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Proceedings of the Regional Peer Review on Northwest Atlantic Spiny Dogfish Framework Part 2: Review of Modeling Approaches and Assessment

Meeting dates: June 27–28, 2018
Location: Dartmouth, NS

Co-chairs: Kent Smedbol and Tana Worcester
Editor: Jennifer Ford

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Canada

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

The last Department of Fisheries and Oceans Canada (DFO) Framework Review and assessment of Northwest Atlantic Spiny Dogfish occurred in 2014, using data up to 2010. Efforts to update the assessment with more recent data became progressively more difficult and, by 2015, abundance estimates for Spiny Dogfish were considered to be implausibly high. A new framework assessment for Spiny Dogfish was needed to provide updated management advice. The new framework was organized into two components, Data Inputs (Part I) and Modelling and Assessment (Part II).

Part II of the Framework Review took place on June 27–28, 2018, with the following objectives: (1) review the consequences of Part I recommendations on the assessment model for Northwest Spiny Dogfish, (2) review updated biological reference points and evaluate the status of the population relative to these reference points, (3) explore the consequences of different harvest levels on abundance and exploitation rate using the assessment model, and (4) recommend an assessment schedule that includes decision rules to trigger a new framework. The assessment model was not accepted as a basis for advice for a number of reasons, so it was not possible to meet these objectives as anticipated. In the absence of an accepted population model, it was agreed that DFO should work to provide advice based on the calibrated US spring survey index for mature females as the primary indicator of stock status in future stock assessments.

INTRODUCTION

The last Department of Fisheries and Oceans Canada (DFO) Framework Review and assessment of Northwest Atlantic Spiny Dogfish occurred in 2014, using data up to 2010 (Fowler and Campana 2015). The accepted model was a forward-projecting, stage-based, spatially explicit population dynamics model with two-time steps. Efforts to update the assessment with more recent data became progressively more difficult and, by 2015, abundance estimates for Spiny Dogfish had become implausibly high (DFO 2016). A new framework assessment for Spiny Dogfish was needed to provide updated management advice. The new framework was organized into two components, Data Inputs (Part I) and Modelling and Assessment (Part II).

Part I took place on September 19 and 20, 2017. Fishery-dependent and fishery-independent data sources from the US and Canada were reviewed, and the factors affecting dogfish catchability in the US spring survey were evaluated to develop an approach for standardization of the time series. Recommendations from this meeting have been applied to the data and used in Part II of the framework, the modeling and assessment component.

Part II of the Framework Review took place on June 27–28, 2018, with the following objectives: (1) review the consequences of Part I recommendations on the assessment model for Northwest Spiny Dogfish, (2) review updated biological reference points and evaluate the status of the population relative to these reference points, (3) explore the consequences of different harvest levels on abundance and exploitation rate using the assessment model, and (4) recommend an assessment schedule that includes decision rules to trigger a new framework.

The meeting Chair, K. Smedbol, introduced himself, followed by an introduction of meeting participants (Appendix 1). The Chair thanked meeting participants for attending the DFO Regional Peer Review Process. The Chair provided a brief overview of the Canadian Science Advisory Secretariat (CSAS) peer review process and invited participants to review the meeting Terms of Reference (Appendix 2) and Agenda (Appendix 3). This Proceedings report is the record of the discussion of the meeting.

To guide discussions, a working paper had been prepared. The meeting Chair noted that the meeting Working Paper is for the purpose of meeting discussion and is not to be distributed, cited or used in any other forum. This Proceedings document constitutes the record of meeting discussions and conclusions, and any statements within should not be attributed as being consensus-based.

