Review of MP design for blue shark in the Indian Ocean

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Background and motivation

Objective

Propose candidate Management Procedures (MPs) for blue shark in the Indian Ocean.

- Management procedures (MP) have been adopted by IOTC for bigeye tuna, skipjack and swordfish [5, 7, 6];
- MPs were developed using simulation (Management Strategy Evalution; MSE);
- The Commission, at its 28th session, mandated the Scientific Committe to develop an MP for BSH using MSE;
- The current project is intended to develop candidate MPs for BSH for consideration by the TCMP in May 2027.

Blue shark (*Prionace glauca*)

Figure 1: Blue shark (*Prionace glauca*); Diego Delso, CC BY-SA 4.0

The most frequently caught species in the Indian Ocean, commonly captured as bycatch but also supports targeted fisheries for several fleets.

Compared to other pelagic sharks, data availability for the blue shark is more comprehensive, which allows the application of an integrated Stock Synthesis assessment model.

Blue shark (*Prionace glauca*)

Figure 1: Blue shark (*Prionace glauca*); Diego Delso, CC BY-SA 4.0

Assessment models currently exist in the Indian [9], Atlantic [4] and Western Pacific Oceans [8].

Both the need for management and the availability of an assessment motivate the development of an MP for BSH, which would be the first for a pelagic shark species.

MP design and testing

For an MP to be useful:

1. It must be able to extract information on stock status from observable data (e.g., an index of abundance);
2. It must be able to control the fishing mortality through a management recommendation (e.g., TAC).

MP Questions:

- What informative data are available?
- How can fishing mortality be controlled?

MP design and testing

To design and test an MP using simulation (MSE):

1. We need a simulation model (Operating Model; OM);
2. We need managment objectives against which the MP can be evaluated.

MSE Questions:

- Can we build an operating model?
- What are we *managing for*...?

MP design and testing

A review of the stock assessment for BSH provides information on:

- What informative data are available that might be useful for an MP;
- Whether we are likely able to build an operating model using the stock assessment.

