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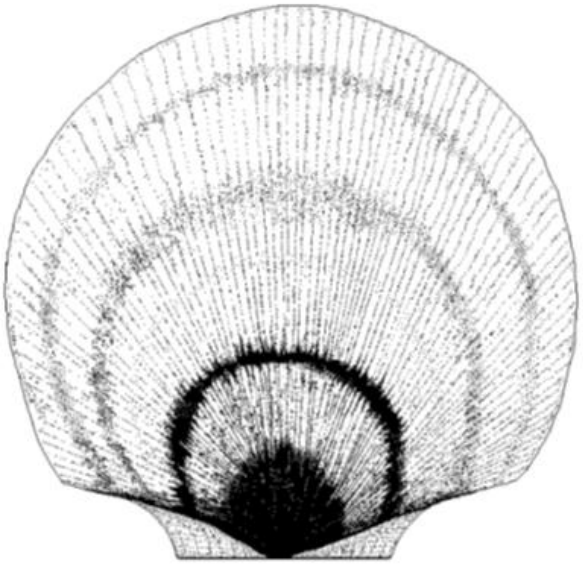
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Maritimes Region

Canadian Science Advisory Secretariat
Science Advisory Report 2024/044

EVALUATION OF TWO-YEAR MODEL PROJECTIONS FOR GEORGES BANK 'A' AND BROWNS BANK NORTH SCALLOP FISHERIES



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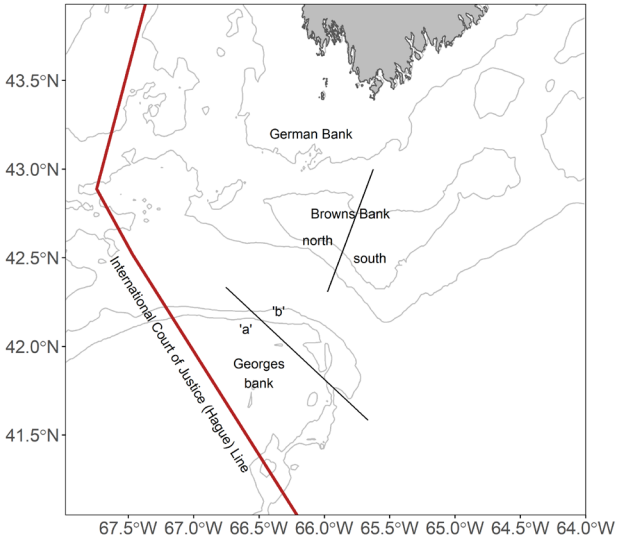

Figure 1. Location of Georges Bank 'a' and Browns Bank North.

Context:

The quota management system for scallop fisheries in the Maritimes Region depends on the timely provision of current year science advice. The present time frame between data acquisition from the surveys (May and August, year t) and the provision of operational science advice required to set management targets (Spring in year t+1) means that catch advice is based on one-year projections; however, in 2020, the DFO Science Offshore Scallop surveys were cancelled. In the absence of survey data, two-year model projections are needed to update the stock status for the Georges Bank 'a' and Browns Bank North Scallop fisheries for 2021.

The objectives of this meeting are to: (1) evaluate the productivity of the modelled stock areas and (2) evaluate the impact and uncertainty of two-year model projections on the science advice for the Georges Bank 'a' and Browns Bank North Scallop fisheries using established reference points, harvest strategies, and indicators.

This Science Advisory Report is from the March 30, 2021, on the Evaluation of Two-year Model Projections for Georges Bank 'a' and Browns Bank North Scallop Fisheries regional advisory-meeting. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