PRESENTATIONS AND DISCUSSION

Working paper:	Framework Review and Assessment of Spiny Dogfish, *Squalus acanthias*, in the Northwest Atlantic. Part II: Modeling and assessment. CSAS Working Paper 2018/10.
Science Leads:	G.M. Fowler and H.D. Bowlby
Rapporteur:	J. Ford

REVIEW OF ATLANTIC SPINY DOGFISH FRAMEWORK PART I: DATA INPUTS

Presentation Summary

M. Fowler reviewed the key recommendations of Part I of the Framework Review:

- If the commercial inputs to the population model, including the US commercial catch, cannot be updated annually, it would be better to interpret spring survey trends rather than update the population model with assumed catch inputs.
- The stock definition should be used to ensure that abundance indices are calculated from consistently sampled strata.
- Stratified abundance at length estimates should be used for all years that sexed dogfish length data are available (unsexed years 1973–1979 remaining as originally provided).
- Observation errors should be specific to sex and maturity stage.
- Constant values for process error should be replaced with annual process errors, calculated relative to the realization of stratified design assumptions for each stratum-year combination.
- The intercepts estimated from quasi-binomial generalized linear model (GLM) fits to data partitioned by sex and length (pup, pelagic and demersal lengths) should be used to standardize *Bigelow* survey catches within these partitions to those of the *Albatross* survey vessel.
- In Part II of the framework assessment, two model structures will be compared: the standardized series with 1 survey catchability (q) time period, and a split unstandardized series with 2 separate survey q time periods (4 q's by sex and stage per time period).

Discussion

It was agreed that the Working Paper reflected the conclusions of the meeting, the *Northwest Atlantic Spiny Dogfish (*Squalus acanthias*) Framework Part I: Review of Data Inputs,* held in September 2017. The results of these changes were explored in the presentation of assessment modelling.

ASSESSMENT MODEL

Presentation Summary

Objective 1. Review the formulation of an assessment model for the northwest Atlantic stock which takes into account catch and abundance indices in Canada and the USA, as well as transboundary mixing.

The model developed for Atlantic Spiny Dogfish (Fowler and Campana 2015) is a forward-projecting, stage-based, spatially explicit population dynamics model with two-time steps (November–April and May–October) in each year. Individuals belong to four possible stages: adult or juvenile, males and females, and have two invariant characteristics: their sex and home region (the region a fish was born in). All US East Coast waters are included in the US region. The Canadian region is defined as the eastern waters of the Gulf of Maine, the Bay of Fundy and the Scotian Shelf (NAFO Divisions 4VWX5YZ), comprising the largest proportion of Spiny Dogfish in Canadian waters (Campana et al. 2007). Spiny Dogfish stock components in the Gulf of St. Lawrence and Newfoundland are not included.

Population components are observed by the US Spring Research Vessel (RV) survey (1968–2015) and Canadian Summer RV survey (1970–2015). Fishing mortalities by component are observed by Commercial Landings + Dead Discards (1922–2015). The model predicts the population components via recruitment, transitions between juvenile and adult stages (theta), migrations between US and Canadian waters, natural mortality (M), and fishing mortality.

As the 2013 framework assessment model became more challenging to update, there were several structural changes made to the model prior to this framework in an attempt to achieve a meaningful fit. These included adding three time series of parameters exclusive to Canadian components of the population: migration deviates (192 parameters), pupping rate estimates and maturation rate estimates (180 parameters). The percentage of the Spiny Dogfish population thought to overwinter in Canadian waters is typically less than 5%. Adding migration deviates to allow Canadian dogfish to move south in winter or pupping and maturation deviates on this same component of the population, would not be expected to have much influence on dynamics. However, such flexibility could be important if the assessment model considered only the Canadian component of the population. Extra natural mortality was also allowed on pups, a tactic used successfully in the earliest interim updates. None of these additional parameters were carried forward in this assessment.

Changes to the Assessment Model

A number of changes to the assessment model relative to the framework model were reviewed, as recommended at the Framework meeting Part I. In addition to the recommended changes to the error structure, changes included lowering the bound on annual pupping rate, standardizing the National Marine Fisheries Service spring survey time series by dividing abundance estimates from the Bigelow by the relative catchabilities of each sex and stage, and running the model with M fixed at three different values for female dogfish.

Ramifications of Changes Relative to the Framework Model

The changes presented impacted the results in several ways, relative to the Framework Model: Peak total population estimates decrease and the adult female proportion in the commercial catch increases, both of which have the effect of lowering the estimate of Maximum Sustainable Yield (MSY). However, the increase in female maturation rates and the decrease in female natural mortality increase the MSY. On balance, the MSY estimate increases from 47,350 mt to 51350 mt with the more recent catch composition, and to 69,150 mt with the lower M for females. It was noted that changes to US discard assumptions (lower now) are critical.