Data and assessments for blue shark

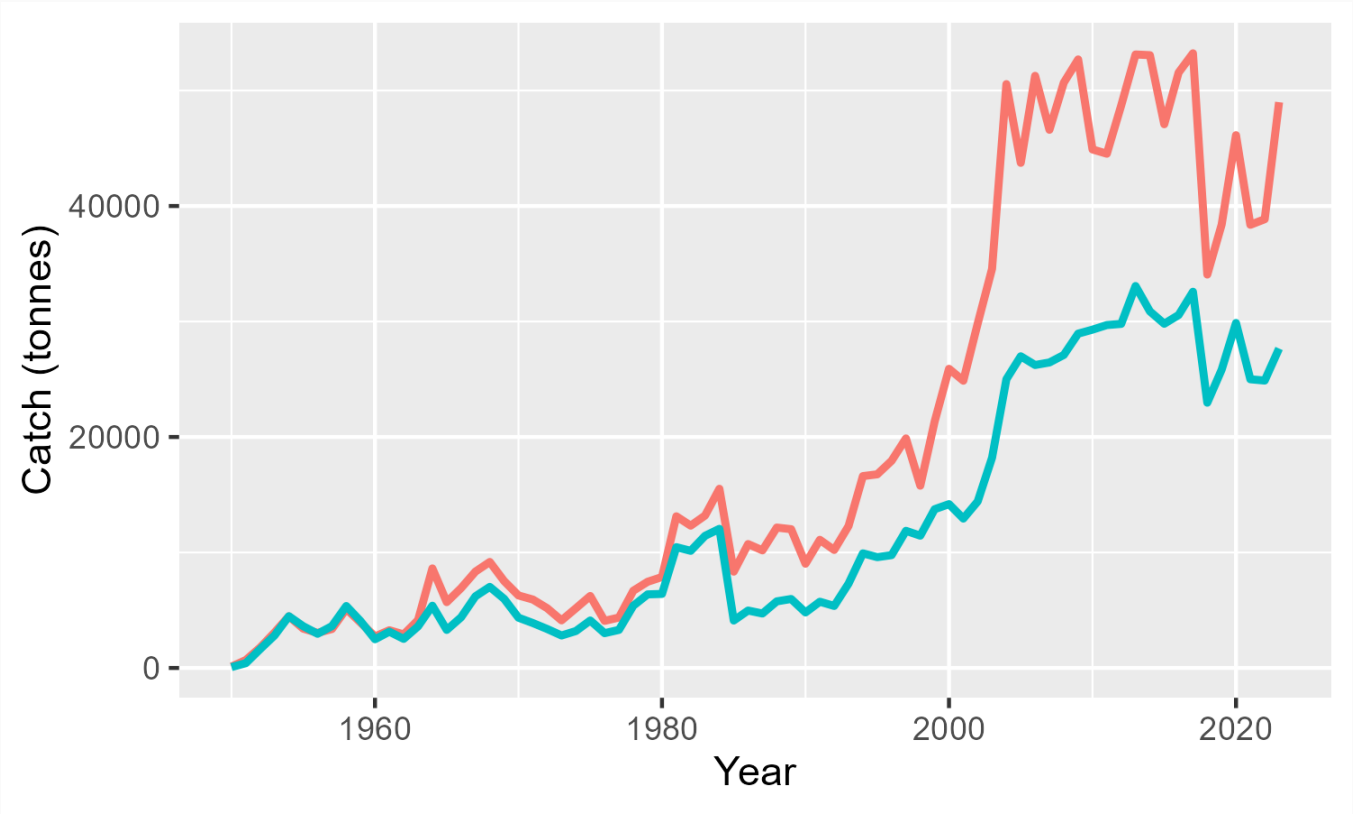

Figure 2: Catch time series for blue shark in the Indian Ocean. High and Low scenarios are shown [2].

