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Maritimes Region

Canadian Science Advisory Secretariat
Science Advisory Report 2025/049

SCIENCE ADVICE ON REFERENCE POINTS FOR SCALLOP FISHING AREAS 25, 26, AND 27B

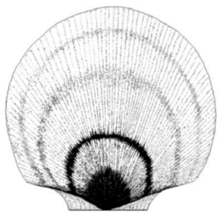

Image: Placopecten magellanicus.

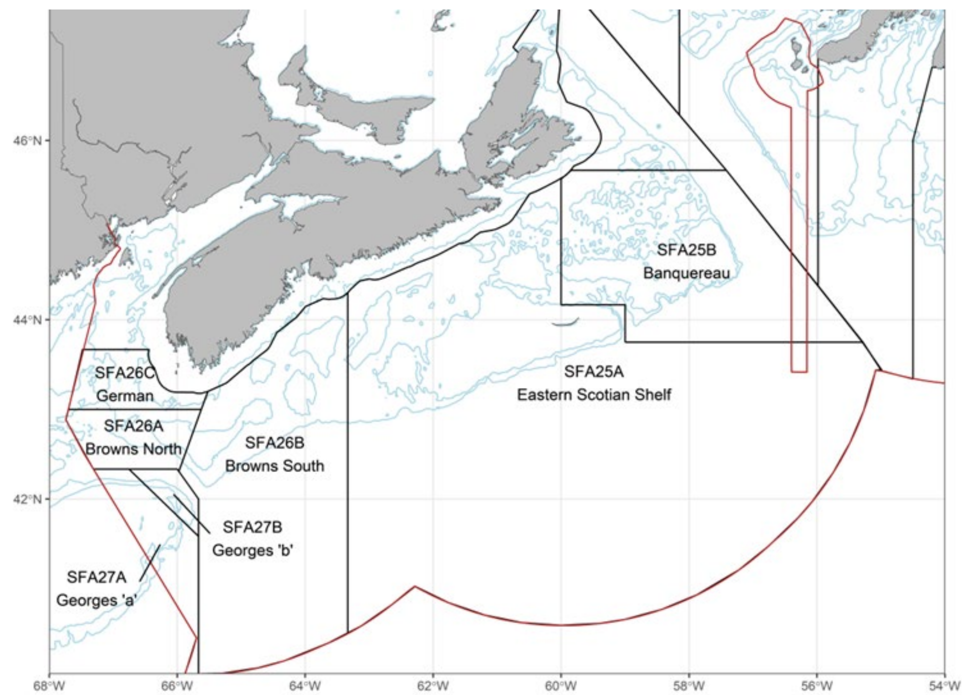

Figure 1. Map showing the offshore scallop fishing areas (SFAs; delineated by black lines) used for management purposes in the Maritimes Region. Red lines delineate the exclusive economic zones for Canada (line along the western and southern portions of the map) and France (long finger cutting through SFA 25B)

CONTEXT

In February of 2024, Fisheries and Oceans Canada (DFO) Maritimes Region held a peer review of data inputs and population modelling approaches for the development of an assessment framework for scallop fishing areas (SFAs) 25A, 26A, 26C, and 27B. The peer review identified and adopted new survey indices for SFAs 25A, 26A, 26C, and 27B, and new population models for SFAs 25A and 26A to support the provision of advice for these stocks. The development of the assessment framework for these SFAs continued with the second peer-review meeting to identify and adopt limit reference points and to provide guidance on other reference points, removal references, and the development of harvest control rules.

