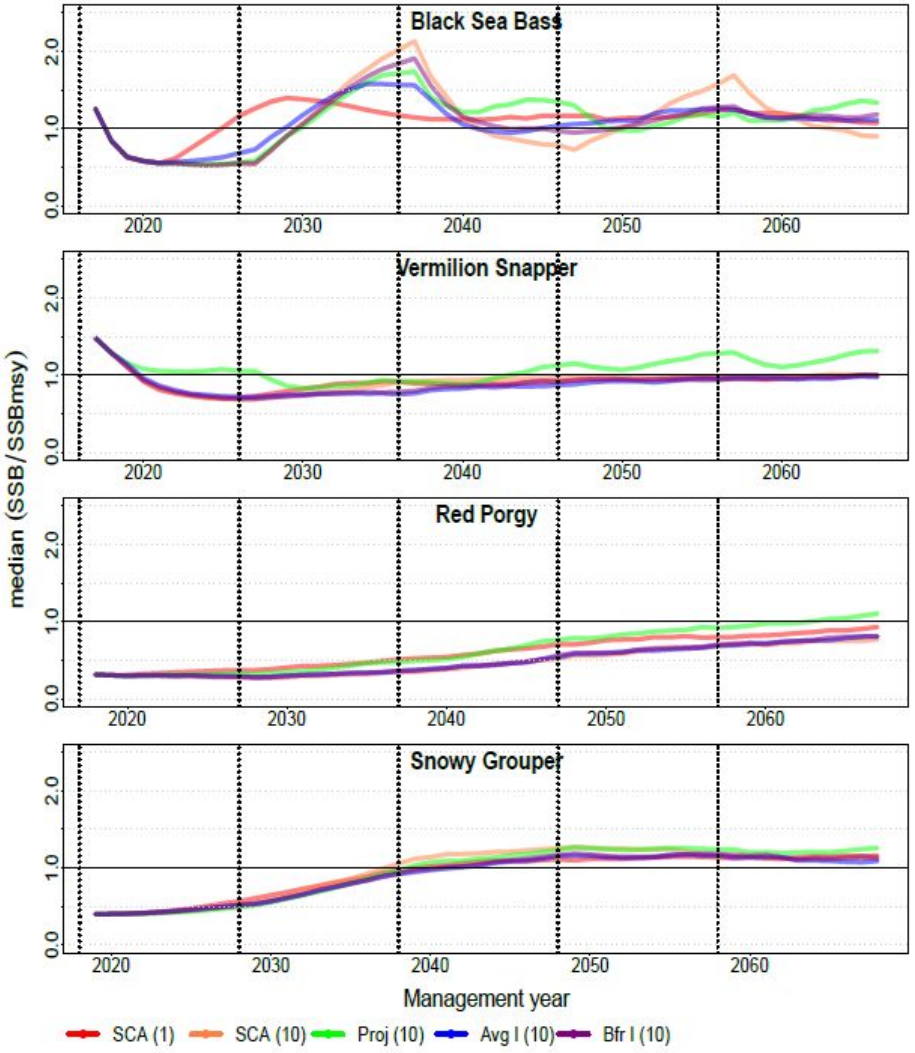
Median (SSB/SSBmsy)

10 yr assessment interval

- vertical dashed lines indicate 10 yr assessments
- note that SCA (1) was conducted every year

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
9	Bfr I (10)	10	adjusted by recent index buffered by SD of index

Fig. 11 (report)