Data and assessments for blue shark

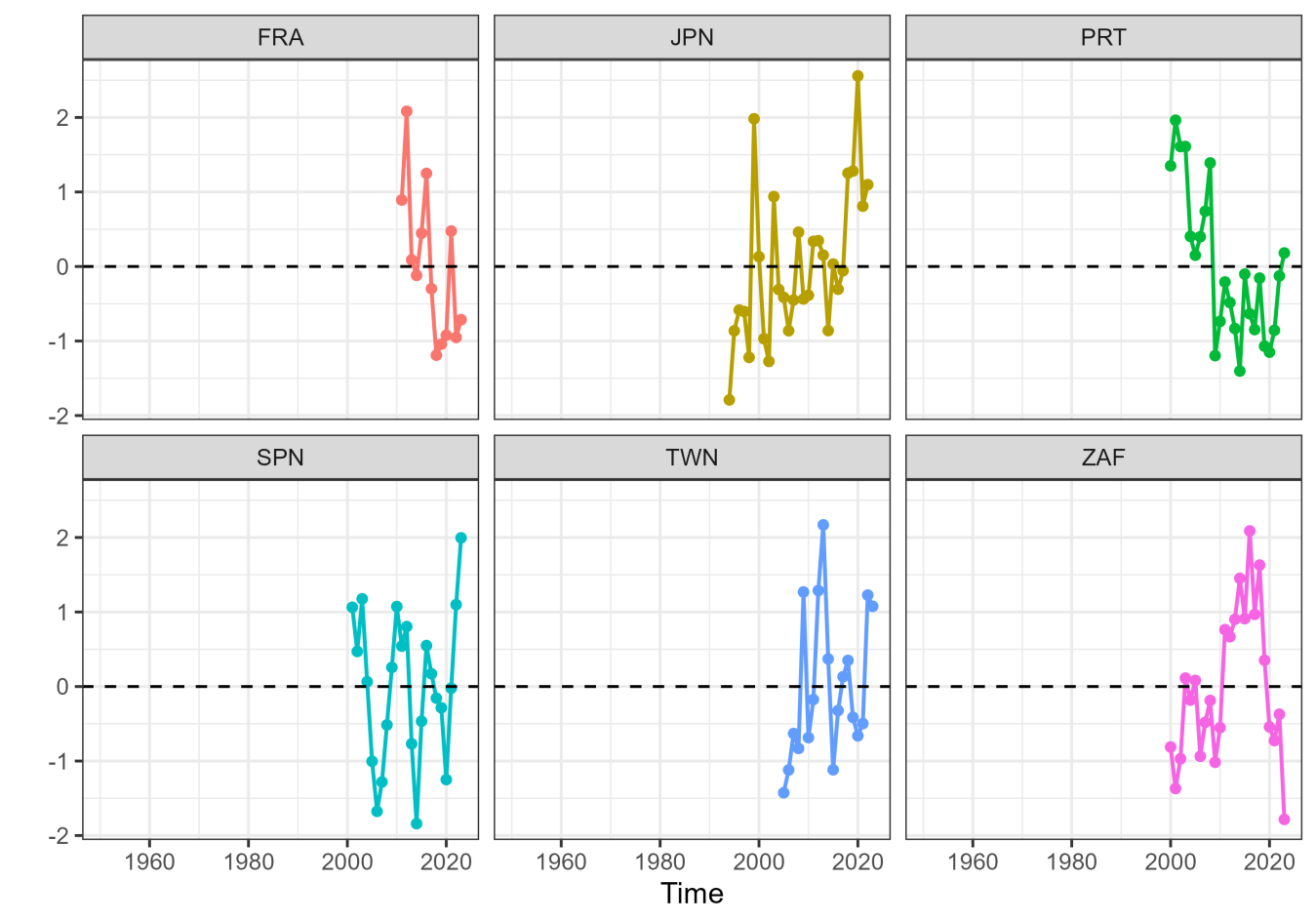

Figure 3: Catch rate abundance indices for blue shark in the Indian Ocean [2].

Data and assessments for blue shark

A simple surplus production model is not able to estimate the population size from catch and abundance data.