This Science Advisory Report is from the regional peer review of January 22–23, 2025 on Framework Development for Scallop Fishing Areas 25a, 25b, 26a, 26b, 26c, and 27b: Part 2 - Reference Point Development. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

SUMMARY

- The stock status indicator for scallop fishing areas (SFAs) 26C and 27B is the most recent three-year geometric mean of the fully-recruited survey biomass index for each area.
- The stock status indicator for SFAs 25A and 26A is the model estimated fully-recruited biomass for each area.
- Where available, model-based approaches were recommended over the survey biomass index-based approaches. Model-based approaches are preferred due to their ability to quantify uncertainty and changes in stock dynamics (productivity).
- Candidate reference points were considered based on modelled maximum sustainable yield (MSY) simulations for SFAs 25A and 26A. These simulations utilized the stock dynamics between 1994 and 2022.
- Using the model-based MSY simulations, limit reference points (LRP) were adopted for SFAs 25A at 1,160 tonnes and 26A at 2,000 tonnes; these LRPs correspond to $B_{MSY(40)}$ (40% of biomass at maximum sustainable yield).
- Candidate reference points were evaluated based on fully-recruited survey biomass index-based proxies of B_{MSY} and B_0 (unfished biomass) for SFAs 26C and 27B.
- Using the index-based approaches, LRPs were adopted for SFAs 26C at 890 tonnes and 27B at 628 tonnes; these LRPs correspond to $B_{MSY(30)}$ (30% of biomass at maximum sustainable yield).
- Guidance was provided for the development of upper stock reference points (USRs) and removal references (RRs) in all areas.
- For each of SFAs 25A and 26A, a scenario was developed using harvest decision rule simulations to demonstrate how this method could quantify the impact of alternative management objectives.

INTRODUCTION

The Atlantic Sea Scallop, *Placopecten magellanicus*, is a bivalve mollusk that occurs on the continental shelf of the northwest Atlantic from the north shore of the Gulf of St. Lawrence south to Cape Hatteras, North Carolina. In the Maritimes Region, the offshore scallop fishery harvests stocks within scallop fishing areas (SFAs) 25, 26, and 27 (Figure 1). SFA 25 encompasses the stocks on Sable Bank and Middle Bank (SFA 25A) and Banquereau Bank (SFA 25B). SFA 26 encompasses the stocks on Browns Bank North (SFA 26A), Browns Bank South (SFA 26B), and German Bank (SFA 26C). SFA 27 encompasses the stocks on Georges Bank 'a' (SFA 27A) and Georges Bank 'b' (SFA 27B). Historically, these stocks have been managed using fishery and survey indices, except for SFA 26A and 27A, which have been informed by a Bayesian delay-difference population model (Hubley et al. 2011, Hubley et al. 2014, Jonsen et al. 2009). In February of 2024, DFO Maritimes Region held a peer-review of data inputs and population modelling approaches for the development of an assessment framework for SFAs 25A, 26A, 26C, and 27B. The peer review identified and adopted new survey indices for SFAs 25A, 26A, 26C, and 27B, and new population models for SFAs 25A and 26A to support the provision of advice for these stocks. The stock status indicator for SFAs 26C and 27B is the most recent three-year geometric mean of the fully-recruited survey biomass index (hereafter referred to as the survey biomass index) for each area whereas the stock status indicator for SFAs 25A and 26A is the model estimated fully-recruited biomass for each area.

The second, and final, part of the peer review of the assessment framework included the review of reference points and a harvest decision rule (HDR) simulation. Limit reference points (LRPs) based on survey biomass indices were adopted for SFAs 26C and 27B, while in SFAs 25A and 26A the LRPs based on maximum sustainable yield (MSY) simulations were adopted. In addition to the LRPs, guidance was provided for development of upper stock references (USRs) and removal references (RRs). In SFAs 25A and 26A a HDR simulation was provided to demonstrate how this method could quantify the impact of alternative management objectives.

ANALYSIS

The LRPs were derived from estimates of the unfished biomass (B_0) or the biomass at maximum sustainable yield (B_{MSY}; Marentette and Kronlund 2020, DFO 2021, 2023). LRPs typically use 20% of the estimated B_0 ($B_{0(20)}$), 30% of B_{MSY} ($B_{MSY(30)}$), or 40% of B_{MSY} ($B_{MSY(40)}$), DFO 2009, 2021, 2023). Two USRs were provided for guidance, following a similar convention: 40% of B_0 ($B_{0(40)}$) or 80% of B_{MSY} ($B_{MSY(80)}$, DFO 2009, Marentette and Kronlund 2020). In addition to the biomass reference points, guidance on removal references was provided. Note that all scallop biomass data refer to meats measured in tonnes.