August 2024

SUMMARY

- Georges Bank ‘a’ (GBa) and Browns Bank North (BBn) comprise the majority of catches from the Offshore Scallop fishery in the Fisheries and Oceans Canada (DFO) Maritimes Region. Both stocks are managed using total allowable catches (TACs).
- The annual assessments use a modified version of a state-space delay-difference population model fit to the survey estimates of fully recruited biomass, recruit biomass, and fishery catch per unit effort.
- In 2020, the DFO Science Offshore Scallop survey was cancelled due to challenges associated with the COVID-19 pandemic. In the absence of survey data, two-year model projections are needed to update the stock status for 2021.
- The scallop stocks on GBa and BBn demonstrate substantial interannual variability in their productivity. For GBa, the surplus production rate estimates ranged from 0.25 to 0.27, which is consistent with previous values. For BBn, the surplus production rate estimates ranged from 0.13 to 0.15, which is higher than previous values.
- If used over the long-term to provide harvest advice, relative to the use of one-year projections, use of two-year projections as the basis for management decisions over the long term would result in substantial risk of either loss in potential catch or overharvesting. Even though the usefulness of two-year projections is limited for long-term advice, they provide context for tactical decision-making in 2021 in the absence of 2020 survey data.
- For GBa, for the two-year projection scenarios evaluated, the probability that the 2021 fully recruited biomass would be above the upper stock reference (USR) and in the healthy zone after removing 4,000 mt (the 2021 interim TAC) is at least 0.98 and is predicted to result in an exploitation rate between 0.08 and 0.1.
- For BBn, for the two-year projection scenarios evaluated, removing 300 mt (the 2021 interim TAC) is predicted to result in an exploitation rate between 0.12 and 0.14 and corresponds to an expected range of biomass change between −14% and 1%.

BACKGROUND

Georges Bank ‘a’ (GBa) and Browns Bank North (BBn) comprise the majority of catches from the Offshore Scallop fishery in the Fisheries and Oceans Canada (DFO) Maritimes Region. Both stocks are managed using total allowable catches (TACs; meats, tonnes, mt) and have annual analytical assessments that use a modified version of a state-space delay-difference population model. This model is fit to the survey estimates of fully recruited (≥ 95 mm shell height) biomass, recruit (85–94.9 mm shell height) biomass, and fishery Catch Per Unit Effort and provides one-year biomass projections to inform the setting of the harvest level (Jonsen et al. 2009, Hubley et al. 2011). DFO Science-Industry surveys occur annually in May for BBn and August for GBa. Survey data collected in spring and summer (year *t*) are processed and analyzed, with formal advice through the Canadian Science Advisory Secretariat (CSAS) provided in the spring of the following year (*t+1*) to inform the setting of final TACs for that year. For each stock, the setting of the final TAC is informed by the one-year projection from the model; thus data from the previous year is used by the model to forecast fully recruited biomass for the following year. The time frame between data acquisition from the surveys (May and August) and science advice needed to set management targets (Spring) means that catch advice is based on one-year projections; however, in 2020, the DFO Science Offshore Scallop

surveys were cancelled due to challenges associated with the COVID-19 pandemic. In the absence of survey data, two-year model projections are being used to update the stock status for 2021.

ASSESSMENT

An analysis of productivity parameters based on the stock assessment model and three surplus production scenarios was conducted and used to inform the two-year projections. The selection of the three surplus production scenarios was based on an evaluation of productivity parameters (fully recruited biomass, recruit biomass, fully recruited and recruit natural mortality, fully recruited and recruit growth, and surplus production). The two-year projections were evaluated relative to one-year projections. One-year projections assume natural mortality is unchanged from the current year (e.g., that natural mortality in 2020 will be unchanged from 2019), and use the growth of fully recruited and recruit size scallop calculated from the most recent survey. To derive two-year model projections, the one-year projections of the fully recruited biomass posteriors (where catch was set to the realized catch for each respective year) were projected forward using 3 scenarios: 1) zero surplus production, 2) median surplus production (for the respective stock), and 3) assuming the same recruitment, mortality, growth, and process error as the one-year projection, hereafter referred to as the ‘status quo’ assumption. The performance of the two-year model projections was evaluated relative to the one-year model projections for 2012–2019 and the stock status in 2021 was evaluated using the two-year projections.

The scallop stocks on GBa and BBn demonstrate substantial interannual variability in their productivity (Figure 2). Relative to the use of one-year projections, two-year projections could result in loss in potential catch or overharvesting if used over the long-term to provide harvest advice. However, in the absence of 2020 survey data, these two-year projections provide context for tactical decision-making in 2021.

