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ROSENSTIEL SCHOOL of MARINE, ATMOSPHERIC & EARTH SCIENCE

The effect of life history uncertainty on rebuilding times for the northwest Atlantic scalloped hammerhead shark (*Sphyrna lewini)*

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Abstract

- This study uses the open-sourced modeling software JABBA to conduct Bayesian surplus production models of northwest Atlantic scalloped hammerhead sharks (*Sphyrna lewini)*
- A sensitivity analysis was conducted by varying life history characteristics and all three life history scenarios indicate the population is recovering well within a short timeframe

Introduction

- Large sharks are vulnerable to overfishing due to their large size and slow growth
- Many sharks are data limited, making it difficult to implement management plans (1)
- Northwest Atlantic *S. lewini* faced heavy fishing in the early 1980s and once again in the early 1990s
- They are protected under CITES Appendix II and the Endangered Species Act but are still caught illegally and as bycatch
  - Sought after for their large fins
- This study aims to assess the population of northwest Atlantic scalloped hammerheads and perform a sensitivity analysis based on a reasonable life history range
- The stock assessment can help determine if the population is overfished and what the timeline for recovery is

Methods

- Catch and catch per unit effort (CPUE) data were sourced from SouthEast Data, Assessment and Review (SEDAR)
- Just Another Bayesian Biomass Assessment (JABBA) (2) was run through R (3)
- 3 life history scenarios were created by varying life history characteristics:
- The intrinsic rate of population increase (r) was given a prior mean of 0.089, 0.104, and 0.121 for low, medium and high respectively (4,5)
- A minimum fixed observation error of 0.1 was set, an informative gamma prior of (0.001,0.001) was used and an initial biomass depletion prior of 0.9 with a CV of 0.25 was set
- Forward projections were created with fishing scenarios based on a proportion of MSY