Results: Base

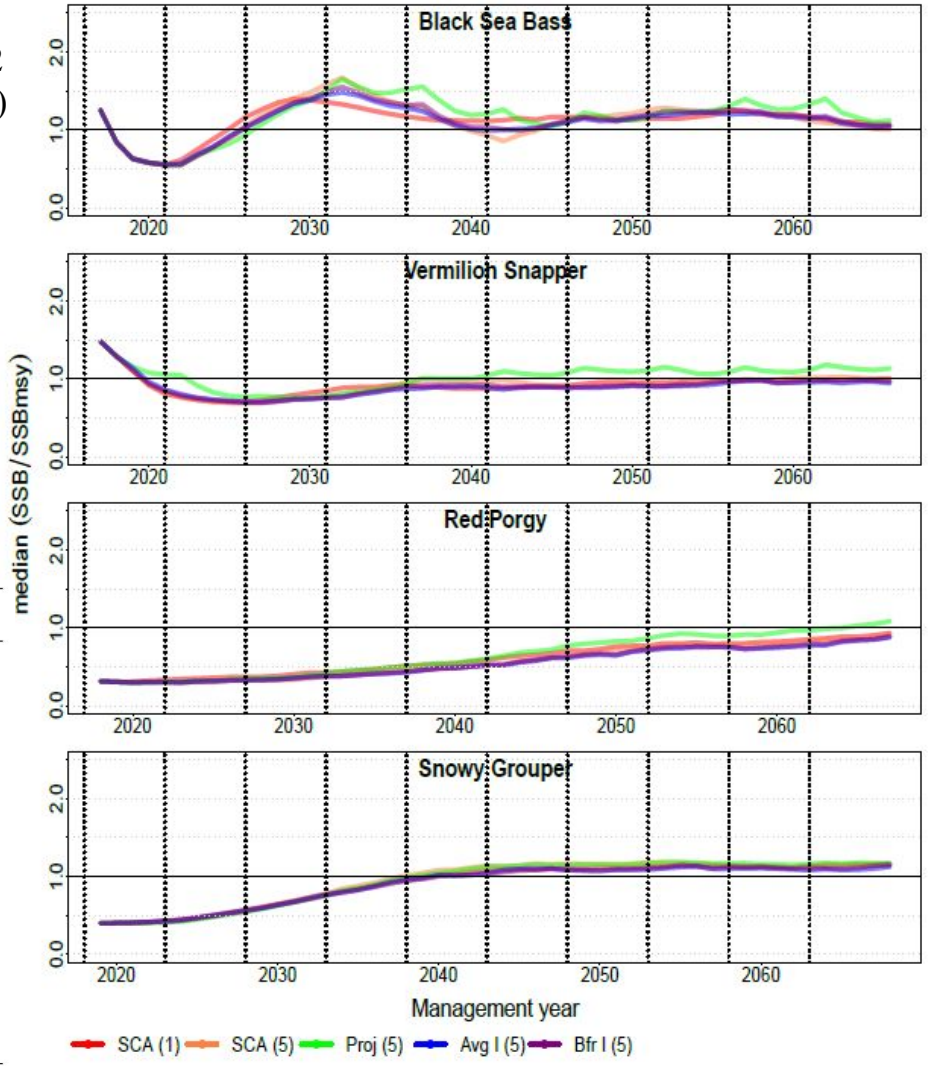
Median (SSB/SSBmsy)

5 yr assessment interval

- vertical dashed lines indicate 5 yr assessments
- note that SCA (1) was conducted every year

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
9	Bfr I (10)	10	adjusted by recent index buffered by SD of index

Fig. 12 (report)



Results: Base

Tradeoff plots

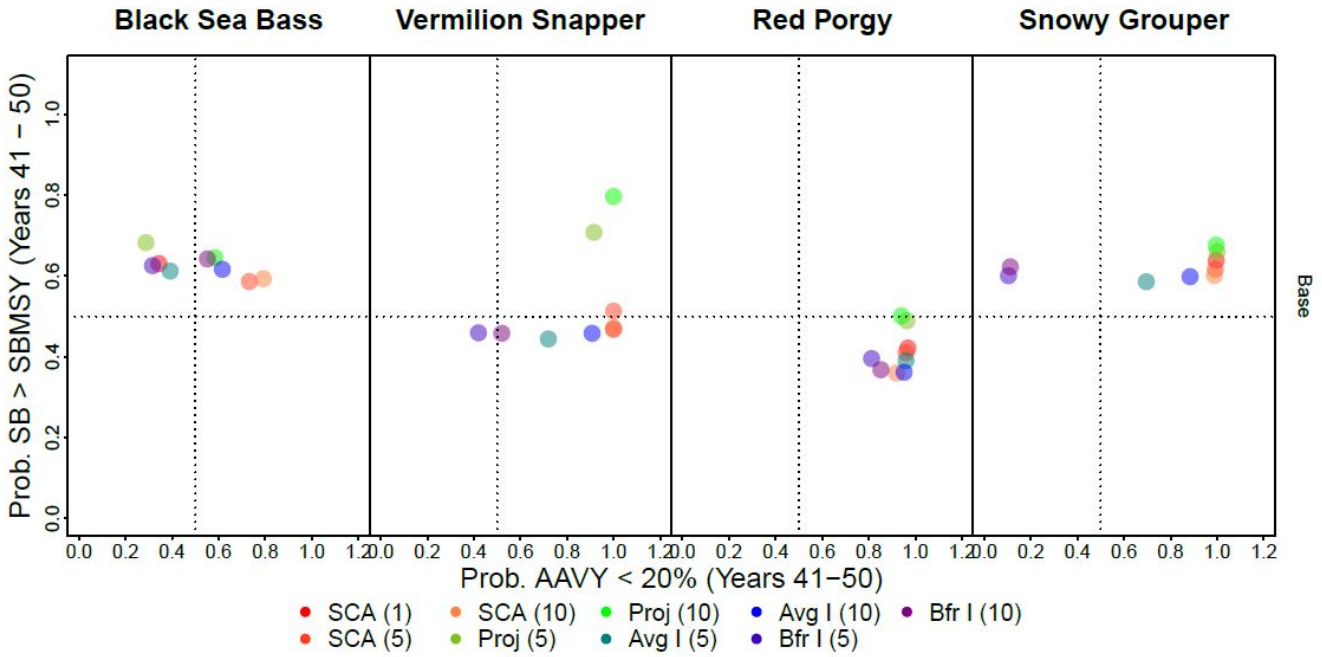


Fig. 13 (report)

