Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat
Maritimes Region **Science Response 2023/011**

STOCK STATUS UPDATE OF SCALLOP (*PLACOPECTEN MAGELLANICUS*) IN SCALLOP PRODUCTION AREAS 1 TO 6 IN THE BAY OF FUNDY

Context

Advice on the status of Scallop in Scallop Production Areas (SPAs) 1 to 6 in the Bay of Fundy (BoF) is requested annually by Fisheries and Oceans Canada (DFO) Resource Management to help determine a Total Allowable Catch (TAC, meat weight) in support of the fishery. The purpose of this report is to update the stock status of Scallop in SPAs 1 to 6 with data from the 2022 Scallop survey and fishery (October 1 to September 30). The last Regional Advisory Process of the BoF Scallop stocks occurred in 2015 (DFO 2016, Nasmith et al. 2016); updates have been conducted since. The last update was in November 2021 (DFO 2022).

This Science Response Report results from the Regional Peer Review of November 24, 2022 on the Stock Status Update of Bay of Fundy Scallop in Scallop Production Areas (SPAs) 1A, 1B, and 3–6.

Background

There are three commercial fleets (Full Bay, Mid Bay, and Upper Bay) in the inshore BoF scallop fishery. Full Bay license holders are permitted to fish throughout the BoF. Mid Bay license holders have access to all areas north of the Mid Bay line. Upper Bay license holders are restricted to the upper reaches of the Bay (Figure A1). The fishery is managed using limited entry, drag gear size limits, seasonal closures, minimum shell height, and meat count. The drag gear width limit is 5.5 metres (m) with a ring size of not less than 82 mm inside diameter. The Full Bay Fleet operates under an Individual Transferable Quota (ITQ) system, while the Mid Bay and Upper Bay fleets fish with competitive quotas. Total Allowable Catches (TACs) and landings are reported in terms of meat weights (adductor muscles).

Population surveys are conducted annually by DFO Science. The population dynamics of commercial and recruit Scallops for all SPAs (Figure A1) were modelled using a Bayesian state-space model with modifications presented in Smith et al. (2012) and Smith and Hubley (2014). A detailed description of survey design and strata boundaries is presented in Nasmith et al. (2016). In this report, Scallops with a shell height of 80 mm and greater are referred to as commercial size. Scallops with a shell height of 65–79 mm are referred to as recruits and are expected to grow to be commercial size in the following year. Scallops less than 65 mm are defined as pre-recruits. Scallop removals accounted for in assessments include commercial landings from all three inshore scallop fleets, and Food, Social and Ceremonial (FSC) catch by scallop drag. Landed recreational and FSC catch by dip netting, diving, tongs, and hand are not accounted for in the assessment. Landing values from 2022 are preliminary (Table A1). In 2020 there was no survey. The indices used as input for the model in 2020 are imputed using the 2019 and 2021 values; this approach is consistent with methods used to address missing information in previous years (e.g., Nasmith et al. 2016).

Analysis and Response

Indicators of Stock Status

Scallop Production Area 1A Stock Status

The biomass estimate of commercial Scallops in 2022 was 2,541 t (meats), which is above the long-term (1997–2021) median of 1,930 t; the probability that the 2022 biomass is currently above the USR and in the Healthy Zone is greater than 0.99 (Figure 1). The 2021 commercial biomass estimate was 2,465 t. The biomass estimate of recruit Scallops in 2022 was 13.3 t, which is below the long-term (1997–2021) median of 55.0 t. The 2021 biomass estimate of recruit Scallop was 36.6 t.

Catch scenarios for the 2022–23 fishing season are presented in Table 1. Biomass projections use the current year estimates of growth, and natural mortality is the average over the last 5 years. For example, Table 1 is interpreted as follows: a catch of 220 t corresponds to an exploitation of 0.09 and is projected to result in a 11% decline in commercial biomass, the probability of commercial biomass increase is 32%, the probability that a catch of 220 t will result in the population remaining above the Limit Reference Point (LRP) is > 99%, and the probability of the population remaining above the Upper Stock Reference (USR) is 98%. In the following fishing year (2023–24), a catch of 213 t would have a probability of 10% of exceeding a removal reference exploitation of 0.15.