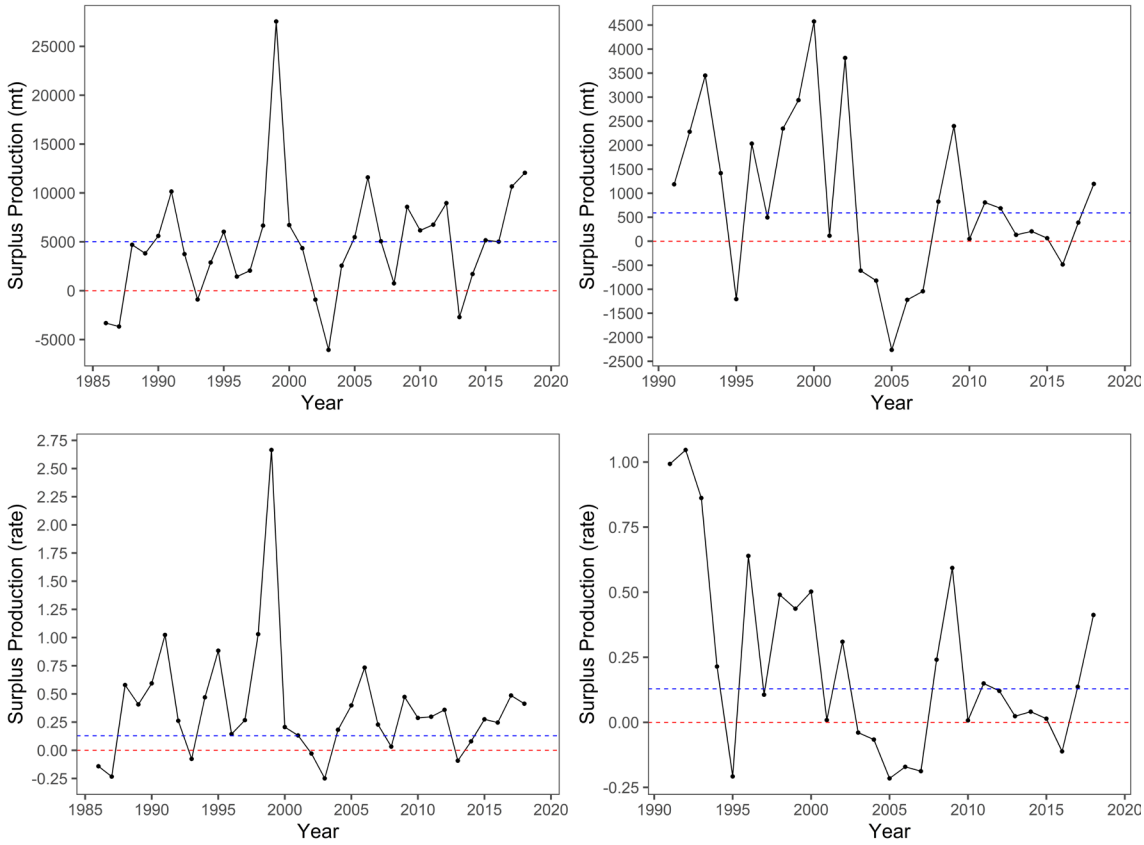

Figure 2. Time series of surplus production (meats, mt) (top panels) and surplus production rate (bottom panels) of fully recruited biomass for Georges Bank 'a' (left panels) and Brown Bank North (right panels). The blue dashed lines represents the long-term medians and the red dashed lines represent zero surplus production.

Georges Bank 'a'

For GBa, the average long-term surplus production rate (0.27) and the results of the zero-change in biomass analyses (0.25) are in agreement with previous analyses of this stock. Although there was autocorrelation in some parameters, the resulting surplus production showed no significant autocorrelation in model parameters after a one-year lag. The lack of autocorrelation in parameters beyond one year decreases the certainty of predictions beyond one year, thus limiting the usefulness of two-year projections. In the current assessment, where advice requires a two-year projection, the zero surplus production scenario follows our current understanding of productivity and is the most conservative of the alternative scenarios explored. Since the predictions of biomass depend on the state of recruitment in the previous year, there was no clear 'best' scenario to assume for the two-year projection. Although no two-year projection scenario assuming negative surplus production was evaluated, negative surplus production has been observed 18% of the time in this stock. For all three two-year projection scenarios, the probability that the 2021 fully recruited biomass would be above the USR and in the healthy zone after removing 4,000 mt (the 2021 interim TAC) is at least 0.98 and is predicted to result in an exploitation rate between 0.08 and 0.1 (Tables 1–3, Figure 3).