Overall, the model outputs from each of the three formulations of the assessment model indicated that the population of Spiny Dogfish at all life stages has increased considerably since the 1980s and is at a high level (Figure 1).

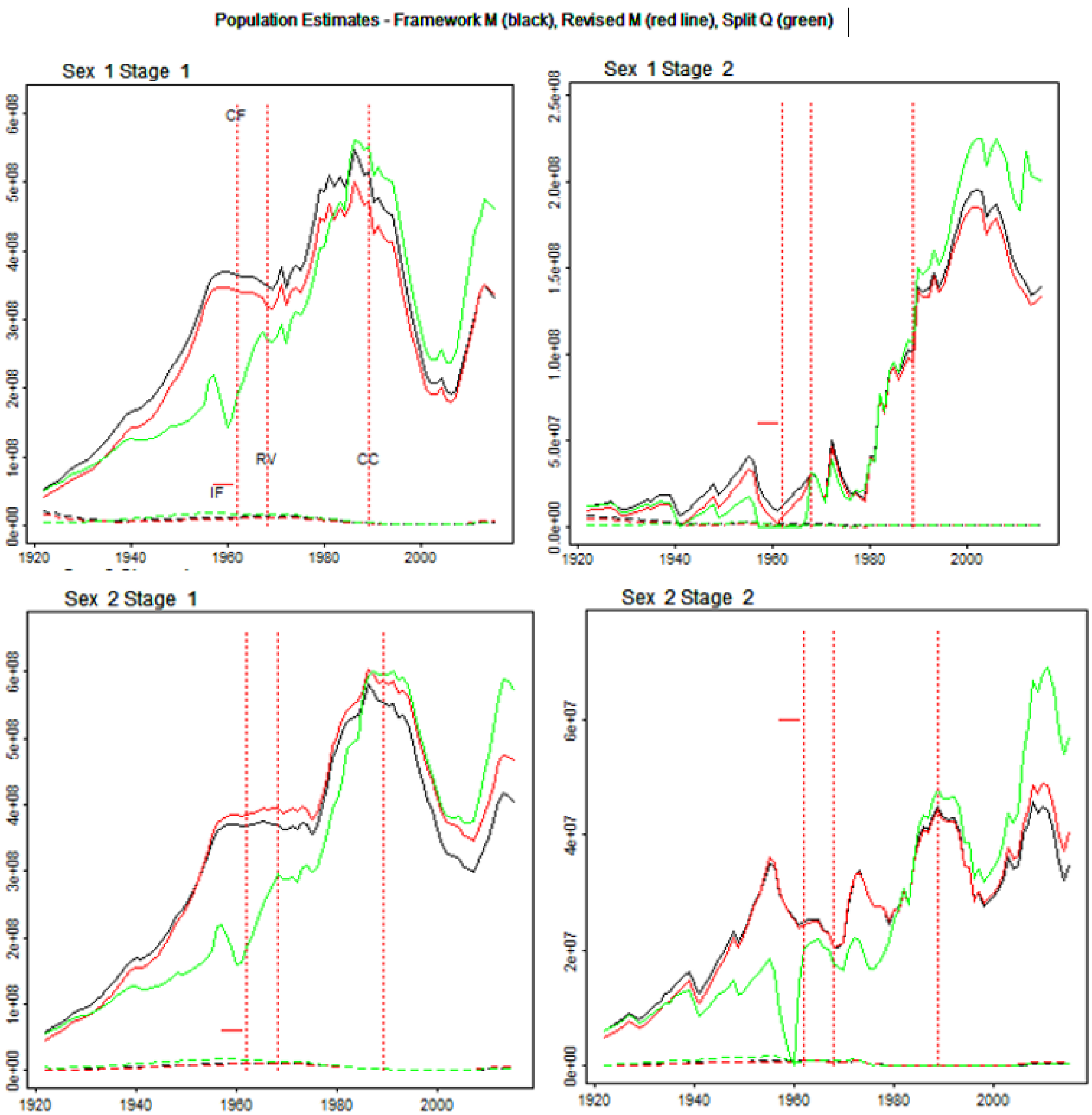

Figure 1. Comparison of the abundance trajectories predicted from the Framework M (black lines), Revised M (red lines), and Split q (green lines) formulations of the assessment model for the US (solid lines) and Canadian (dashed lines) components of the population. Dashed vertical lines denote years of interest: IF = Industrial fishery, CF = landings distinguished by fishery, RV = initiation of Research Vessel surveys, CC = beginning of catch composition data. Sex 1 = male, 2= female. Stage 1 = juvenile, 2 = adult.