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
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Results: Base

Tradeoff plots

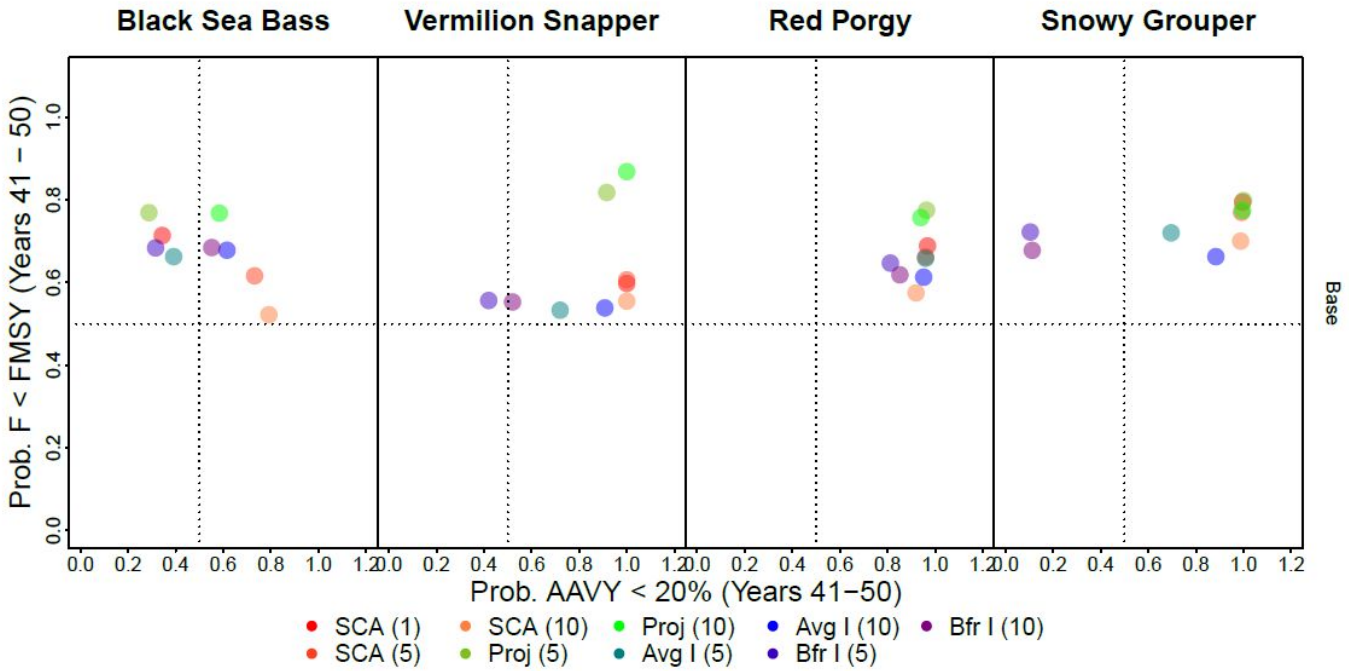


Fig. 14 (report)

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
9	Bfr I (10)	10	adjusted by recent index buffered by SD of index