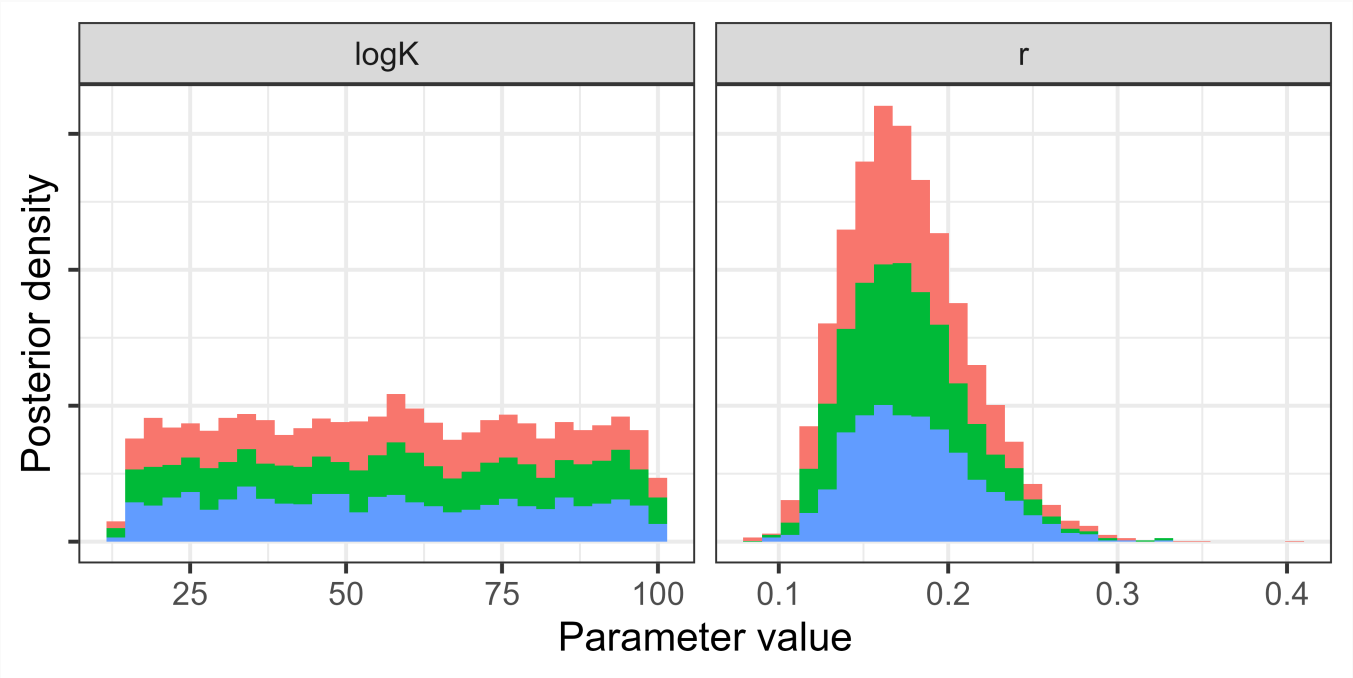

Figure 4: Posterior probability distributions for $\log(K)$ and r generated from a surplus production model fitted to the abundance data in Figure 3 and assuming the high catch scenario in Figure 2. Independent chains are indicated by different colours.

Data and assessments for blue shark

The Stock Synthesis assessment model likely obtains information on fishing mortality from the length-frequency data.