Population projections were used to evaluate the long-term consequences of different harvest levels. An iterative search was done to find the harvest level (total fishery removals) that would lead to approximately 50% of the population trajectories to be above abundance at maximum sustainable yield (A_{msy}) for adult females at year 40 in the projection. This value was approximately 51,000 mt for observed life-history parameters, and approximately 48,000 mt for the model-estimated life-history parameters. For comparison, total fishery removals from Canada and the US in 2015 were 5,715 mt.

Plotting annual spawning stock number relative to annual fishing mortality gives information on population status relative to the Harvest Control Rule. For the population to be considered healthy, adult female abundance needs to be greater than A_{msy} and fishing mortality needs to be below F_{Amsy}. Data from all recent years including 2015 meets this criterion (Figure 2); suggesting that overfishing is not occurring and that the population of Spiny Dogfish is large.

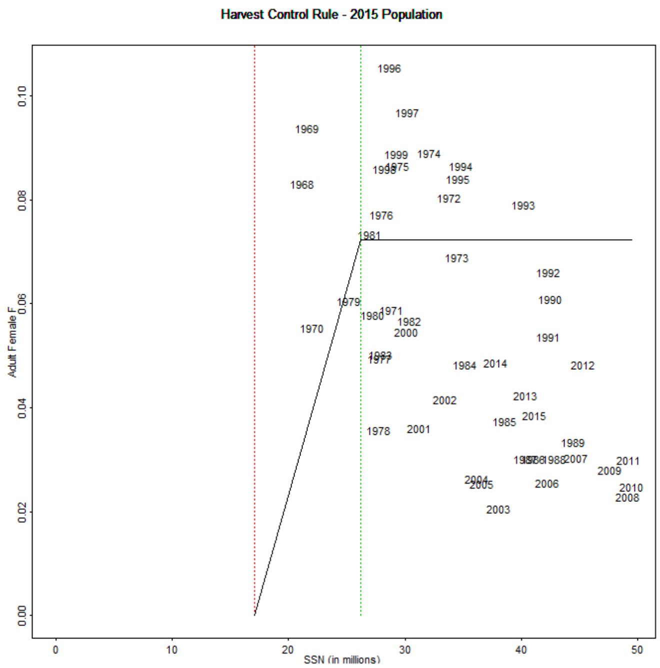

Figure 2. Harvest control rule (HCR) up to 2015, under the Framework M model formulation, showing the stock in the healthy zone according to the HCR developed from this assessment.

Sensitivity Analysis Using a Freely Estimated Catchability Parameter, q

A sensitivity analysis was presented in which the model freely estimated the catchability parameter, q, instead of bounding q between 0 and 1. The results from this model run differed markedly, with the population trajectory varying between different sexes and life stages, but declining in recent years, particularly for adult females (Figure 3). In particular, adult female biomass shows a marked decline in this sensitivity analysis to a low level that would indicate the stock is in the critical zone. For this model run, estimates of q were well in excess of 1 for many life-history stages. As a result, the sensitivity analysis was not recommended as a basis for advice.