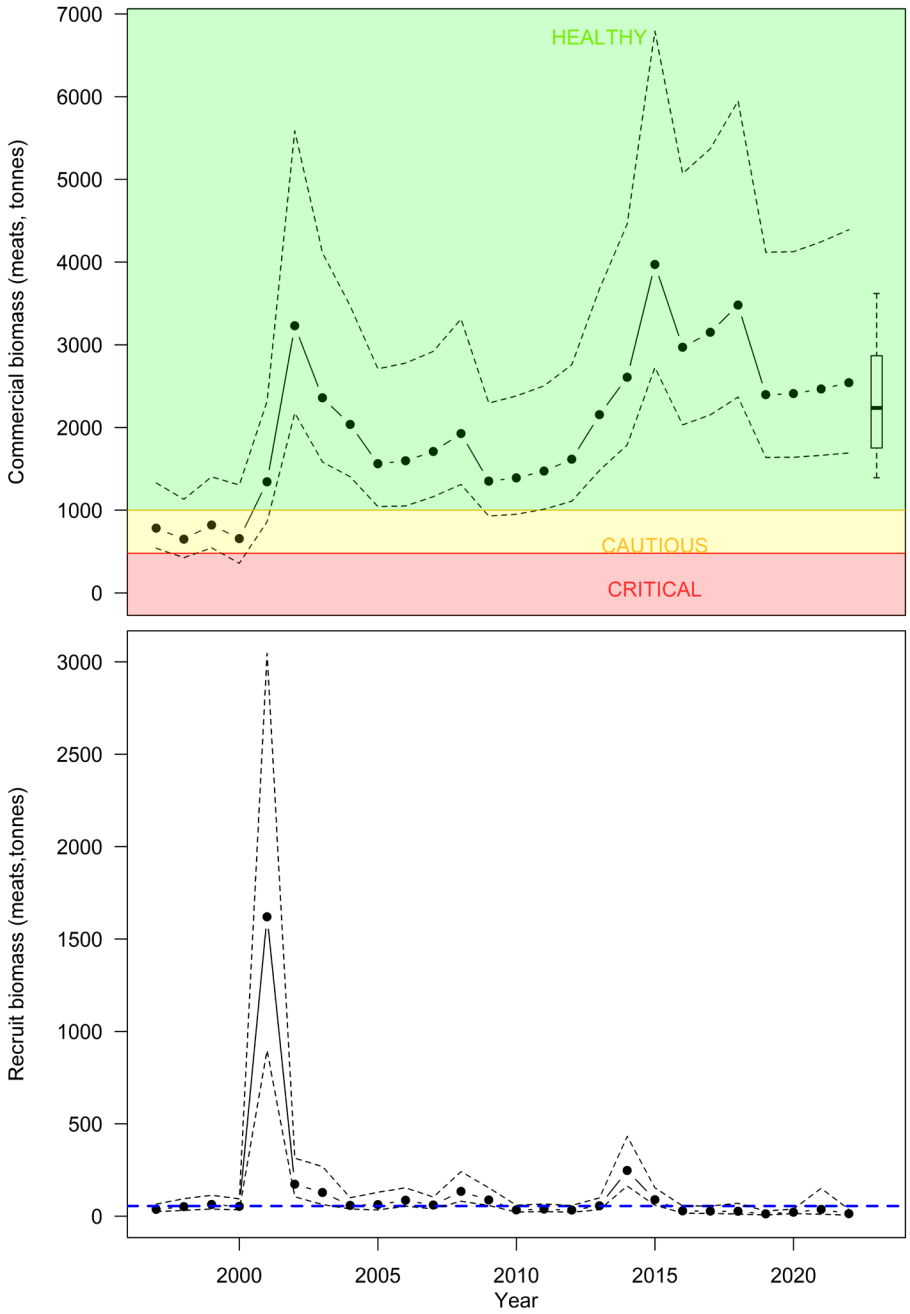

Figure 1. Median biomass estimates in SPA 1A for commercial (top panel) and recruit (bottom panel) size Scallops in meat weight (tonnes) from the assessment model fit to the survey and commercial data. Dashed lines are the upper and lower 95% credible limits on the estimates. The predicted commercial size biomass for 2023, assuming the 2022–23 interim TAC (250 t), is displayed as a box plot with median, 50% credible limits (box) and 80% credible limits (whiskers). The green-shaded area represents the Healthy Zone (based on an Upper Stock Reference [USR] point of 1,000 t), the yellow-shaded area represents the Cautious Zone, and red-shaded area represents the Critical Zone (based on Limit Reference Point [LRP] of 480 t; Nasmith et al. [2014]). The blue horizontal dashed line in the lower panel represents the long-term median (1997–2021) recruit biomass.

Table 1. Harvest scenario table for SPA 1A to evaluate 2022–23 catch levels in terms of resulting exploitation (e), expected changes in commercial biomass (%), probability (Pr) of commercial biomass increase, probability that after removal the stock will be above the Upper Stock Reference (USR; 1,000 t), and above the Limit Reference Point (LRP; 480 t). Potential catches (t) in 2023–24 are evaluated in terms of the posterior probability of exceeding a removal reference exploitation of 0.15.