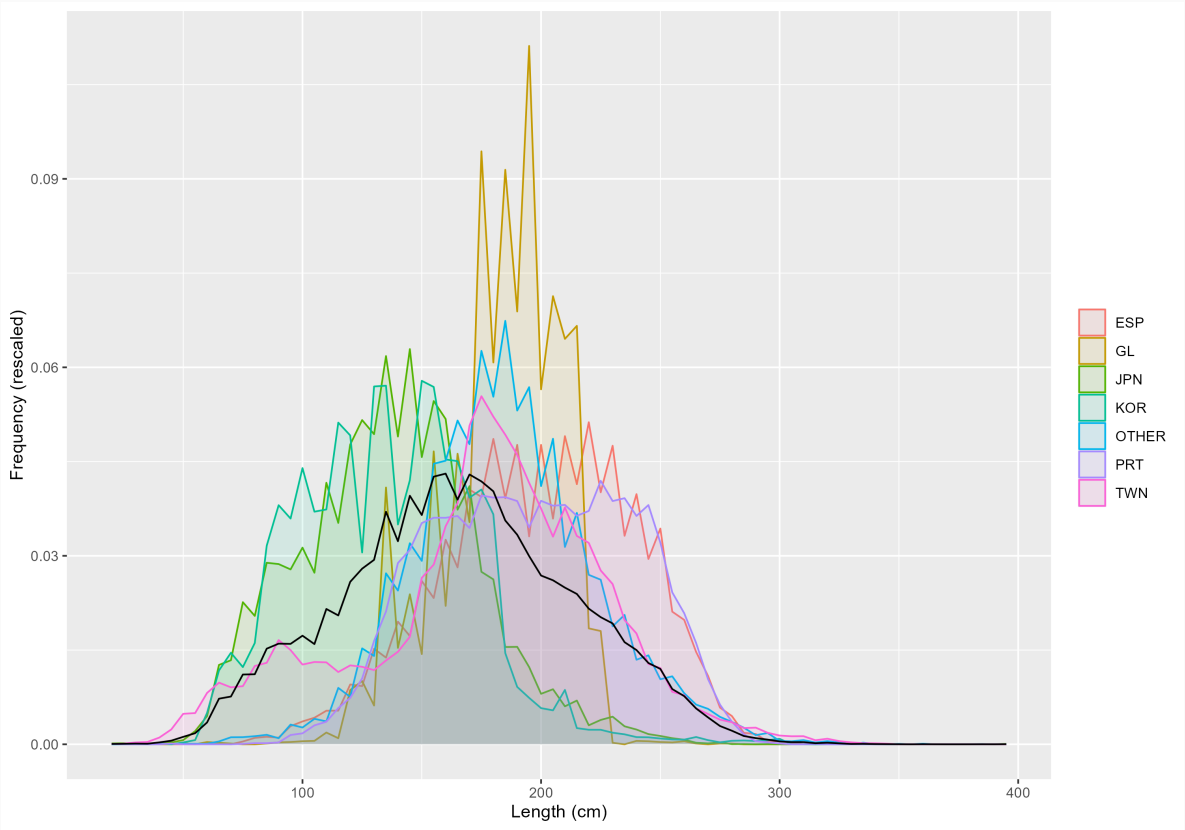

Figure 5: Length frequency data for blue shark in the Indian Ocean, aggregatted across years and renormalised to the same scale [9].

Data and assessments for blue shark

Conclusions:

- Catch rate indices do not appear to provide information on the stock status or fishing mortality;
- Length-frequency data are likely the most informative data currently available;
- Substantial uncertainties exist in the catch (and discard) data.

Despite the limitations in the data, the current Stock Synthesis assessment model is still able to represent the data being provided to it, indicating that it provides a reasonable representation of the system dynamics:

$\Longrightarrow$ assessment model is likely suitable as the basis for an OM.

Data and assessments for blue shark

MP inputs:

- At present there is no evidence that catch-rate data are informative (even if they might be);
- Length frequency data may provide the most reliable information with which to inform an MP;
- Standardised data from target fisheries would likely be the most suitable;
- Information on stock status could possibly be obtained from simple models designed for this purpose;
- Likely sensitive to assumptions regarding selectivity and discarding.

MP design and testing

MP Questions:

- What informative data are available? Length-frequency data likely the most informative.
- How can fishing mortality be controlled?

MSE Questions:

- Can we build an operating model? Likely able to build an OM based on the current Stock Synthesis assessment model.
- What are we *managing for*...?

MP design and testing

Management measures are required that are suitable for both target and bycatch fisheries. For example, EU longliners can target both swordfish (SWO) and BSH, whereas Japanese longliners target tuna with BSH as bycatch.

MP outputs:

- A catch limit (TAC) may be less suitable for a bycatch species, because there is a risk that it will limit fishing on targetted tuna or SWO;
- Management measures are required that will limit fishing mortality on BSH but without enforcing a significant reduction in the fishing effort for target species.

Size-based management measures

Population productivity of blue shark is likely dependent on the survivorship of juveniles, with protection of juveniles considered beneficial [3, 10, 1].

- Minimum size limits have the potential to limit fishing mortality without restricting target effort;
- Could be used in conjunction with a TAC.