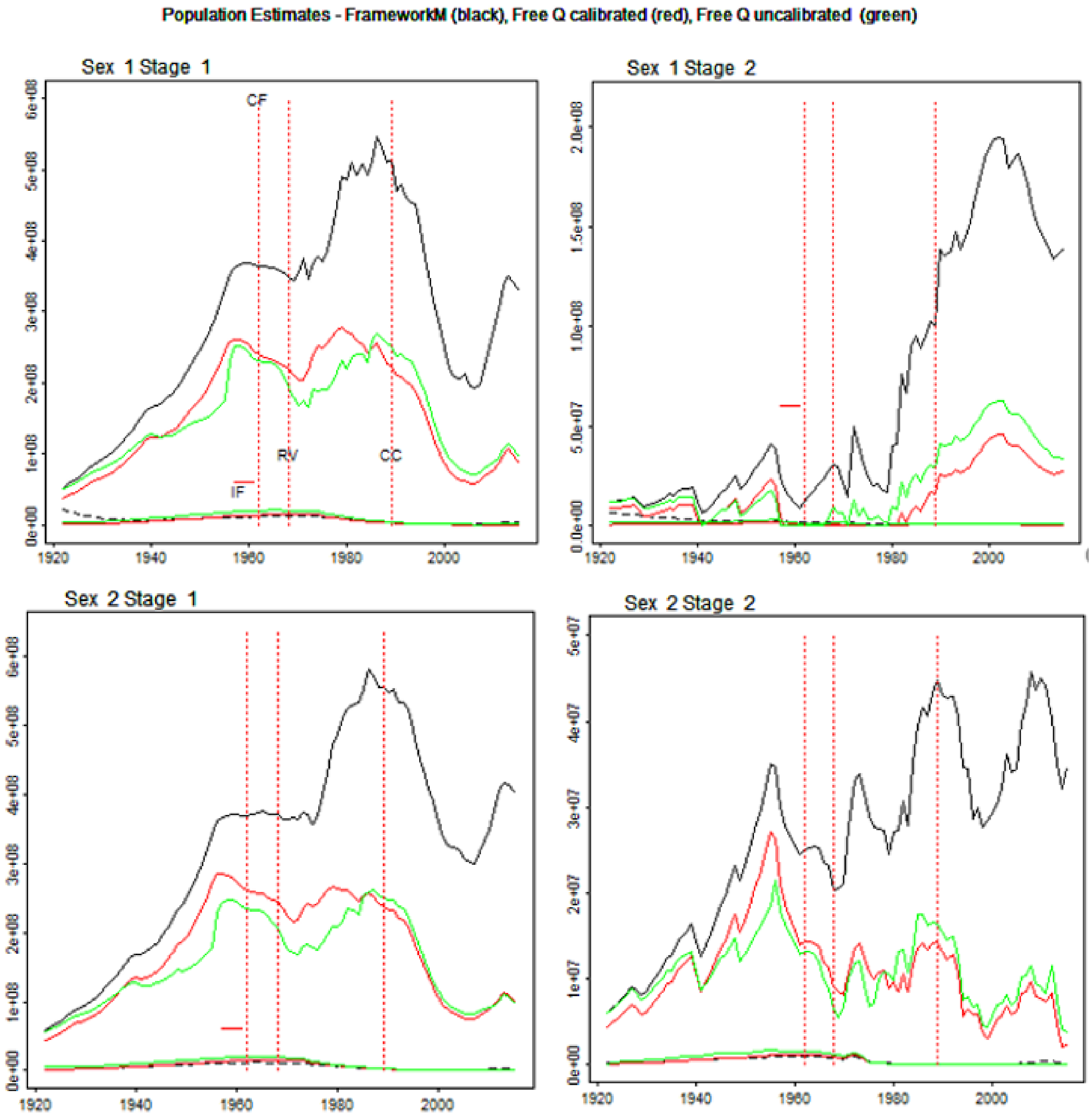

Figure 3. Population abundance estimates by sex (1 = male, 2 = female) and stage (1 = juvenile, 2 = adult), under the Framework M model (0 < q < 1; black line), compared with two model formulations that freely estimated q (red and green lines).

Discussion

The assessment model was not accepted as a basis for advice for a number of reasons, including:

- the predicted abundance trajectory was very sensitive to bounds on the US spring survey catchability (q between 0 and1) and, when these bounds were removed, abundance was scaled downwards and recent trends in abundance of adult females were reversed;
- residual patterns for pupping rates and maturation;

- lack of density-dependence in the model; and
- strong retrospective pattern in predicted abundance for adult females in recent years.

In the absence of an accepted population model, it was agreed that DFO should work to provide advice based on the calibrated US spring survey index for mature females as the primary indicator of stock status.

The implications of using such a long, time series were discussed, particularly since reliable catch data categorized by sex and life-history stage does not become available until much later in the time series. A sensitivity run was done that started the data series in 1968 (i.e., after initialization of the US spring survey), but it was determined that the trajectories and predicted abundance were similar to those when the full time series was used.