One- and two-year projections of biomass for the same year varied substantially across all three two-year projection scenarios for the evaluated period of 2012–2019. The relative difference in

median biomass of the one- and two-year projections ranged from −51% to 68% (−20,800 mt and 11,600 mt), −37% to 120% (−15,200 mt and 19,900 mt), and −35% to 130% (−14,400 to 21,500 mt), for the zero surplus production, median surplus production, and status quo scenarios, respectively. The simulated impact of two-year projections on harvest advice was evaluated as the relative difference in potential catch between one- and two-year projections for a fixed exploitation rate of 0.25. The relative difference in catch of the one- and two-year projections ranged from −47% to 63% (−5,550 mt to 3,210 mt), −33% to 110% (−3,810 mt to 5,520 mt), −33% to 110% (−3,880 mt to 5,740 mt), for the zero surplus production, median surplus production, and status quo scenarios, respectively.

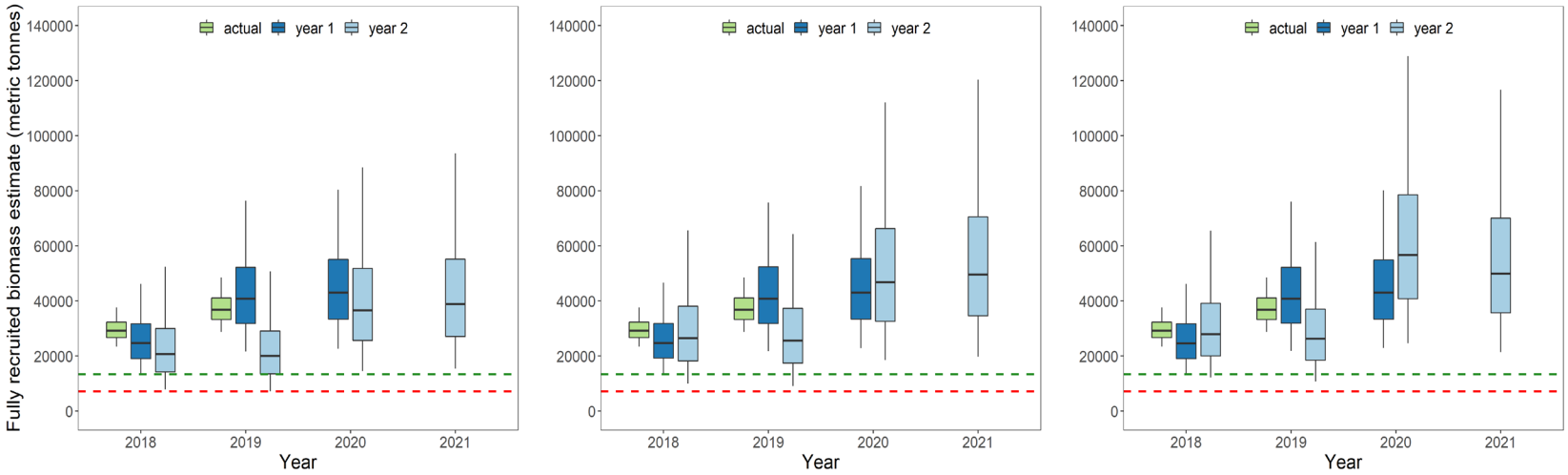

Figure 3. Evaluation of the model projection performance from 2018 to 2021 on Georges Bank 'a' relative to the upper stock reference (USR; green dashed line) and limit reference point (LRP; red dashed line). The green box and whisker plots summarize the posterior distribution of the fully recruited biomass in year t using data up to and including year t (e.g., 2012 predictions based on data up to and including 2012). The dark blue box and whisker plots summarize posterior distributions of fully recruited biomass in year t based on model fit to year t−1 (e.g., 2012 predictions based on data up to and including 2011). The light blue box and whisker plots summarize posterior distributions of fully recruited biomass in year t based on model fit to year t−2 (e.g., 2012 predictions based on data up to and including 2010). Box plots show median (horizontal line), 50% credible limits (box), and 90% credible limits (whiskers). The projections for 2020 assumes landings of 4,096 mt is caught, and for 2021 the interim total allowable catch of 4,000 mt is caught. Prediction evaluations presented for three two-year projection scenarios; zero surplus production (left panel), median surplus production (middle panel), and the status quo assumption (i.e., same conditions as the one-year projection in year t−1; right panel).

Table 1. Catch scenarios for Georges Bank 'a' in 2021 in terms of exploitation and expected changes in fully recruited biomass. Potential catches in 2021 are evaluated in terms of the probability of a decline in biomass and exceeding the upper stock reference (USR) and limit reference point (LRP). These probabilities account for uncertainty in the biomass forecasts and are presented assuming zero surplus production from 2020 to 2021.