Size-based management measures

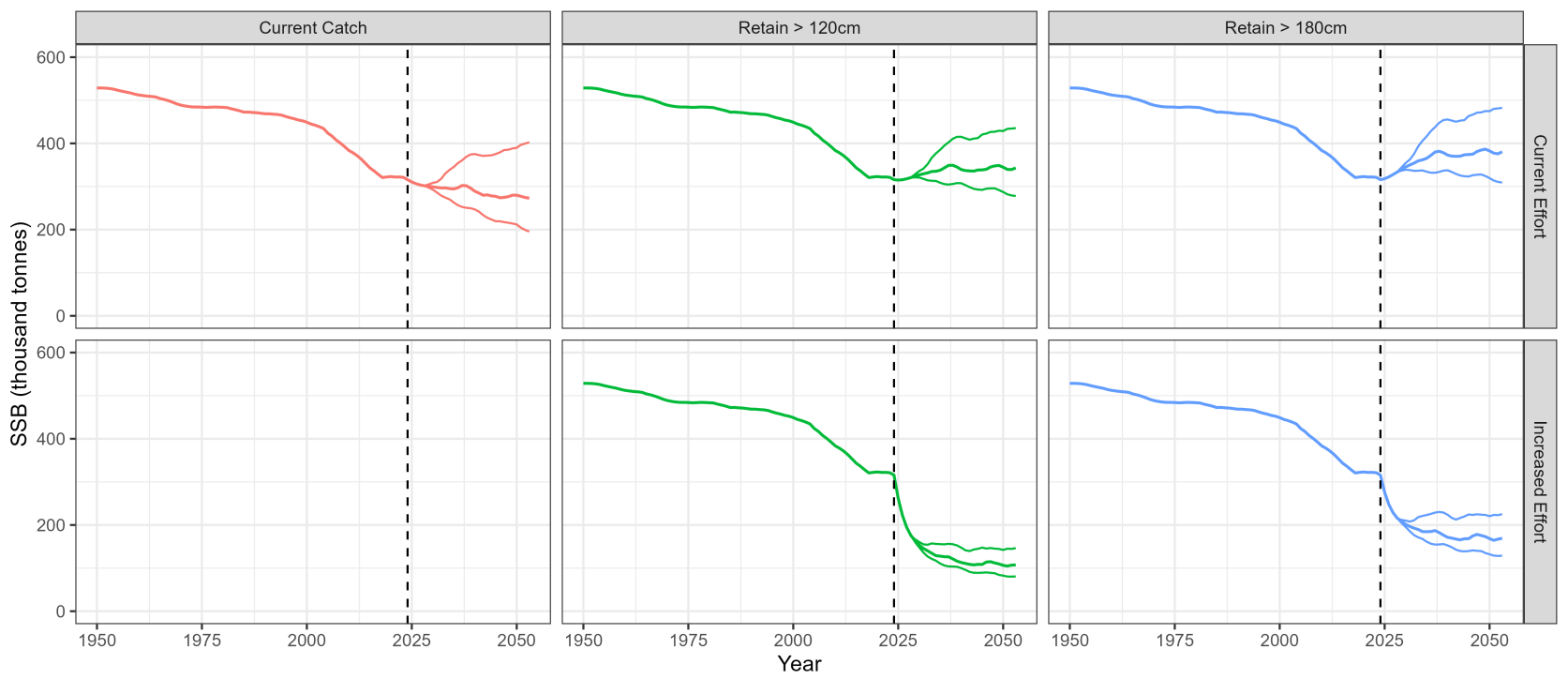

Figure 6: Population projections with fishing mortality determined by a constant catch or size limits. For the size limit, catch is determined by the effort. Two effort scenarios are shown, with an effort input equal to the current effort or increased by 500%. The projection model conforms to that of [9].