2022–23 Fishing Season						2023–24 Fishing Season					
Catch (t)	*e*	% Change	Pr Increase	Pr > LRP	Pr > USR	Probability Exploitation > 0.15 *Potential Catch (t)*					
						0.1	0.2	0.3	0.4	0.5	0.6
200	0.08	−11	0.33	> 0.99	0.98	215	253	284	313	343	376
220	0.09	−11	0.32	> 0.99	0.98	213	251	282	310	340	373
240	0.10	−12	0.31	> 0.99	0.98	210	248	279	308	338	372
260	0.10	−13	0.30	> 0.99	0.98	209	245	276	305	335	368
280	0.11	−14	0.28	> 0.99	0.98	205	243	274	303	332	365
300	0.12	−15	0.28	> 0.99	0.98	203	241	271	300	330	362
320	0.13	−15	0.26	> 0.99	0.98	202	238	268	297	326	359
340	0.14	−16	0.25	> 0.99	0.98	199	236	266	294	323	356
360	0.14	−17	0.24	> 0.99	0.97	196	233	263	292	320	352
380	0.15	−18	0.23	> 0.99	0.97	194	231	260	289	318	349

Scallop Production Area 1B Stock Status

The biomass estimate of commercial Scallops in 2022 was 3,748 t (meats), which is above the long-term (1997–2021) median of 2,751 t; the probability that the 2022 biomass is currently above the USR and in the Healthy Zone is greater than 0.99 (Figure 2). The 2021 commercial biomass estimate was 3,247 t. The biomass estimate of recruit Scallops in 2022 was 176.6 t, which is above the long-term (1997–2021) median of 150.5 t. The 2021 biomass estimate of recruit Scallop was 274.4 t.

Catch scenarios for the 2022–23 fishing season are presented in Table 2. Biomass projections use the current year estimates of growth and natural mortality is the average over the last 5 years. See SPA 1A Stock Status section in this document for an example of interpreting the table.