Review and Update Biological Reference Points

Objective 2. Review and update biological reference points for Northwest Atlantic Spiny Dogfish and evaluate the status of the stock up to 2015/16 in relation to these reference points. Comment on the uncertainty and relative informative value of the candidate reference points.

Since the model was not accepted, no biological reference points could be determined. Meeting participants agreed that, in the absence of model reference points, proxy reference points should be developed for review at a stock assessment meeting in December 2018, based on the adult female biomass index in the US spring survey. For example, 1988–92 was a high period for this indicator and the average biomass over this time could serve as a proxy for MSY and the Upper Stock Reference (USR), with 40% of that value as the Lower Reference Point (LRP). A second suggestion was to use 80% of the 1988–92 mean abundance as the USR. Adult female biomass estimates from the US survey alone are considered to be more variable than is biologically plausible; therefore, the average of the last 3 years was recommended as the index of stock status to be assessed relative to the reference points, and it was suggested that bootstrapping could be used to describe uncertainty. The assessment team was asked to consider these suggestions and develop a possible approach to assessing and tracking stock status for future review.

It was noted that our understanding of stock status depends on whether or not the calibrated estimates from the US summer survey are used to deal with the change from the survey vessel the Bigelow to the Albatross, with the accepted approach being to use the calibrated estimates.

Evaluation of Stock Status and Consequences of Different Harvest Levels

Objective 3. Apply the accepted framework assessment model, evaluate the consequences of different harvest levels over a 5-40 year time period on stock abundance and exploitation rate.

It was not possible to assess the consequences of different harvest levels. However, it was noted that current harvest levels in the Canadian fishery are very low. Historical directed fisheries targeted adult female dogfish, which is inherently risky given that adult females are the least abundant population component (< 5% of total biomass), time to maturity in this species is long (approximately 12 years), and targeting adult females directly reduces the reproductive capacity of the stock.

It was also noted that at this time, fishing mortality is mainly from discards, and at-sea observer coverage is currently too low to estimate discards in many fisheries that encounter dogfish. Improving the estimation of discards in other fisheries should be a priority for the management of this stock. Further, while Canadian exploitation levels are low, the US fishery is believed to be at a level that will affect the stock, which increases the amount of caution that should be employed when managing this stock in Canadian waters.

Multi-Year Assessment Framework

Objective 4. Provide recommendations on the schedule for ongoing assessment of Northwest Atlantic Spiny Dogfish. Outline a process and guidelines for the monitoring of indicators and other events (e.g., decision rules) that could trigger an earlier than scheduled assessment.

For several reasons, it was recommended that a modeling approach to Spiny Dogfish assessment not be pursued at this time. As the fishery targets adult female dogfish, which are both a small part of the overall population and the portion of most interest for stock assessment, the detailed catch composition from the US fishery is necessary. However, it is not available in a timely manner; for example, the most recent catch breakdown available for this assessment was to 2015. It was noted that if the catchability estimate (q) from the last US assessment was used (Rago and Sosebee 2015), it would be possible to estimate adult female abundance from the survey alone, although this approach is completely reliant on a single index of abundance and would be more uncertain than a model-based approach.

At the stock assessment planned for later in 2018, a threshold value (perhaps in the range of 200–1,000 t) should be recommended, such that if landings plus discard mortality pass that level, a new stock assessment would be required. In the interim, it was recommended that the following information be provided to Resource Management annually: the catch (landed and discarded) and the US adult female abundance index. Until a stock assessment is completed, the US adult female abundance index would be compared to the proxy reference points discussed above, as an indicator of stock status.

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Fowler, G.M. and Campana, S.E. 2015. Framework Assessment and 2013 Update using a Stage-based Population Model for Spiny Dogfish (*Squalus acanthias*) in the Northwest Atlantic. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/065.

Rago, P. and Sosebee, K. 2015. Update on the Status of Spiny Dogfish in 2015 and Projected Harvests at the Fmsy Proxy and Pstar of 40%. Draft Working Paper of the Mid Atlantic Fishery Management Council.