Size-based management measures

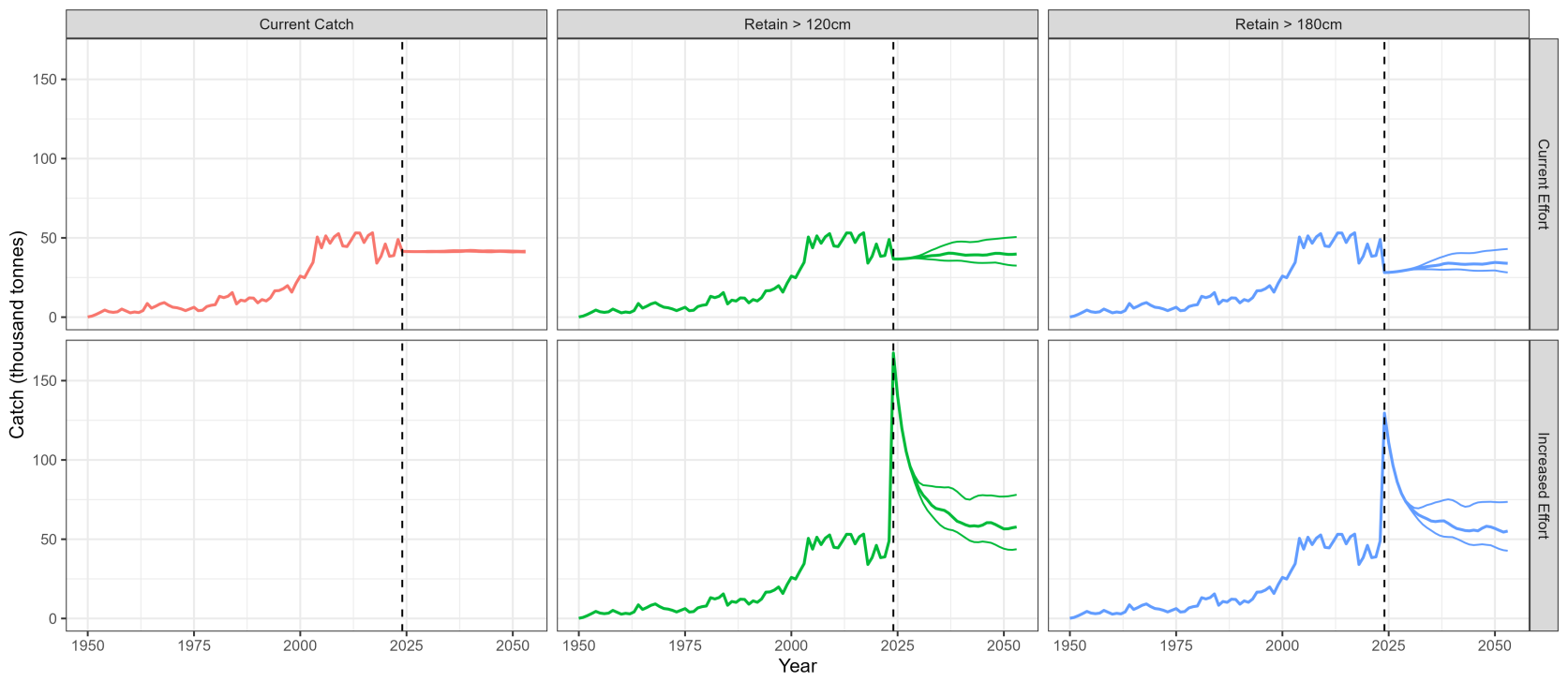

Figure 7: Predicted catch associated with the projections in Figure 6.