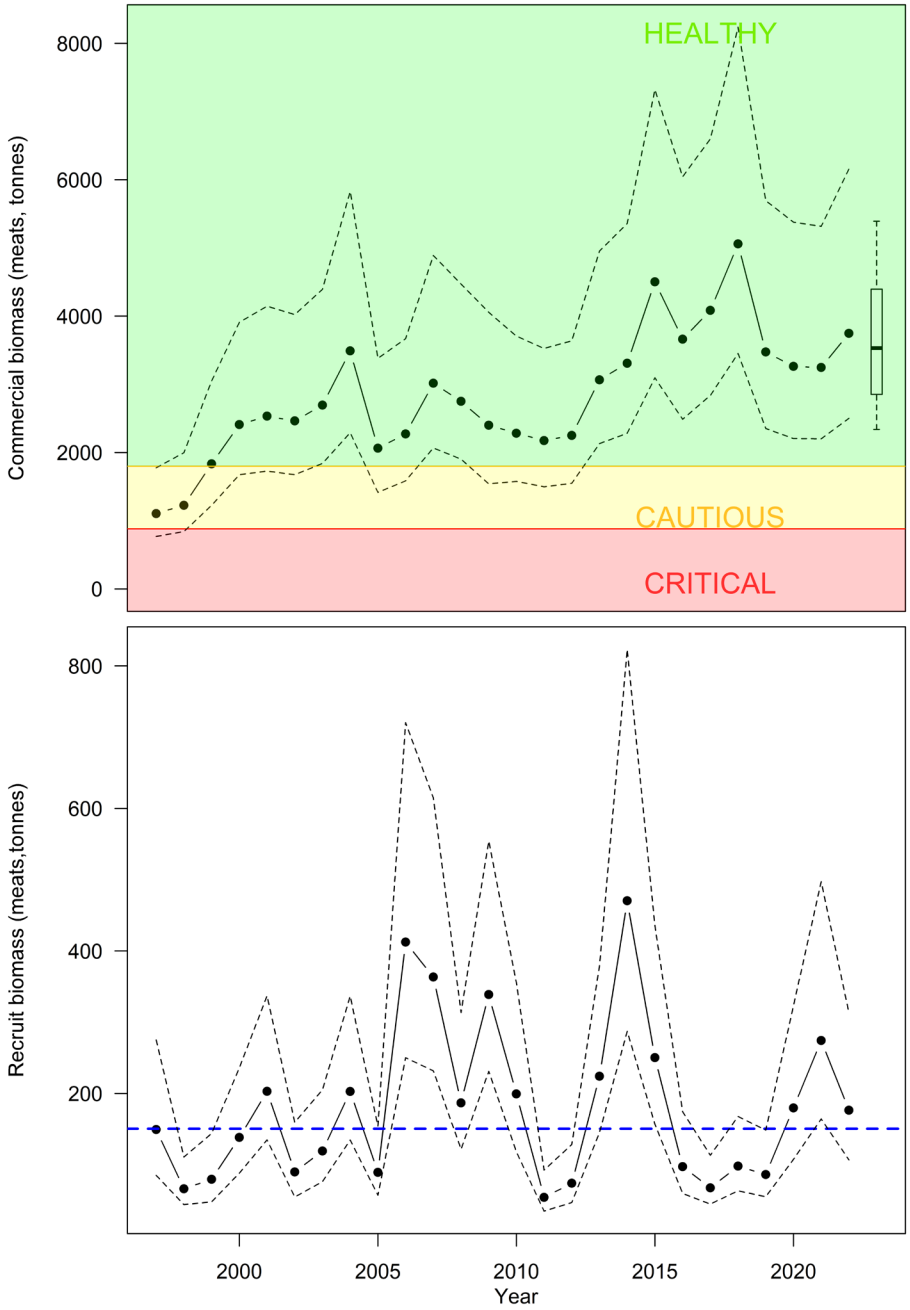

Figure 2. Median biomass estimates in SPA 1B for commercial (top panel) and recruit (bottom panel) size Scallops in meat weight (tonnes) from the assessment model fit to the survey and commercial data. Dashed lines are the upper and lower 95% credible limits on the estimates. The predicted commercial size biomass for 2023, assuming the 2022–23 interim TAC (200 t), is displayed as a box plot with median, 50% credible limits (box) and 80% credible limits (whiskers). The green-shaded area represents the Healthy Zone (based on an Upper Stock Reference [USR] point of 1,800 t), the yellow-shaded area represents the Cautious Zone, and red-shaded area represents the Critical Zone (based on Limit Reference Point [LRP] of 880 t; Nasmith et al. [2014]). The blue horizontal dashed line in the lower panel represents the long-term median (1997–2021) recruit biomass.

Table 2. Harvest scenario table for SPA 1B to evaluate 2022–23 catch levels in terms of resulting exploitation (e), expected changes in commercial biomass (%), probability (Pr) of commercial biomass increase, probability that after removal the stock will be above the Upper Stock Reference (USR; 1,800 t), and above the Limit Reference Point (LRP; 880 t). Potential catches (t) in 2023–24 are evaluated in terms of the posterior probability of exceeding a removal reference exploitation of 0.15.

2022–23 Fishing Season						2023–24 Fishing Season					
Catch (t)	*e*	% Change	Pr Increase	Pr > LRP	Pr > USR	Probability Exploitation > 0.15 *Potential Catch (t)* 0.1	0.2	0.3	0.4	0.5	0.6
175	0.05	−6	0.40	> 0.99	0.98	354	409	453	493	534	580
225	0.06	−7	0.38	> 0.99	0.98	350	403	446	488	529	573
275	0.07	−8	0.35	> 0.99	0.98	344	396	440	480	521	565
325	0.09	−9	0.33	> 0.99	0.97	338	391	433	473	512	557
375	0.10	−10	0.31	> 0.99	0.97	333	385	427	466	507	551
425	0.11	−12	0.28	> 0.99	0.97	326	379	420	460	499	543
475	0.13	−13	0.26	> 0.99	0.96	320	371	413	452	491	533
525	0.14	−14	0.24	> 0.99	0.96	314	366	407	446	486	529
575	0.15	−16	0.22	> 0.99	0.95	309	359	400	438	477	520

Scallop Production Area 2

Scallop Production Area 2 is considered to be marginal habitat for Scallops and is not monitored regularly. This area was last assessed in 2006 (DFO 2007).

Scallop Production Area 3 Stock Status

The biomass estimate of commercial Scallops in 2022 was 1,362 t (meats), which is below the long-term (1996–2021) median of 1,635 t; the probability that the 2022 biomass is currently above the USR and in the Healthy Zone is 0.90 (Figure 3). The 2021 commercial biomass estimate was 2,059 t. The biomass estimate of recruit Scallops in 2022 was 16.7 t, which is below the long-term (1996–2021) median of 59.1 t. The 2021 biomass estimate of recruit Scallop was 31.3 t.

Catch scenarios for the 2022–23 fishing season are presented in Table 3. Biomass projections use the current year estimates of growth and natural mortality is the average over the last 5 years. See SPA 1A Stock Status section in this document for an example of interpreting the table.