Catch (mt)	Exploitation Rate	Probability of Biomass Decline	Expected Change in Biomass (%)	Probability biomass will exceed LRP	Probability biomass will exceed USR
1,800	0.05	0.56	−5.0	> 0.99	0.98
2,300	0.06	0.57	−6.0	> 0.99	0.98
2,700	0.07	0.59	−7.1	> 0.99	0.98
3,100	0.08	0.60	−7.9	> 0.99	0.98
3,600	0.09	0.61	−9.1	> 0.99	0.98
4,000	0.10	0.63	−10.1	> 0.99	0.98
4,400	0.11	0.64	−10.8	> 0.99	0.98
4,900	0.12	0.65	−12.0	> 0.99	0.98
5,200	0.13	0.66	−13.2	> 0.99	0.98
5,700	0.14	0.68	−14.0	> 0.99	0.97
6,100	0.15	0.69	−15.1	> 0.99	0.97
6,600	0.16	0.70	−15.9	> 0.99	0.97
7,000	0.17	0.72	−17.2	> 0.99	0.97
7,400	0.18	0.73	−18.1	> 0.99	0.97
7,800	0.19	0.74	−19.0	> 0.99	0.97
8,300	0.20	0.75	−20.2	> 0.99	0.96
8,700	0.21	0.77	−21.3	> 0.99	0.97
9,200	0.22	0.77	−21.7	> 0.99	0.96
9,600	0.23	0.79	−23.3	> 0.99	0.96
10,000	0.24	0.80	−24.3	> 0.99	0.96
10,500	0.25	0.81	−24.9	> 0.99	0.96

Table 2. Catch scenarios for Georges Bank 'a' in 2021 in terms of exploitation and expected changes in fully recruited biomass. Potential catches in 2021 are evaluated in terms of the probability of a decline in biomass and exceeding the upper stock reference (USR) and limit reference point (LRP). These probabilities account for uncertainty in the biomass forecasts and are presented assuming the time series median surplus production (0.27) from 2020 to 2021.

Catch (mt)	Exploitation Rate	Probability of Biomass Decline	Expected Change in Biomass (%)	Probability biomass will exceed LRP	Probability biomass will exceed USR
2,400	0.05	0.28	20.9	> 0.99	0.99
3,000	0.06	0.29	19.9	> 0.99	0.99
3,500	0.07	0.30	18.6	> 0.99	0.99
4,100	0.08	0.31	17.6	> 0.99	0.99
4,600	0.09	0.33	16.0	> 0.99	0.99
5,200	0.10	0.34	14.5	> 0.99	0.99
5,700	0.11	0.36	13.1	> 0.99	0.99
6,300	0.12	0.36	12.5	> 0.99	0.99
6,900	0.13	0.37	11.1	> 0.99	0.99
7,300	0.14	0.39	9.2	> 0.99	0.99
8,000	0.15	0.40	8.5	> 0.99	0.99
8,400	0.16	0.42	7.2	> 0.99	0.99
9,000	0.17	0.43	5.8	> 0.99	0.99
9,600	0.18	0.44	4.7	> 0.99	0.99
10,100	0.19	0.46	2.9	> 0.99	0.99
10,700	0.20	0.48	2.0	> 0.99	0.99
11,200	0.21	0.49	0.8	> 0.99	0.99
11,700	0.22	0.51	−0.8	> 0.99	0.99
12,300	0.23	0.52	−1.9	> 0.99	0.99
12,800	0.24	0.54	−3.2	> 0.99	0.98
13,300	0.25	0.56	−4.7	> 0.99	0.98

Table 3. Catch scenarios for Georges Bank 'a' in 2021 in terms of exploitation and expected changes in fully recruited biomass. Potential catches in 2021 are evaluated in terms of the probability of a decline in biomass and exceeding the upper stock reference (USR) and limit reference point (LRP). These probabilities account for uncertainty in the biomass forecasts and are presented assuming the status quo assumption (same recruitment, mortality, and growth as for the 2020 projection).