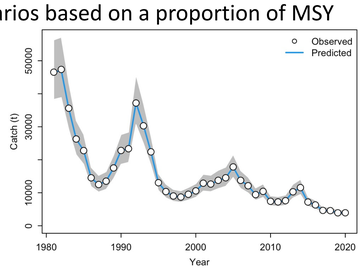

Figure 1: *S. lewini* catch time series

Results

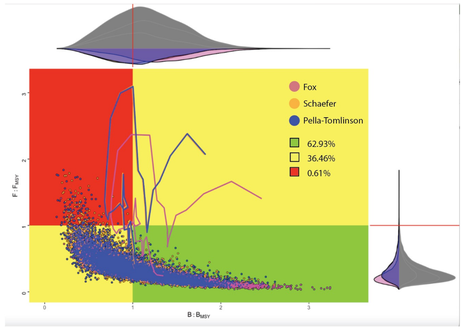

Figure 2: Kobe plot for low life history scenario combined run

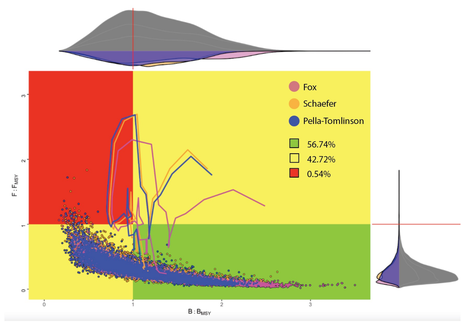

Figure 3: Kobe plot for medium life history scenario combined run

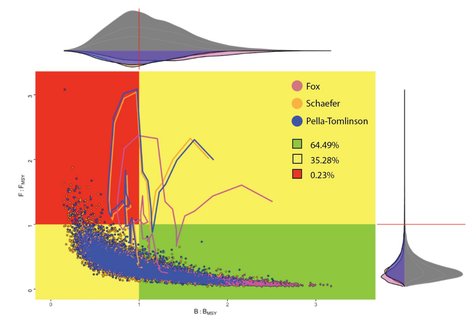

Figure 4: Kobe plot for high life history scenario combined run

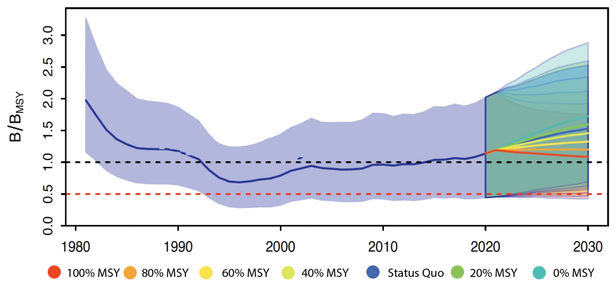

Figure 5: Biomass trajectory for low life history scenario combined run

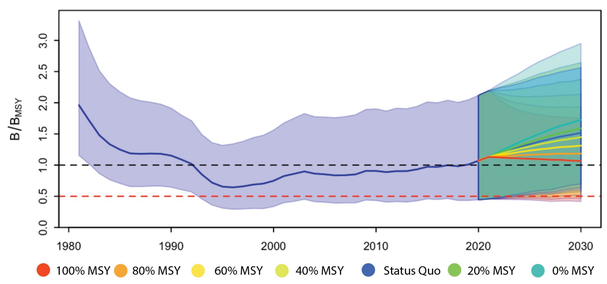

Figure 6: Biomass trajectory for medium life history scenario combined run

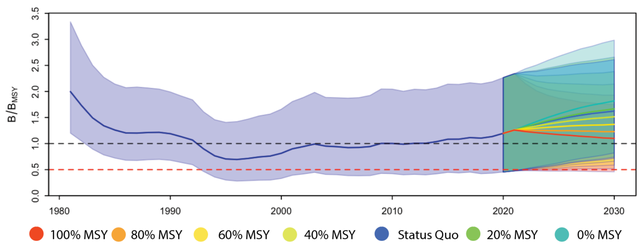

Figure 7: Biomass trajectory for low life history scenario combined run

Run	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fsq	67%	70%	74%	77%	79%	81%	83%	85%	86%	87%
0%	67%	72%	76%	80%	83%	86%	87%	89%	90%	92%
20%	67%	71%	74%	78%	81%	83%	85%	87%	88%	89%
40%	67%	70%	73%	75%	78%	79%	81%	83%	84%	85%
60%	67%	69%	71%	73%	74%	75%	77%	78%	79%	80%
80%	67%	67%	68%	69%	70%	70%	71%	71%	71%	72%
100%	67%	66%	66%	65%	65%	64%	63%	62%	61%	61%

Figure 8: Probability that B > Bmsy for low life history scenario combined run

Run	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fsq	62%	67%	71%	75%	78%	80%	83%	85%	86%	87%
0%	62%	69%	75%	79%	83%	86%	88%	90%	91%	92%
20%	62%	68%	73%	77%	80%	83%	85%	87%	88%	90%
40%	62%	67%	70%	74%	77%	79%	81%	83%	84%	85%
60%	62%	65%	68%	70%	72%	74%	75%	77%	78%	79%
80%	62%	64%	65%	66%	68%	68%	69%	69%	70%	70%
100%	62%	62%	62%	62%	61%	61%	61%	60%	59%	59%

Figure 9: Probability that B > Bmsy for medium life history scenario combined run

Run	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Fsq	70%	75%	78%	81%	84%	86%	88%	89%	90%	91%
0%	70%	76%	81%	84%	87%	89%	91%	93%	94%	95%
20%	70%	75%	79%	82%	85%	87%	89%	90%	91%	92%
40%	70%	74%	77%	79%	82%	83%	85%	86%	87%	88%
60%	70%	72%	74%	76%	78%	79%	80%	81%	82%	83%
80%	70%	71%	72%	72%	73%	73%	74%	74%	74%	74%
100%	70%	70%	69%	68%	67%	66%	65%	65%	63%	63%

Figure 10: Probability that B > Bmsy for high life history scenario combined run

Discussion

- The high life history scenario is the most optimistic currently and in the future across all fishing levels
- The low life history scenario is more optimistic than the medium scenario in the present
- The medium life history scenario is more optimistic in the future at low levels of fishing
- There is natural variability associated with the standard deviation and this could account for differences
- All life history scenarios have a similar and positive outlook for current stock status
- The rebuilding target for most sharks is 70% probability of recovery and it is reached in all scenarios except low and medium life history runs with fishing at 100% MSY (maximum sustainable yield)
- The status quo represents current fishing and passes 70% in all three models by 2023
- While these outlooks are positive, they do not measure spawning stock fecundity and incorporating this usually results in a more pessimistic analysis
- Commercial fishing is also more common in the Pacific and threatens *S. lewini* there

Future Studies

- JABBA does not factor in spawning stock fecundity
- Simple Stock Synthesis is a good alternative for simple age structured modeling
- More complex age structured models would provide more accurate insight and predictions of population
- Continuing to gather catch and CPUE data is important in updating current and future predictions of biomass

Acknowledgements

I would like to thank Dr. Elizabeth Babcock for her endless guidance. She was extremely generous in her time spent helping me learn everything I know. I would also like to thank Dr. Catherine Macdonald and Dr. William Drennan for their support in constructing and editing my thesis.

References

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(6) NOAA, 2023