Results: Base

Tradeoff plots

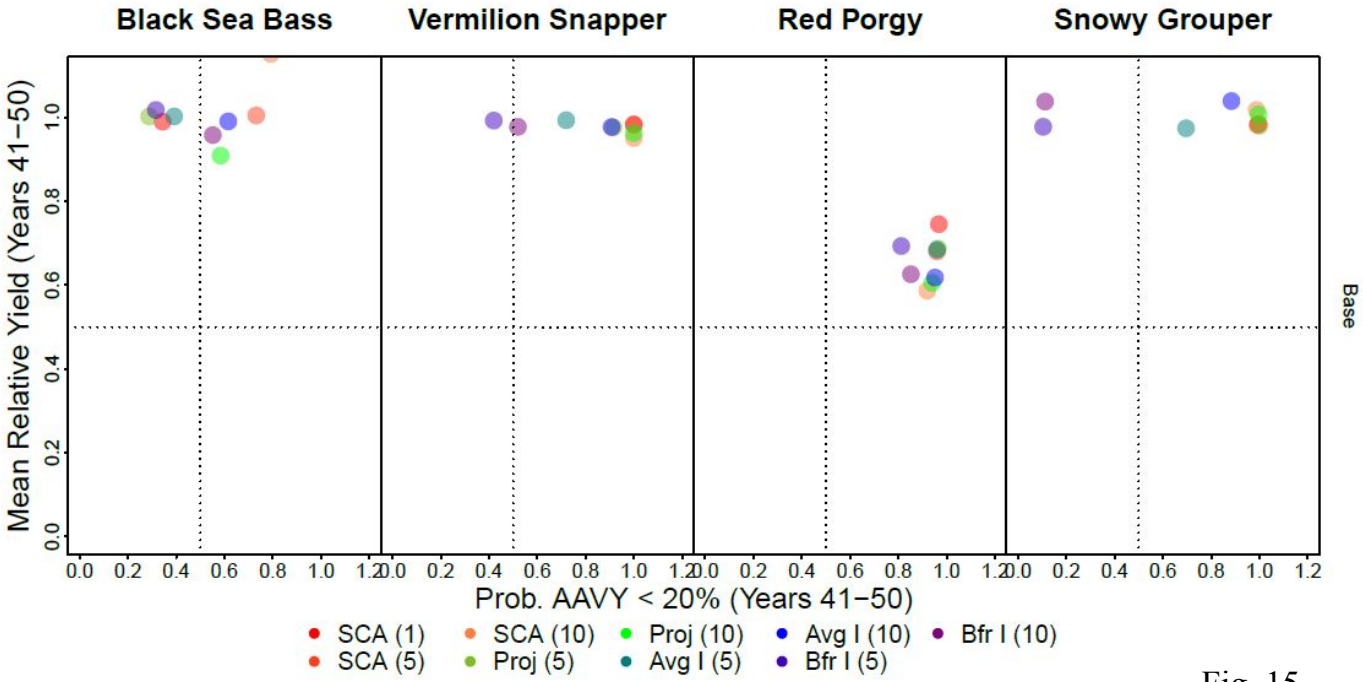


Fig. 15 (report)

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
9	Bfr I (10)	10	adjusted by recent index buffered by SD of index

Results: Base

Tradeoff plots

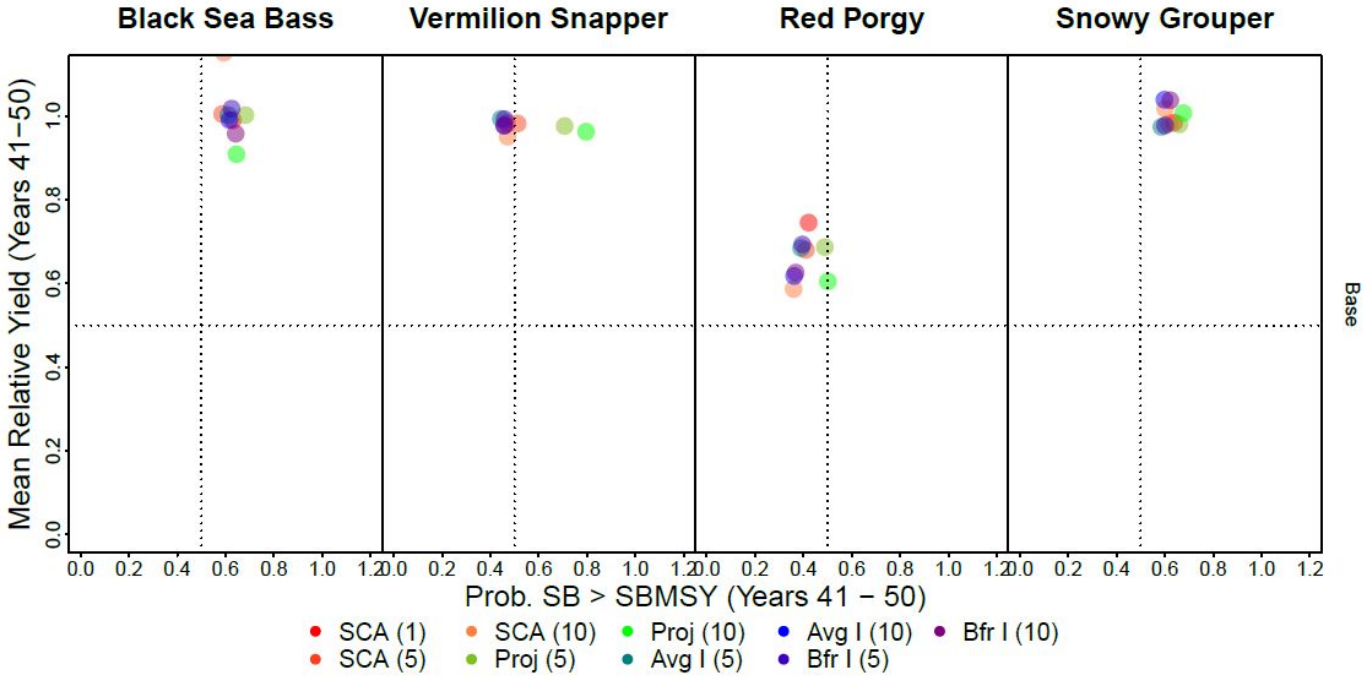


Fig. 16 (report)