Catch (mt)	Exploitation Rate	Probability of Biomass Decline	Expected Change in Biomass (%)	Probability biomass will exceed LRP	Probability biomass will exceed USR
2,400	0.05	0.28	20.9	> 0.99	> 0.99
3,000	0.06	0.29	20.1	> 0.99	> 0.99
3,500	0.07	0.30	18.7	> 0.99	> 0.99
4,100	0.08	0.31	17.2	> 0.99	> 0.99
4,600	0.09	0.33	16.0	> 0.99	> 0.99
5,200	0.10	0.33	15.1	> 0.99	> 0.99
5,700	0.11	0.35	13.5	> 0.99	0.99
6,200	0.12	0.36	12.7	> 0.99	0.99
6,800	0.13	0.38	10.9	> 0.99	0.99
7,400	0.14	0.38	10.2	> 0.99	0.99
7,900	0.15	0.40	8.7	> 0.99	0.99
8,400	0.16	0.41	7.6	> 0.99	0.99
9,000	0.17	0.43	6.1	> 0.99	0.99
9,600	0.18	0.44	4.7	> 0.99	0.99
10,100	0.19	0.46	3.6	> 0.99	0.99
10,600	0.20	0.47	2.3	> 0.99	0.99
11,200	0.21	0.49	1.0	> 0.99	0.99
11,800	0.22	0.51	−0.4	> 0.99	0.99
12,300	0.23	0.52	−1.6	> 0.99	0.99
12,800	0.24	0.53	−2.7	> 0.99	0.99
13,400	0.25	0.55	−4.3	> 0.99	0.99

Browns Bank North

For BBn, the average long-term surplus production rate (0.13) and the results of the zero-change in biomass analyses (0.15) support a higher surplus production rate than reported previously for this stock (Smith and Hubley 2012). There was significant autocorrelation in the surplus production and recruit biomass time series after a one-year lag and significant autocorrelation in fully recruited biomasses at one- and two-year lags. However, despite the two-year autocorrelation in fully recruited biomass, the two-year projections evaluated in this analysis did not perform well (relative to one-year projections). The status quo and median surplus production scenarios for the two-year projection tended to overestimate the fully recruited biomass compared to the one-year projection. The zero SP scenario tended to provide better two-year projections than the other scenarios because there have not been any major fluctuations in fully recruited biomass during the period used for the prediction evaluations. Although no two-year projection scenario assuming negative surplus production was evaluated, negative surplus production has been observed 25% of the time in this stock. For all three two-year projection scenarios, removing 300 mt (the 2021 interim TAC) is predicted to result in an exploitation rate between 0.12 and 0.14 and correspond to an expected range of biomass change between -14% and 1% (Tables 4–6, Figures 4).

One- and two-year projections of biomass for the same year varied substantially across all three two-year projection scenarios for the evaluated period of 2012–2019. The relative difference in median biomass of the one- and two-year projections ranged from −44% to 21% (−1,810 mt and 768 mt), −36% to 37% (−1,500 mt and 1,490 mt), and −39 to 62% (−1,610 to 3,980 mt), for the zero surplus production, median surplus production, and status quo scenarios, respectively. The simulated impact of two-year projections on harvest advice was evaluated as the relative differences in potential catch between one- and two-year projections for a fixed exploitation rate of 0.15. The relative difference in catch of the one- and two-year projections ranged from -42% to 22% (−290 mt to 148 mt), −35% to 37% (−240 mt to 245 mt), and −39% to 55% (−267 mt to 603 mt), for the zero surplus production, median surplus production, and status quo scenarios, respectively.