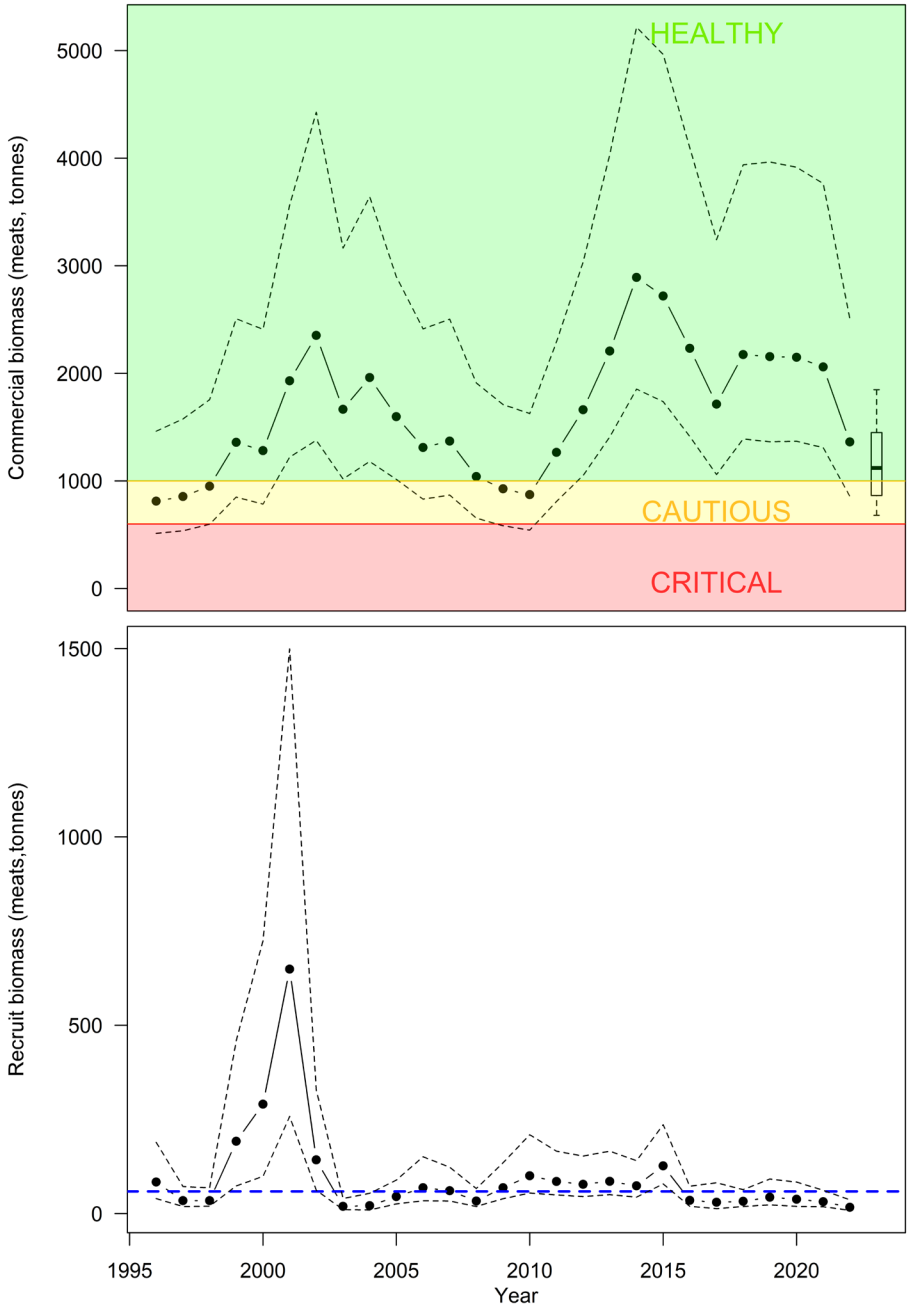

Figure 3. Median biomass estimates in SPA 3 for commercial (top panel) and recruit (bottom panel) size Scallops in meat weight (tonnes) from the assessment model fit to the survey and commercial data. Dashed lines are the upper and lower 95% credible limits on the estimates. The predicted commercial size biomass for 2023, assuming the 2022–23 interim TAC (125 t), is displayed as a box plot with median, 50% credible limits (box) and 80% credible limits (whiskers). The green-shaded area represents the Healthy Zone (based on an Upper Stock Reference [USR] point of 1,000 t), the yellow-shaded area represents the Cautious Zone, and red-shaded area represents the Critical Zone (based on Limit Reference Point [LRP] of 600 t; Nasmith et al. [2014]). The blue horizontal dashed line in the lower panel represents the long-term median (1997–2021) recruit biomass.