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
9	Bfr I (10)	10	adjusted by recent index buffered by SD of index

Results: Base

Tradeoff plots

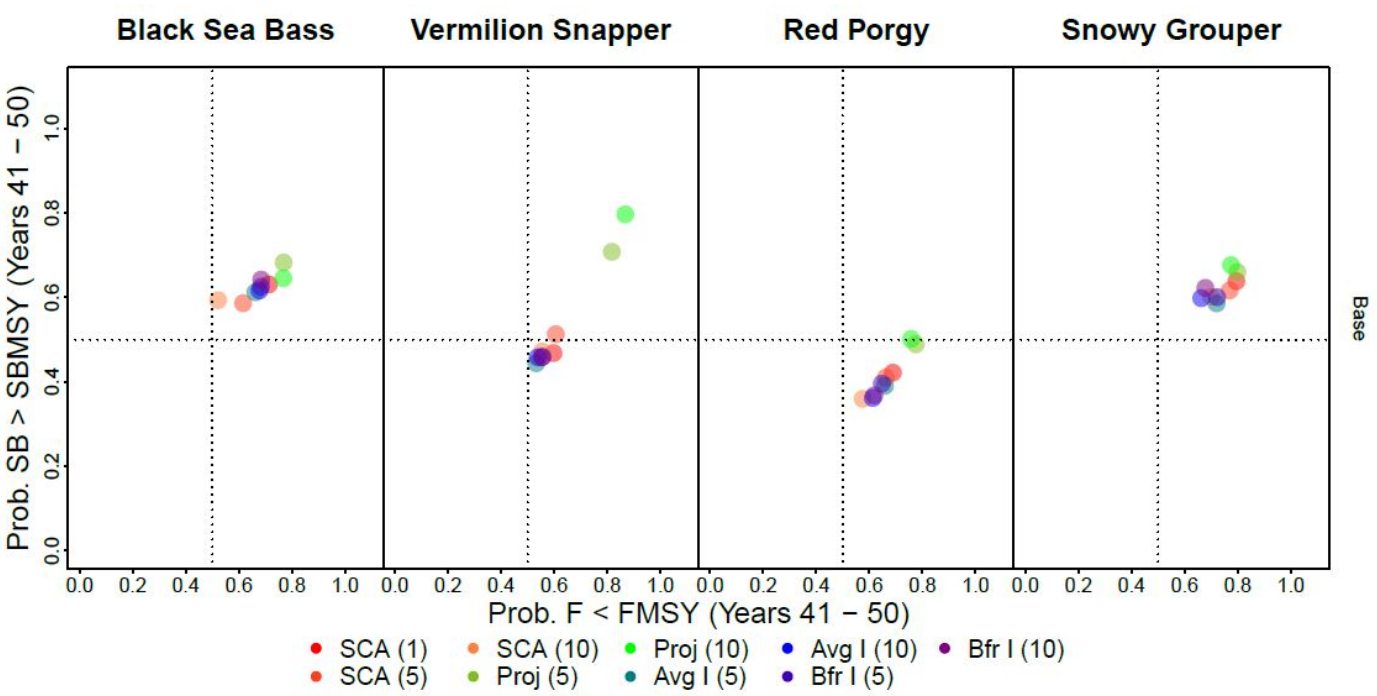


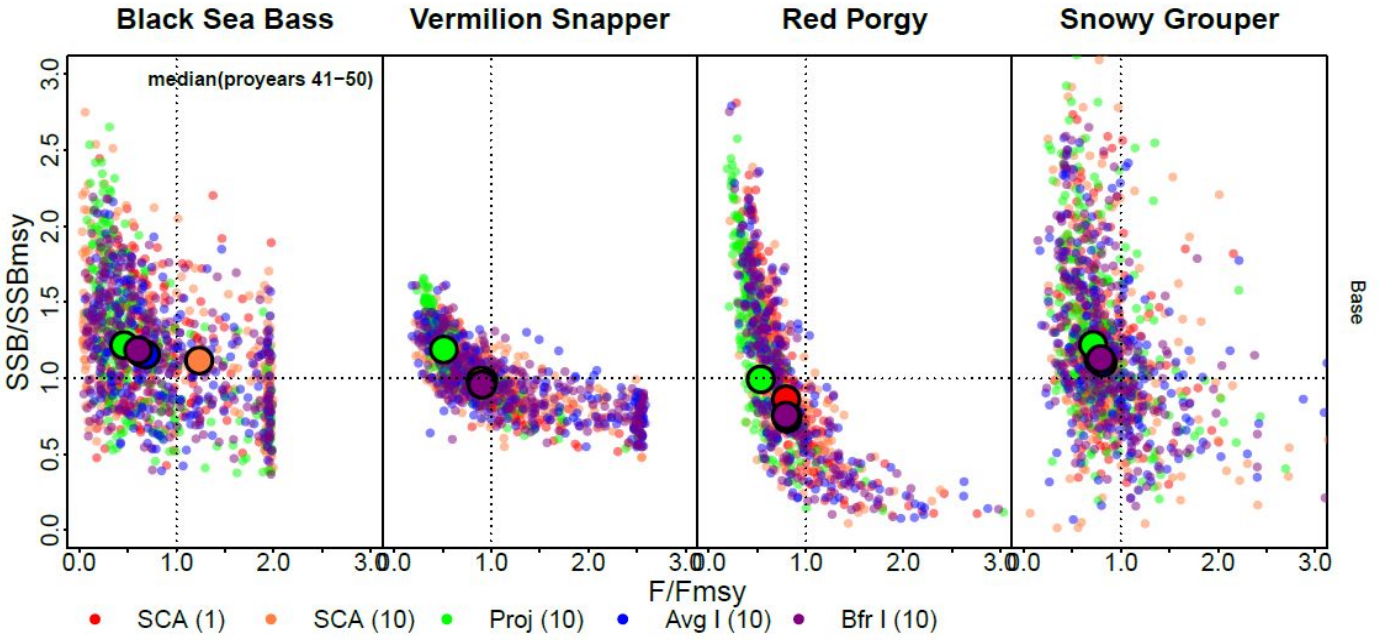
Fig. 17 (report)

	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