Index-Based Reference Points

LRPs were developed using the survey biomass index time series in SFAs 26C and 27B. The data for these analyses are from the DFO Maritimes Offshore Scallop Survey, 1994 to 2022. The survey biomass indices were scaled to an absolute biomass based on an assumed gear catchability of 0.33 in all areas. For SFA 26C, a liner was added to the gear in 2008 to increase the catchability of smaller scallop; therefore, the analyses for this area were limited to 2008-2022 as changes in the gear can affect selectivity (Keyser et al. In prep.[1]). It is acknowledged that this is a relatively short time period from which to derive reference points and this area will need to be closely monitored and reassessed as more information on this area is collected. In addition, SFA 27B forms part of the broader Georges Bank stock complex, recruitment for this area can be influenced by larval dispersion from outside of this management zone. It is acknowledged that the productivity of SFA 27B can be substantially impacted by ecological factors that occur outside of the management zone.

Survey index-based reference points were developed using:

1. the highest three-year geometric mean survey biomass index as a proxy for the stock's carrying capacity or unfished biomass B_0; and
2. the geometric mean of the time series as a proxy for the biomass at maximum sustainable yield (B_{MSY}).

In addition to the LRPs, guidance was provided on USRs and RRs.

MSY Simulations

The MSY simulations were undertaken for SFAs 25A and 26A using the productivity parameters from the respective stock assessment models for each area using data from 1994 to 2022. The MSY simulations explored the impact of multiple exploitation rate scenarios and utilized the

[1] Keyser, F.M., Keith, D.M., Glass, A., Pearo Drew, T., and Sameoto, J.A. In prep. Framework Development for Scallop Fishing Areas 25a, 25b, 26a, 26b, 26c, and 27b: Data Inputs. DFO Can. Sci. Advis. Sec. Res. Doc.

modelled productivity parameters adopted for the one-year ahead projections for the respective areas (Keith et al. In prep.[2]).

The MSY simulations build off previous MSY simulation methods developed for other scallop stocks in the Maritimes Region, with the current MSY simulations more fully characterizing the productivity dynamics of scallop than previous efforts; for example, the previous processes typically assumed a fixed level of recruitment in the simulations, while the current MSY simulations utilized the observed relationship between recruitment and stock biomass (e.g., Smith et al. 2015). More fully characterizing the productivity dynamics aligns with recommended ‘best practices’ for the development of reference points (Marentette and Kronlund 2020; Marentette et al. 2021); moreover, the methods employed for the scallop MSY simulations enabled the exploration of the impact of complex harvest strategies on the stock dynamics (see the HDR Simulations section for more details).

B_{MSY} and B_0 were estimated from the MSY simulation results. B_0 was calculated as the median biomass of the final 100 years from the simulations in which the exploitation rate was set to zero. B_{MSY} was calculated as the median biomass of the final 100 years of the simulations using the exploitation rate that resulted in the average yield from the fishery being maximized (i.e., at MSY) using the final 100 years of simulated data. The exploitation rate at B_{MSY} was the long-term target exploitation rate and this can be used to inform the setting of the RR.

HDR Simulations

The stochastic simulations developed for the MSY simulations can be used to explore scenarios that utilize more complex harvest strategies than explored in the MSY simulations (where the exploitation rate for each scenario is fixed through time). For the HDR simulations, the productivity parameters are simulated, but instead of using a fixed (constant) exploitation rate, the exploitation rate can be varied as a function of the simulated biomass. In addition, HDR scenarios can be developed that link the exploitation rates to the reference points. This enables exploration of how varying the exploitation rates at each of the reference points (often referred to as control points) will impact the stock dynamics over the long-term. A HDR scenario for each of SFAs 25A and 26A was presented as guidance and to demonstrate the utility of this approach.