Table 3. Harvest scenario table for SPA 3 to evaluate 2022–23 catch levels in terms of resulting exploitation (e), expected changes in commercial biomass (%), probability (Pr) of commercial biomass increase, probability that after removal the stock will be above the Upper Stock Reference (USR; 1,000 t), and above the Limit Reference Point (LRP; 600 t). Potential catches (t) in 2023–24 are evaluated in terms of the posterior probability of exceeding a removal reference exploitation of 0.15.

2022–23 Fishing Season						2023–24 Fishing Season					
Catch (t)	*e*	% Change	Pr Increase	Pr > LRP	Pr > USR	Probability Exploitation > 0.15 *Potential Catch (t)* 0.1	0.2	0.3	0.4	0.5	0.6
110	0.09	−18	0.22	0.95	0.63	104	123	139	154	170	187
120	0.10	−19	0.21	0.94	0.62	102	122	138	153	168	186
130	0.10	−19	0.20	0.94	0.61	101	121	137	152	168	185
140	0.11	−20	0.19	0.94	0.60	100	119	135	150	166	183
150	0.12	−21	0.18	0.94	0.60	100	119	134	149	164	181
160	0.13	−21	0.17	0.93	0.58	98	117	133	148	163	180
170	0.14	−22	0.17	0.93	0.58	98	116	132	147	162	179
180	0.14	−22	0.16	0.92	0.57	96	115	130	145	161	178
190	0.15	−23	0.15	0.92	0.56	95	114	130	144	159	176

Scallop Production Area 4 and 5 Stock Status

SPA 4

The biomass estimate of commercial Scallops in 2022 was 1,363 t (meats), which is above the long-term (1983–2021) median of 1,125 t; the probability that the 2022 biomass is currently above the USR and in the Healthy Zone is greater than 0.99 (Figure 4). The 2021 commercial biomass estimate was 1,459 t. The biomass estimate of recruit Scallops in 2022 was 7.6 t, which is below the long-term (1983–2021) median of 28.5 t. The 2021 biomass estimate of recruit Scallop was 13.6 t.

Catch scenarios for the 2022–23 fishing season are presented in Table 4. Biomass projections use the current year estimates of growth and natural mortality is the average over the last 5 years. See SPA 1A Stock Status section in this document for an example of interpreting the table.