9	Bfr I (10)	10	adjusted by recent index buffered by SD of index

Results: Base

Phase plots

10 yr assessment interval



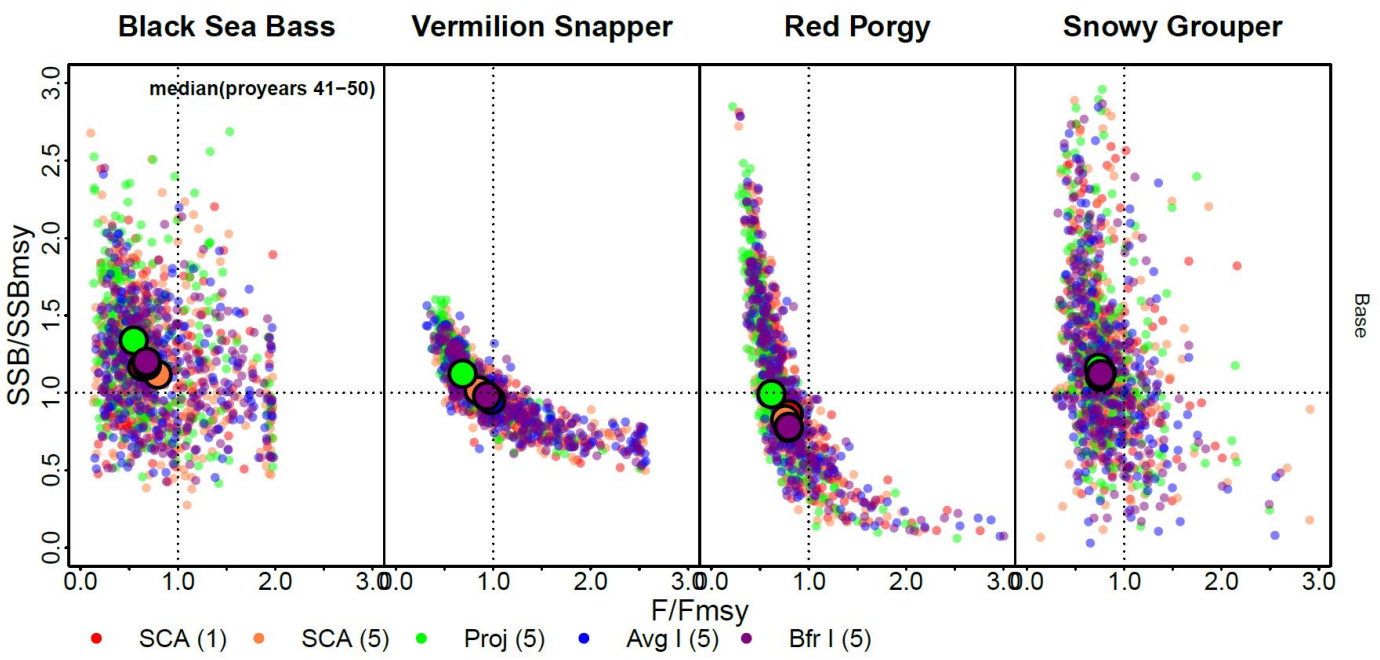
	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
9	Bfr I (10)	10	adjusted by recent index buffered by SD of index