For the HDR scenarios, example management objectives were evaluated; these example objectives were to

1. maintain the stock near a target reference point (TRP),
2. increase the long-term average removals from the fishery, and
3. reduce the percentage of the years that the stock was below the LRP.

The example HDR scenario results for objectives b) and c) were compared to the results from the MSY simulations scenario in which the exploitation rate resulted in the population being at B_{MSY}. In each HDR scenario, the TRP was set at the B_{MSY} estimate, the LRP was set at $B_{0(20)}$, and the USR was set at $B_{0(40)}$.

[2] Keith, D.M., Keyser, F.M., McDonald, R., Pearo Drew, T., and Sameoto, J.A. In prep. Framework Development for Scallop Fishing Areas 25a, 25b, 26a, 26b, 26c, and 27b: Stock Assessment Models for SFAs 25 and 26. DFO Can. Sci. Advis. Sec. Res. Doc.

RESULTS

Index-Based Limit Reference Points

Various LRPs were provided for review. The consensus was that $B_{MSY(30)}$ was appropriate for the survey index based LRPs. The survey index B_{MSY} values are 2,967 tonnes for SFA 26C and 2,093 tonnes for SFA 27B. The LRP adopted for SFA 26C was 890 tonnes and was 628 tonnes for SFA 27B; these values are based on $B_{MSY(30)}$ (Table 1 and Figure 2).

MSY Simulation Based Limit Reference Points

Various LRPs were provided for review. The consensus was that $B_{MSY(40)}$ was appropriate for the MSY simulation LRPs. MSY simulations resulted in B_{MSY} values of 2,900 tonnes for SFA 25A and 5,000 tonnes for SFA 26A. The LRP adopted for SFA 25A was 1,160 tonnes and was 2,000 tonnes for 26A; these values are based on $B_{MSY(40)}$ (Table 1 and Figure 3).

Table 1. Summary of adopted limit reference points (LRPs) presented in terms of scallop biomass (meats, tonnes). In scallop fishing area (SFA) 26C and SFA 27B the LRPs are catchability corrected using a catchability of 0.33.

SFA	Method	Basis of LRP	LRP values (meats, tonnes)
SFA 26C	survey index-based	$B_{MSY(30)}$	890
SFA 27B	survey index-based	$B_{MSY(30)}$	628
SFA 25A	modelled	$B_{MSY(40)}$	1,160
SFA 26A	modelled	$B_{MSY(40)}$	2,000