APPENDICES

APPENDIX 1: LIST OF MEETING PARTICIPANTS

Name	Affiliation
Bowlby, Heather	DFO Maritimes / Population Ecology Division (BIO)
Doherty, Penny	DFO Maritimes / Resource Management
Finley, Monica	DFO Maritimes / Population Ecology Division (SABS)
Ford, Jennifer	DFO Maritimes / Centre for Science Advice
Fowler, Mark	DFO Maritimes / Population Ecology Division (BIO)
Miller, Tim	National Oceanographic Atmospheric Administration/ National Marine Fisheries Service - Northeast Fisheries Science Center
Muise, Leo	Nova Scotia Seafood Alliance
Smedbol, Kent	DFO Maritimes / Population Ecology Division (BIO)
Stone, Heath	DFO Maritimes / Population Ecology Division (BIO)
Worcester, Tana	DFO Maritimes / Centre for Science Advice

APPENDIX 2: TERMS OF REFERENCE

Northwest Atlantic Spiny Dogfish Framework Part 2: Review of Modeling Approaches and Assessment

Regional Advisory Process – Maritimes Region

June 27–28, 2018

Dartmouth, Nova Scotia

Chairperson: Kent Smedbol

Context

The Northwest Atlantic Spiny Dogfish is a transboundary resource with significant catches in Canada and the United States (USA). The last DFO framework review and assessment of Northwest Atlantic Spiny Dogfish occurred in January and May 2014 using data up to 2010 (Fowler and Campana 2015). The accepted model was a forward-projecting stage-based, spatially explicit population dynamics model with two-time steps. Efforts to incorporate more recent data into the framework model have not been successful.

Fisheries Management has requested annual updates for Northwest Atlantic Spiny Dogfish. DFO Science has determined that a new framework assessment is required to meet this request. The first part of this framework assessment, a review of data inputs, was held in September 2017. This second meeting addresses modelling approaches and provides advice to management on the Northwest Atlantic Spiny Dogfish stock.

Objectives

The objectives of the Regional Advisory Process are to:

1. Review the formulation of an assessment model for the northwest Atlantic stock which takes into account catch and abundance indices in Canada and the USA, as well as transboundary mixing.
2. Review and update biological reference points for Northwest Atlantic Spiny Dogfish and evaluate the status of the stock up to 2015/16 in relation to these reference points. Comment on the uncertainty and relative informative value of the candidate reference points.
3. Apply the accepted framework assessment model, evaluate the consequences of different harvest levels over a 5–40 year time period on stock abundance and exploitation rate.
4. Provide recommendations on the schedule for ongoing assessment of Northwest Atlantic Spiny Dogfish. Outline a process and guidelines for the monitoring of indicators and other events (e.g., decision rules) that could trigger an earlier than scheduled assessment.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Expected Participation

- DFO Science
- DFO Resource Management
- DFO Species at Risk Management
- Indigenous Communities/Organizations
- U.S. National Marine Fisheries Service
- Fishing industry Representatives
- Invited external experts
- Environmental Non-Governmental Organizations

Reference

Fowler, G.M. and Campana, S.E. 2015. Framework Assessment and 2013 Update using a Stage-based Population Model for Spiny Dogfish (*Squalus acanthias*) in the Northwest Atlantic. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/065.

APPENDIX 3: MEETING AGENDA

DAY 1 (June 27, 2018)

Time	Topic
9:00–9:15	Welcome & Introductions
9:15–9:45	Review results of Framework meeting Part I: Data Inputs
9:45–10:30	Presentation of Assessment Modelling
10:30–10:45	Break (hospitality provided)
10:45–12:00	Presentation of Assessment Modelling cont'd
12:00–1:00	Lunch (hospitality not provided)
1:00–3:00	Assessment Modelling - Review and Discussion
3:00–3:15	Break (hospitality not provided)
3:15–4:30	Review and Update Biological Reference Points

DAY 2 (June 28, 2018)

Time	Topic
9:00–9:15	Recap of Day 1
9:15–10:30	Evaluation of Stock Status and Consequences of Different Harvest Levels
10:30–10:45	Break (hospitality provided)
11:00–12:00	Multi-Year Assessment Framework
12:00–1:00	Lunch (hospitality not provided)
1:00–3:00	Review of Science Advisory Report
3:00–3:15	Break (hospitality not provided)
3:15–4:30	Review of Science Advisory Report cont'd