Fig. 18, upper (report)

Results: Base

Phase plots

5 yr assessment interval



	Method	Assessment Frequency (yr)	Interim TAC
1	SCA (1)	1	fixed
2	SCA (5)	5	fixed
3	SCA (10)	10	fixed
4	Proj (5)	5	projected
5	Proj (10)	10	projected
6	Avg I (5)	5	adjusted by 3 yr moving avg. of index
7	Avg I (10)	10	adjusted by 3 yr moving avg. of index
8	Bfr I (5)	5	adjusted by recent index buffered by SD of index
9	Bfr I (10)	10	adjusted by recent index buffered by SD of index

Fig. 18, lower (report)

Results: Base

SUMMARY

- Average performance of interim MPs in the base scenario was not better than fixed TAC MPs
- Yield was more variable between years for interim MPs

Results: Alternative scenarios

SUMMARY

- Specific differences exist but results are generally similar to the base scenario

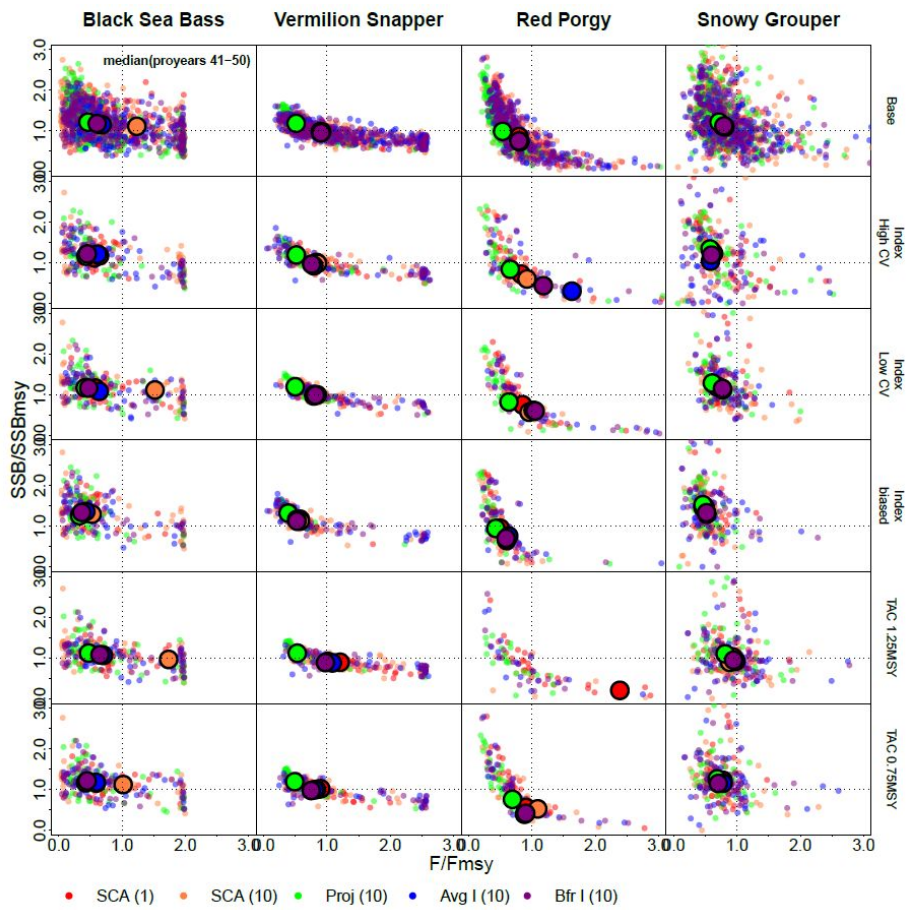


Fig. S15 (report)

Discussion

- In the current analysis, performance of interim MPs was not substantially different than the status quo approach
- Our analysis generally focused on average long term performance of MPs but other performance metrics may suggest different relationships among MPs
- If variability in yield is a concern, interim MPs could be modified such that changes in TACs need not be implemented unless the change in the index exceeds a particular value (e.g. shows a concerning decrease)
    - This could also substantially reduce the burden on management to annually modify TACs
    - Performance of such and MP could be investigated with further MSE
- Scenarios presented here assume stationarity, no model-misspecification, no implementation error
    - Further MSE work could explore these assumptions and additional “torture testing”