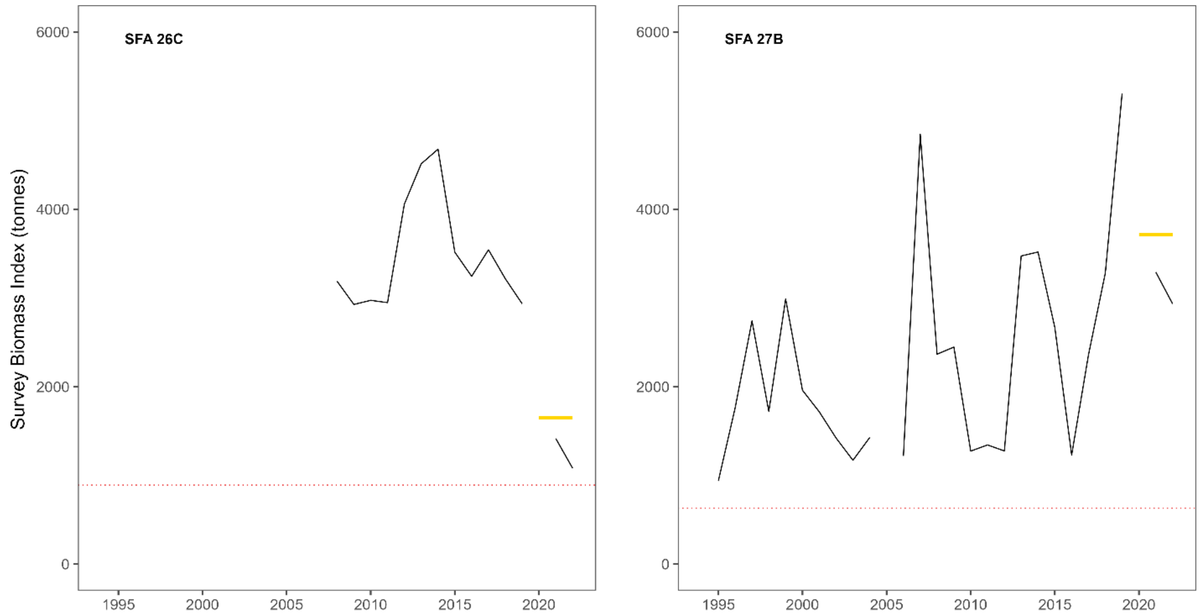

Figure 2. Survey biomass index time series (black line) relative to the adopted LRPs ($B_{MSY(30)}$, dotted red line) of 890 tonnes for scallop fishing area (SFA) 26C (left panel) and 628 tonnes for SFA 27B (right panel). The yellow line represents the geometric mean of the most recent three years of data. The survey biomass index is catchability corrected using a value of 0.33. There was no survey in either area in 2020, and no survey in SFA 27B in 2005.

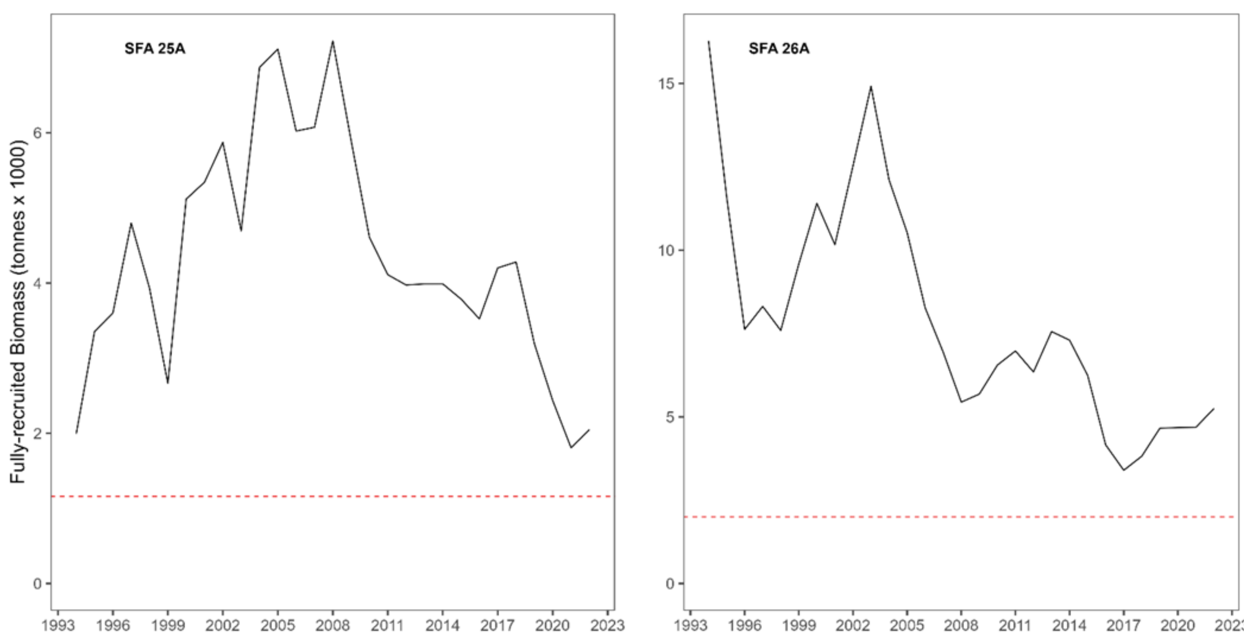

Figure 3. The modelled, fully-recruited biomass time series (black line) relative to the adopted LRP ($B_{MSY(40)}$, dashed red line) of 1,160 tonnes for scallop fishing area (SFA) 25A (left panel) and 2,000 tonnes for SFA 26A (right panel). There was no survey in either area in 2020.