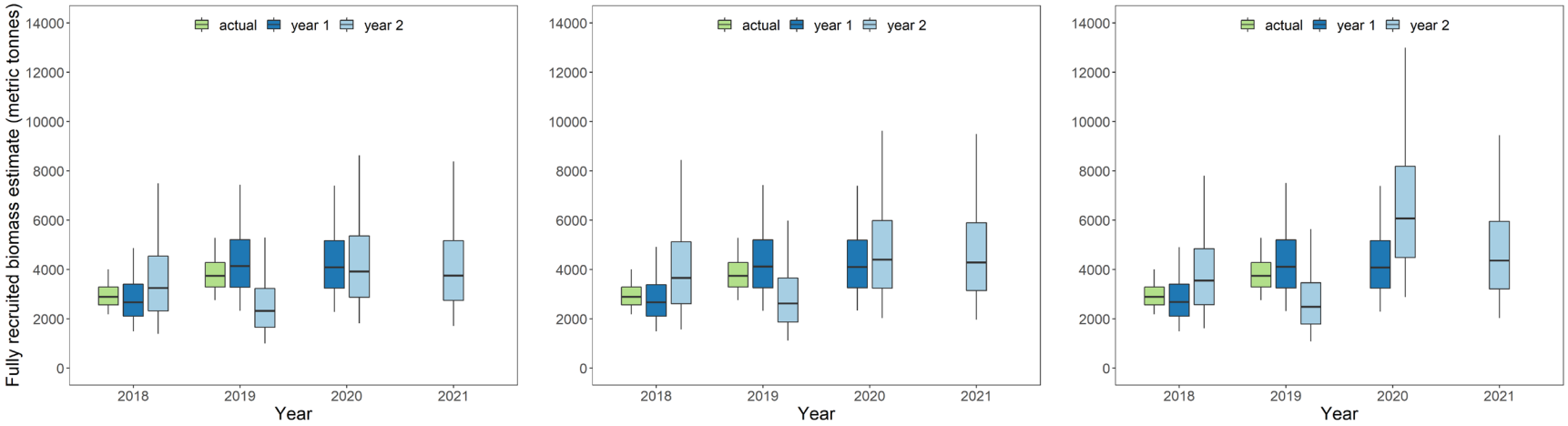

Figure 4. Evaluation of the model projection performance from 2018 to 2021 on Browns Bank North. Green box and whisker plots summarize the posterior distribution of the fully recruited biomass in year t using data up to and including year t (e.g., 2012 predictions based on data up to and including 2012). Dark blue box and whisker plots summarize posterior distributions of fully recruited biomass in year t based on model fit to year t−1 (e.g., 2012 predictions based on data up to and including 2011). Light blue box and whisker plots summarize posterior distributions of fully recruited biomass in year t based on model fit to year t−2 (e.g., 2012 predictions based on data up to and including 2010). Box plots show median (horizontal line), 50% credible limits (box), and 90% credible limits (whiskers). The projections for 2020 assumes landings of 211 mt is caught, and for 2021 the interim total allowable catch of 300 mt is caught. Prediction evaluations presented for three two-year projection scenarios; zero surplus production (left panel), median surplus production (middle panel), and the recent year assumption (i.e., same conditions as the one-year projection in year t−1; right panel).

Table 4. Catch scenarios for Browns Bank North in 2021 in terms of exploitation and expected changes in fully recruited biomass. Potential catches in 2021 are evaluated in terms of the probability of a decline in biomass. These probabilities account for uncertainty in the biomass forecasts and are presented assuming zero surplus production from 2020 to 2021.

Catch (mt)	Exploitation Rate	Probability of Biomass Decline	Expected Change in Biomass (%)
60	0.08	0.62	−7.8
100	0.09	0.63	−8.9
140	0.10	0.65	−9.9
180	0.11	0.66	−11.0
220	0.12	0.68	−11.7
260	0.13	0.69	−12.8
300	0.14	0.71	−14.1
350	0.15	0.73	−14.9
390	0.16	0.73	−16.0
430	0.17	0.75	−17.0
470	0.18	0.76	−17.9
510	0.19	0.78	−18.9
550	0.20	0.79	−20.3
590	0.21	0.80	−21.0
630	0.22	0.81	−22.1
670	0.23	0.82	−23.0
720	0.24	0.83	−23.7
750	0.25	0.85	−25.0

Table 5. Catch scenarios for Browns Bank North in 2021 in terms of exploitation and expected changes in fully recruited biomass. Potential catches in 2021 are evaluated in terms of the probability of a decline in biomass. These probabilities account for uncertainty in the biomass forecasts and are presented assuming the time series median surplus production (0.13) from 2020 to 2021.

Catch (mt)	Exploitation Rate	Probability of Biomass Decline	Expected Change in Biomass (%)
100	0.08	0.44	4.2
150	0.09	0.46	2.6
190	0.10	0.48	1.3
240	0.11	0.49	0.9
280	0.12	0.51	−0.7
330	0.13	0.52	−1.6
380	0.14	0.54	−3.0
420	0.15	0.56	−4.1
470	0.16	0.58	−5.3
510	0.17	0.59	−6.4
560	0.18	0.61	−7.5
610	0.19	0.63	−8.5
660	0.20	0.65	−10.2
700	0.21	0.66	−10.6
740	0.22	0.68	−12.1
800	0.23	0.69	−12.7
840	0.24	0.71	−14.5
880	0.25	0.73	−15.5

Table 6. Catch scenarios for Browns Bank North in 2021 in terms of exploitation and expected changes in fully recruited biomass. Potential catches in 2021 are evaluated in terms of the probability of a decline in biomass. These probabilities account for uncertainty in the biomass forecasts and are presented assuming the status quo assumption (same recruitment, mortality, and growth as for the 2020 projection).