Size-based management measures

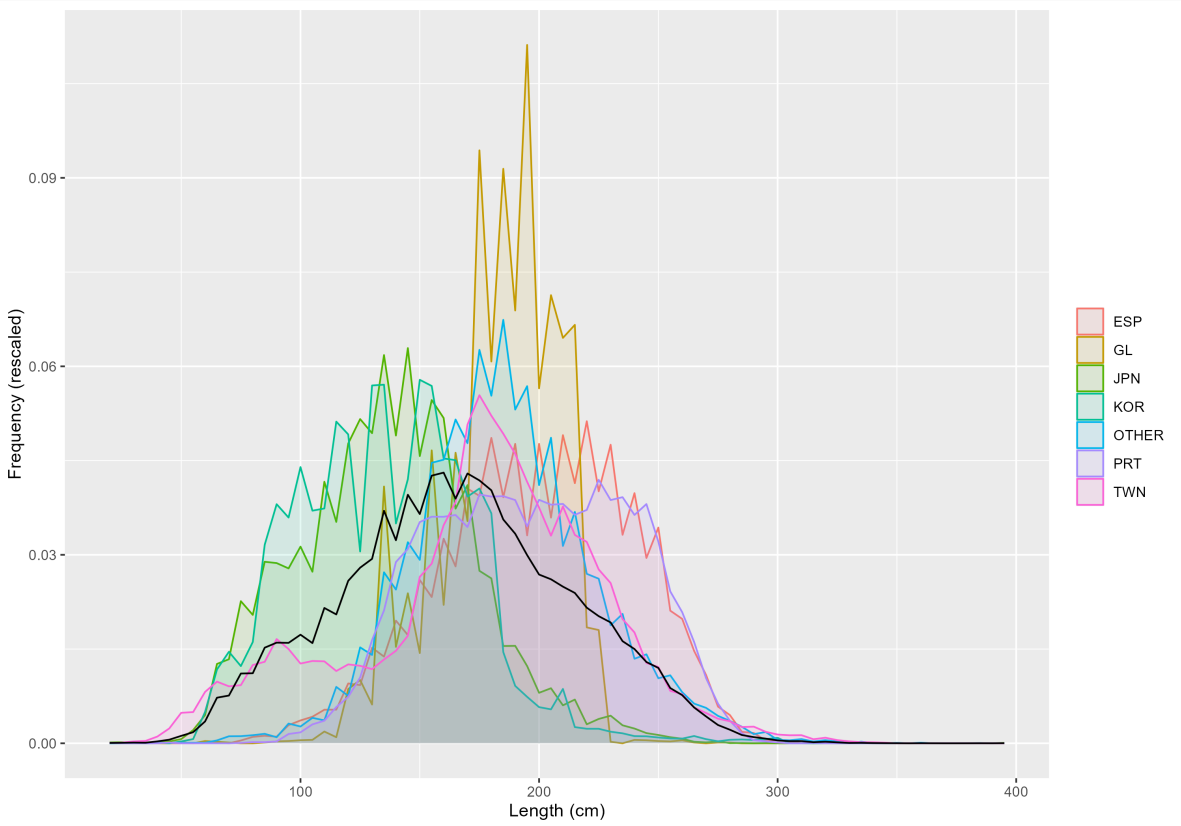

Figure 8: Length frequency data for blue shark in the Indian Ocean, aggregatted across years and renormalised to the same scale [9].

Size-based management measures

Size limits:

- Can limit fishing mortality and therefore protect sustainability of the stock;
- Do not necessarily limit the total catch;
- Provide an incentive to discard.

Caveats:

- Effect different fleets differently, due to their selectivities;
- This may create barriers to acceptance.

MP design and testing

MP outputs (Option 1):

- Fixed size limit;
- Fixed TAC.

MP outputs (Option 2):

- Fixed size limit;
- Fixed TAC; but monitor CPUE or length-frequency for signs of stock collapse.

MP outputs (Option 3):

- Fixed size limit;
- TAC set via feedback control using estimates of population status from length-frequency data.

MP design and testing

MP Questions:

- What informative data are available? Length-frequency data likely the most informative.
- How can fishing mortality be controlled? Both size limits and a TAC could be used.

MSE Questions:

- Can we build an operating model? Likely able to build an OM based on the current Stock Synthesis assessment model.
- What are we *managing for*...?

Management objectives

MP evaluation:

- Population sustainability objectives are not yet defined;
- Likely impossible to estimate MSY given uncertainties in the available catch data;
- Unclear whether objectives should consider numbers caught or weight;
- Management may impact fleets differently depending on whether BSH is targetted;
- Target or bycatch fleets are yet to be propertly defined.

Conclusions

Construction of an MP for BSH is likely feasible, given the available data and potential management measures. However, the management framework, including objectives and likely acceptance of a size-based approach, is not yet clear.

Outstanding questions:

1. How feasible or desireable would it be to implement a minimum size limit?
2. Could a TAC for BSH be implemented despite potential for conflict with SWO and tuna target fisheries?
3. How should catch return be measured: numbers or weight?
4. How should population sutainability targets be defined?
5. How should target or bycatch fisheries be defined?

Conclusions

Acknowledgements:

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- IOTC Working Party on Methods (Victoria, Seychelles, 27–28 October, 2025)
- Tom Carruthers and Adrian Hordyk (Blue Matter Science, Vancouver, Canada).

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