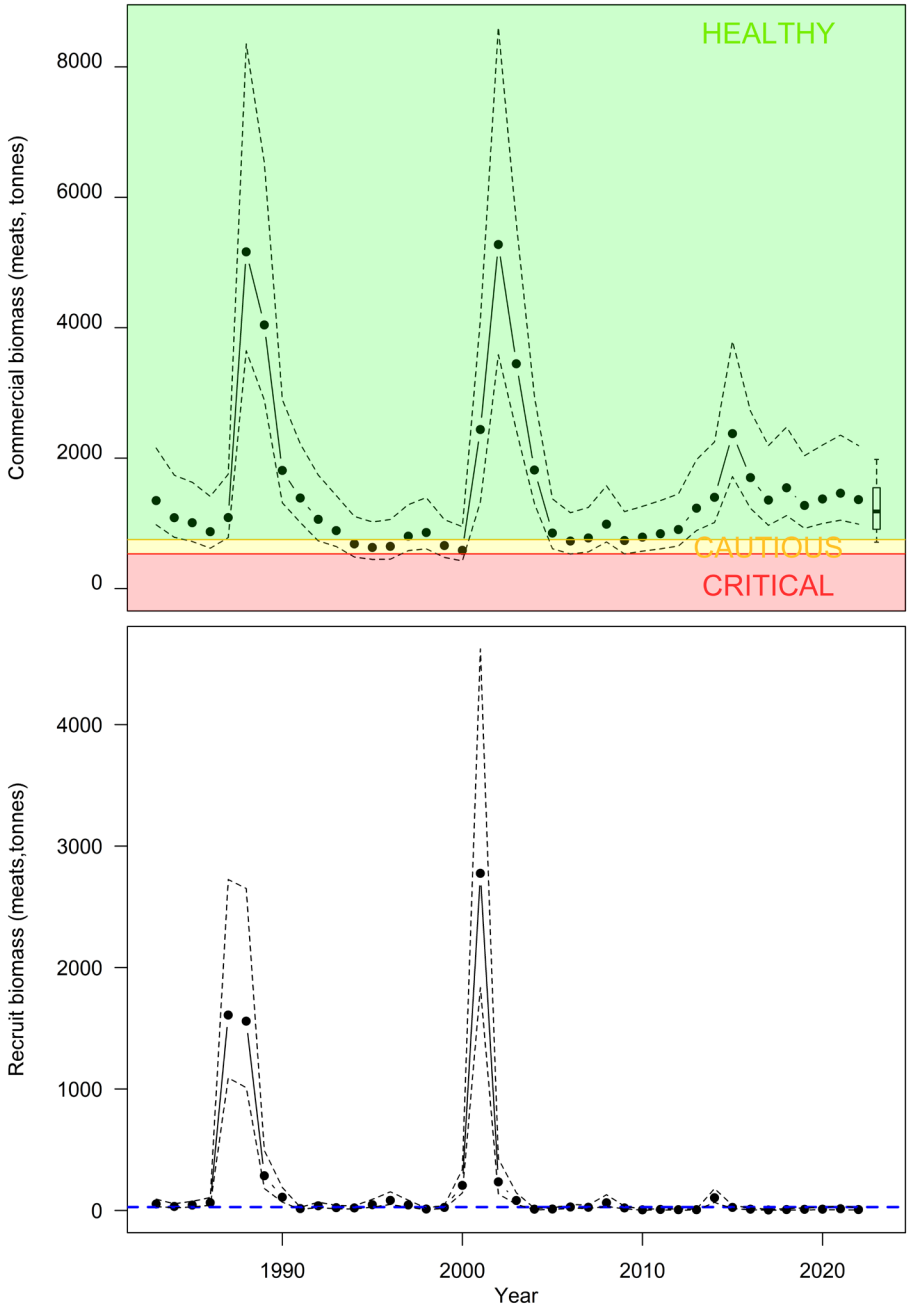

Figure 4. Median biomass estimates in SPA 4 for commercial (top panel) and recruit (bottom panel) size Scallops in meat weight (tonnes) from the assessment model fit to the survey and commercial data. Dashed lines are the upper and lower 95% credible limits on the estimates. The predicted commercial size biomass for 2023, assuming the 2022–23 interim TAC (150 t), is displayed as a box plot with median, 50% credible limits (box) and 80% credible limits (whiskers). The green-shaded area represents the Healthy Zone (based on an Upper Stock Reference [USR] point of 750 t), the yellow-shaded area represents the Cautious Zone, and red-shaded area represents the Critical Zone (based on Limit Reference Point [LRP] of 530 t; Nasmith et al. [2014]). The blue horizontal dashed line in the lower panel represents the long-term median (1997–2021) recruit biomass.

Table 4. Harvest scenario table for SPA 4 to evaluate 2022–23 catch levels in terms of resulting exploitation (e), expected changes in commercial biomass (%), probability (Pr) of commercial biomass increase, probability that after removal the stock will be above the Upper Stock Reference (USR; 750 t), and above the Limit Reference Point (LRP; 530 t). Potential catches (t) in 2023–24 are evaluated in terms of the posterior probability of exceeding a removal reference exploitation of 0.15.

2022–23 Fishing Season						2023–24 Fishing Season					
Catch (t)	*e*	% Change	Pr Increase	Pr > LRP	Pr > USR	Probability Exploitation > 0.15 *Potential Catch (t)* 0.1	0.2	0.3	0.4	0.5	0.6
100	0.07	−11	0.36	0.98	0.90	111	133	151	167	184	203
120	0.09	−12	0.34	0.98	0.89	110	131	148	164	181	200
140	0.10	−14	0.32	0.98	0.88	108	128	145	161	178	197
160	0.12	−15	0.31	0.98	0.87	105	126	143	159	176	194
180	0.14	−17	0.29	0.97	0.86	104	124	140	156	173	191
200	0.15	−18	0.27	0.97	0.85	102	121	137	153	169	187
220	0.16	−19	0.25	0.97	0.84	100	119	135	151	167	184

SPA 5

The annual survey in SPA 5 was discontinued in 2009 after consultation with industry, and the sampling effort was redirected to other areas in the BoF. Since the 2014 survey, a small number (n = 5) of tows have been conducted in SPA 5 annually, with the exception of 2020. Survey trends are compared to the historic long-term medians (1990–2008). The commercial weight per tow in 2022 was 1.4 kilograms per tow (kg/tow) which is equal to the historic long-term (1990–2008) median (1.4 kg/tow); commercial weight per tow in 2021 was 0.6 kg/tow. In 2022, no recruits were observed; recruit weight per tow in 2021 was 0.02 kg/tow.