Catch (mt)	Exploitation Rate	Probability of Biomass Decline	Expected Change in Biomass (%)
110	0.08	0.42	5.9
150	0.09	0.44	4.6
200	0.10	0.46	3.0
250	0.11	0.47	2.3
290	0.12	0.48	1.1
340	0.13	0.51	−0.4
380	0.14	0.53	−1.8
440	0.15	0.53	−2.1
480	0.16	0.55	−3.7
530	0.17	0.56	−4.3
580	0.18	0.59	−5.9
620	0.19	0.61	−7.5
670	0.20	0.62	−7.9
720	0.21	0.63	−9.1
770	0.22	0.65	−10.2
810	0.23	0.67	−11.5
860	0.24	0.69	−12.8
910	0.25	0.70	−13.6

Sources of Uncertainty

For one-year biomass projections, assumptions were made regarding expected biomass growth and natural mortality. These estimates are based on current survey data and mortality is assumed to be unchanged from the current year; however, these estimates may not reflect actual changes over the following year(s). Two-year projections were evaluated for three scenarios: 1) zero surplus production, 2) median surplus production, and 3) ‘status quo’ – assuming the same assumptions as the one-year projection in year *t−1*. This range of scenarios is expected to cover a likely range of potential outcomes; however, although observed in these stocks, negative surplus production scenarios were not evaluated.

CONCLUSIONS AND ADVICE

The scallop stocks on GBa and BBn demonstrate substantial interannual variability in their productivity and this is reflected in the lack of autocorrelation in the primary model parameters and in surplus production beyond a one-year lag. Relative to the use of one-year projections, two-year projections could result in loss in potential catch or overharvesting if used over the long-term to provide harvest advice. However, in the absence of 2020 survey data, these two-year projections provide context for tactical one-year decision making for the 2021 harvest levels. For GBa, the surplus production rate was estimated from 0.25 to 0.27, which is consistent with previous estimates. For the two-year projection scenarios evaluated, the

probability that the 2021 fully recruited biomass would be above the USR and in the healthy zone after removing 4,000 mt (the 2021 interim TAC) is at least 0.98 and is predicted to result in an exploitation rate between 0.08 and 0.1. For BBn, the surplus production rate was estimated from 0.13 to 0.15, which is higher than previous estimates. For the two-year projection scenarios evaluated, removing 300 mt (the 2021 interim TAC) is predicted to result in an exploitation rate between 0.12 and 0.14 and corresponds to an expected range of biomass change between −14% and 1%.

LIST OF MEETING PARTICIPANTS

Name	Affiliation
Lottie Bennett	DFO Science, Maritimes Region
Rénald Belley	DFO Science, Quebec Region
Alan Reeves	DFO Resource Management, Maritimes Region
Sara Quigley	DFO Resource Management, Maritimes Region
Tricia Pearo Drew	DFO Science, Maritimes Region
Lei Harris	DFO Science, Maritimes Region
Kent Smedbol	DFO Science, Maritimes Region
Monique Niles	DFO Science, Gulf Region
Heather Bowlby	DFO Science, Maritimes Region
Adam Cook	DFO Science, Maritimes Region
Una Goggin	DFO Science, Maritimes Region
Brittany Wilson	DFO Science, Maritimes Region
Anne-Sara Sean	DFO Science, Quebec Region
Jessica Sameoto	DFO Science, Maritimes Region
Dave Keith	DFO Science, Maritimes Region
Freya Keyser	DFO Science, Maritimes Region
Ginette Robert	Seafood Producers Association of Nova Scotia
James Mosher	Clearwater Seafoods
Raphael MacDonald	Dalhousie University
Christine Penny	Clearwater Seafoods
Jamie Raper	DFO Science, Maritimes Region
Adam Mugridge	DFA, Province of NS

SOURCES OF INFORMATION

This Science Advisory Report is from the March 30, 2021, regional advisory meeting on the Evaluation of Two-year Model Projections for Georges Bank ‘a’ and Browns Bank North Scallop Fisheries. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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E-Mail: MaritimesRAP.XMAR@dfo-mpo.gc.ca
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