Upper Stock Reference, Removal Reference, and HDR Simulations

Guidance was provided on USRs and RRs for all areas using survey index-based methods, and using MSY simulation for the SFAs where models exist (i.e., SFAs 25A and 26A).

The HDR scenarios highlighted how this approach can be used to identify candidate RRs and TRPs for the modelled areas. This simulation method can be used for further exploration of potential USRs, TRPs, and RRs. Scenarios can be set up to explore the impact of various management objectives using the example scenario as guidance. A publicly available repository has been developed and is available (on Github) to facilitate this exercise.

Sources of Uncertainty

Reference points derived from survey indices are inherently more uncertain than those from modelled MSY simulations because survey indices do not explain the underlying population dynamics, whereas the models do. Further, model-based approaches are preferred due to their ability to quantify uncertainty and changes in stock dynamics (productivity). As additional information is collected, the survey based reference points should be reviewed if evidence for changes in the dynamics of the population are observed. Alternative methods of estimating reference points (e.g., other data limited methods, yield per recruit modelling) should be explored as new information becomes available (such as detailed growth and aging data).

The methods developed for estimating RRs for the areas using the survey biomass index-based reference points, were either unable to provide an estimate for the RR or were deemed inappropriate for the surveyed areas. The development of alternative methods was recommended.

For SFA 26C, the survey biomass index used to derive the LRP was from 2008 to 2022. It was acknowledged that is a relatively short period of time from which to estimate proxies for B_{MSY} and B_0.

CONCLUSIONS AND ADVICE

LRPs were developed and adopted for SFAs 25A and 26A using a modelled approach to simulate MSY based on the model years 1994–2022. The adopted LRPs, based on $B_{MSY(40)}$, are 1,160 tonnes in SFA 25A and 2,000 tonnes in SFA 26A (Table 1). The survey biomass index-based LRP developed and adopted for SFA 26C was 890 tonnes and was 628 tonnes for SFA 27B. The survey biomass index-based LRPs are based on $B_{MSY(30)}$, are catchability corrected using a value of 0.33 (Table 1), and use the survey data from 1994–2022 for SFA 27B and from 2008–2022 for SFA 26C.

Advice was provided on potential methods for identifying USRs and RRs using the MSY simulations for SFAs 25A and 26A, and using the survey biomass index-based approach for SFAs 26C and 27B. Additionally, HDR scenarios were presented to highlight how a HDR simulation approach can be used to identify candidate RRs and TRPs for the modelled areas.

OTHER CONSIDERATIONS

Although models were adopted for SFAs 25A and 26A, the utility of using the survey biomass indices as a proxy for stock status was explored. This may be useful to apply in cases where the modelled biomass estimates are unavailable. In SFA 25A, the survey biomass index is highly correlated with the model biomass estimate, so the survey biomass can be used to infer stock status. In SFA 26A, while the survey biomass index is somewhat correlated to the model biomass estimate, the differences between the two metrics can be substantial and caution is recommended if attempting to use the survey biomass index as a proxy for the modelled biomass.

The models in SFA 25A and 26A should be subject to re-evaluation to ensure they continue to capture the population dynamics of the areas, and to monitor for changes in the productivity of each stock. It is challenging to predict when the models should next be re-evaluated. It is recommended to monitor the growth, per capita recruitment (RPS), natural mortality, and process error components of the models. A long-term directional bias in the growth, RPS, natural mortality, or process error would indicate a shift in the productivity of the stock. This would indicate the need for additional research to understand the processes driving such changes. Such a productivity shift would also require that the reference points be re-evaluated.

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