Discussion

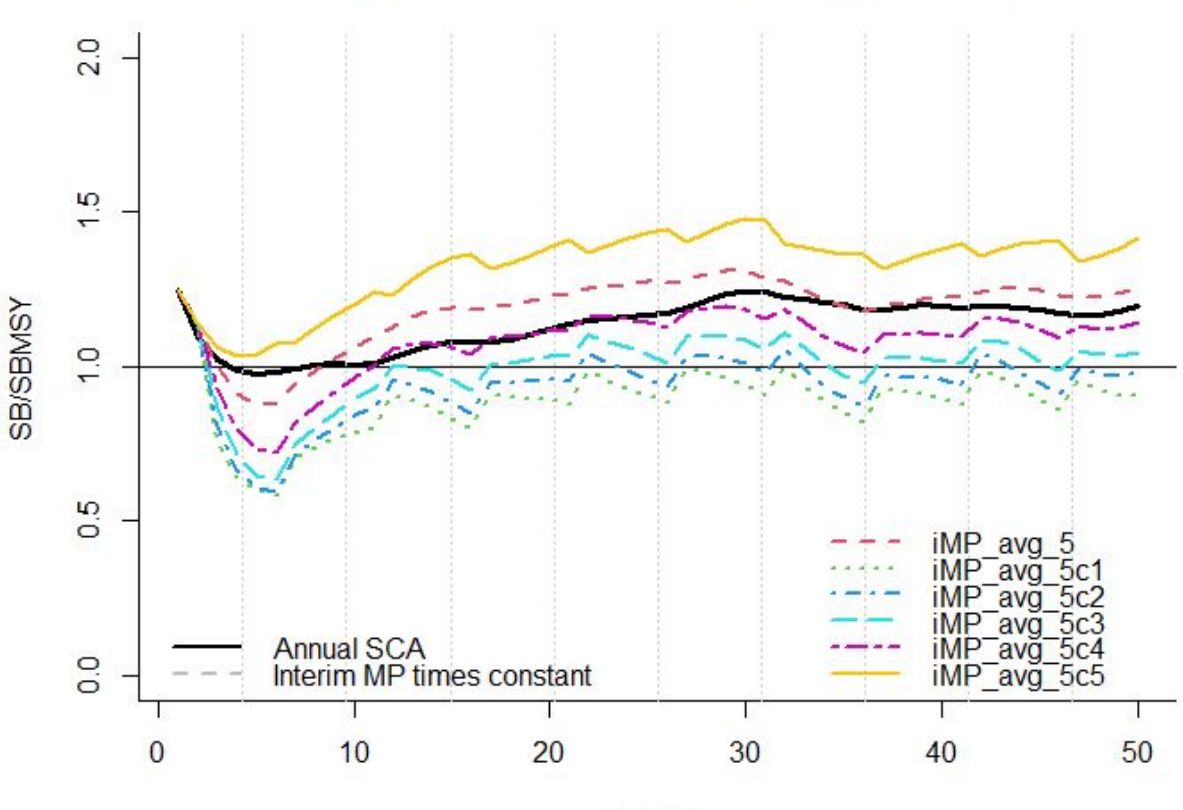
- Logistical considerations
  - Gulf of Mexico example
    - The scientific effort of running an interim analysis is only about 1 week of analyst time per year
    - Time between completion of interim analysis and implementation of management is about 12-18 months
    - Recently proposed process could shorten this timeline: (https://gulfcouncil.org/aug-council-meeting-2022/; “Mechanisms and Options for Automating Catch Advice from Interim Analysis”)
  - Recall that current analysis presented here assumes that new TACs are implemented in at the start of year *y*+1, where the interim analysis is completed in year *y*, based on the index from year *y*
    - For current fishery independent indices, the updated value for year *y* is usually not available until Jun-Aug of year *y*+1, so the earliest that management could likely be implemented is *y*+2

Discussion

- Topics for consideration
  - How well would interim MPs have to perform in order to compensate for increased variability in yield?
  - What performance metrics are most important to the SAFMC?
  - How quickly could catch advice from interim analyses be implemented?
    - If the interim analysis methodology was reviewed and approved in advance, could the review of catch advice be simplified or waved for relatively minor changes in a reference index, to implement changes to TACs more quickly?

EXTRA MATERIALS

Example of how interim assessment can be modified to adjust MP performance (e.g., multiply by a constant) applied to black sea bass “base” OM



EXTRA MATERIALS

Interim assessment performance across longer interim periods for black sea bass “base” OM

(where black solid line is annual assessment)