Scallop Production Area 6 Stock Status

For SPA 6, the current stock status indicator is the commercial catch rate time series starting in 1997 for all subareas combined. The LRP is 6.2 kg/h, the lowest catch rate observed in the time series since 1997, and the USR is 9.1 kg/h, based on the average catch rate from 2005 to 2011 (Nasmith et al. 2016). In 2022, the catch rate across all areas was 28.8 kg/h, which was above the USR, and in the Healthy Zone (Figure 5). In 2021 the catch rate was 29.9 kg/h. Given that current reference points are not biomass based, an Inshore Scallop Advisory Committee (ISAC) working group was established and DFO Science presented recommendations in May 2022. Biomass based candidate reference points were recommended by the working group to ISAC on September 22, 2022. The Candidate USR (C.USR) was 471 t and the Candidate LRP (C.LRP) was 236 t. Candidate removal reference exploitation was proposed to be between 17 and 18%.

The productivity of Scallops is tied closely to habitat suitability and in the absence of detailed habitat information, the spatial distribution of fishing effort can be a good indicator of suitable habitat (Smith et al. 2009, Brown et al. 2012, Sameoto et al. 2014, Smith et al. 2015). The modelled area for SPA 6 corresponds to an area of historically high fishing intensity as described in Nasmith et al. (2016). However, unlike other SPAs in the Bay of Fundy, the modelled area of SPA 6 represents a subset of the core Scallop habitat (Nasmith et al. 2016). The proportion of landings associated with the modelled area ranged from 64–81% between 2006 and 2021.

In 2022, the proportion of landings that came from the modelled area was 64%. The biomass estimate of commercial Scallops in 2022 was 1,207 t (meats), which is above the long-term (1983–2021) median of 749 t; the probability that the 2022 biomass is currently above the

C.USR is greater than 0.99 (Figure 6). The 2021 commercial biomass estimate was 1,108 t. The biomass estimate of recruit Scallops in 2022 was 12.1 t, which is below the long-term (2006–2021) median of 42.5 t. The 2021 biomass estimate of recruit Scallop was 6.2 t.

Catch scenarios for 2022–23 are presented in Table 5. Biomass projections use the current year estimates of growth and natural mortality is the average over the last 5 years. Table 5 is interpreted as follows, a catch of 120 t in the modelled area of SPA 6 would correspond to an exploitation of 0.10 and is projected to result in a 13% decline in commercial biomass in the modelled area, the probability of commercial biomass increase in the modelled area is 33%. The probability that a catch of 120 t will result in the population remaining above the C.LRP is > 99%, and the probability of the population remaining above the C.USR is 96%. Conditional on the proportion of catch from the modelled area staying the same in 2023 as 2022, a catch of 120 t from the modelled area would correspond to a total SPA 6 catch of 188 t.

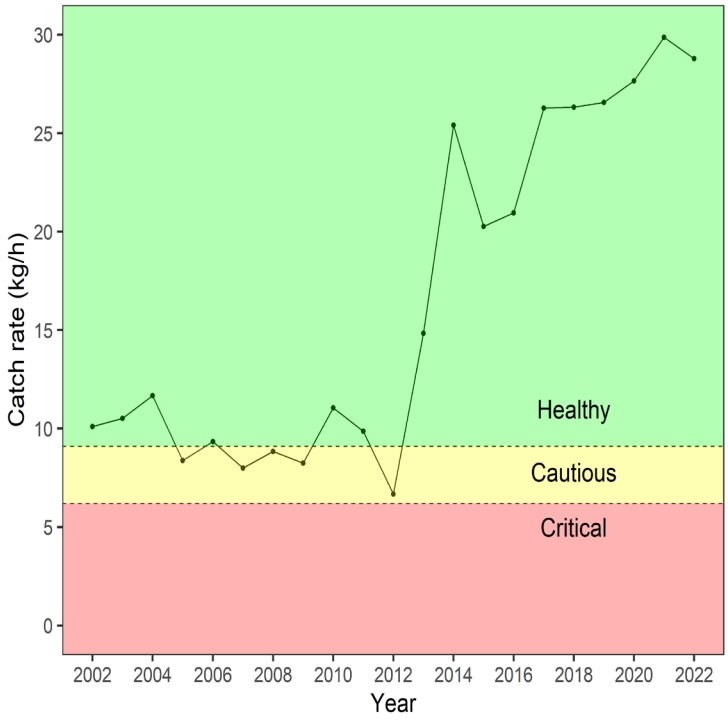

Figure 5. Annual commercial catch rate (kilogram/hour [kg/h]) for SPA 6 for all subareas and both fleets combined. The green-shaded area represents the Healthy Zone (based on an Upper Stock Reference of 9.1 kg/h), the yellow-shaded area represents the Cautious Zone, and the red-shaded area represents the Critical Zone (based on Limit Reference Point of 6.2 kg/h).

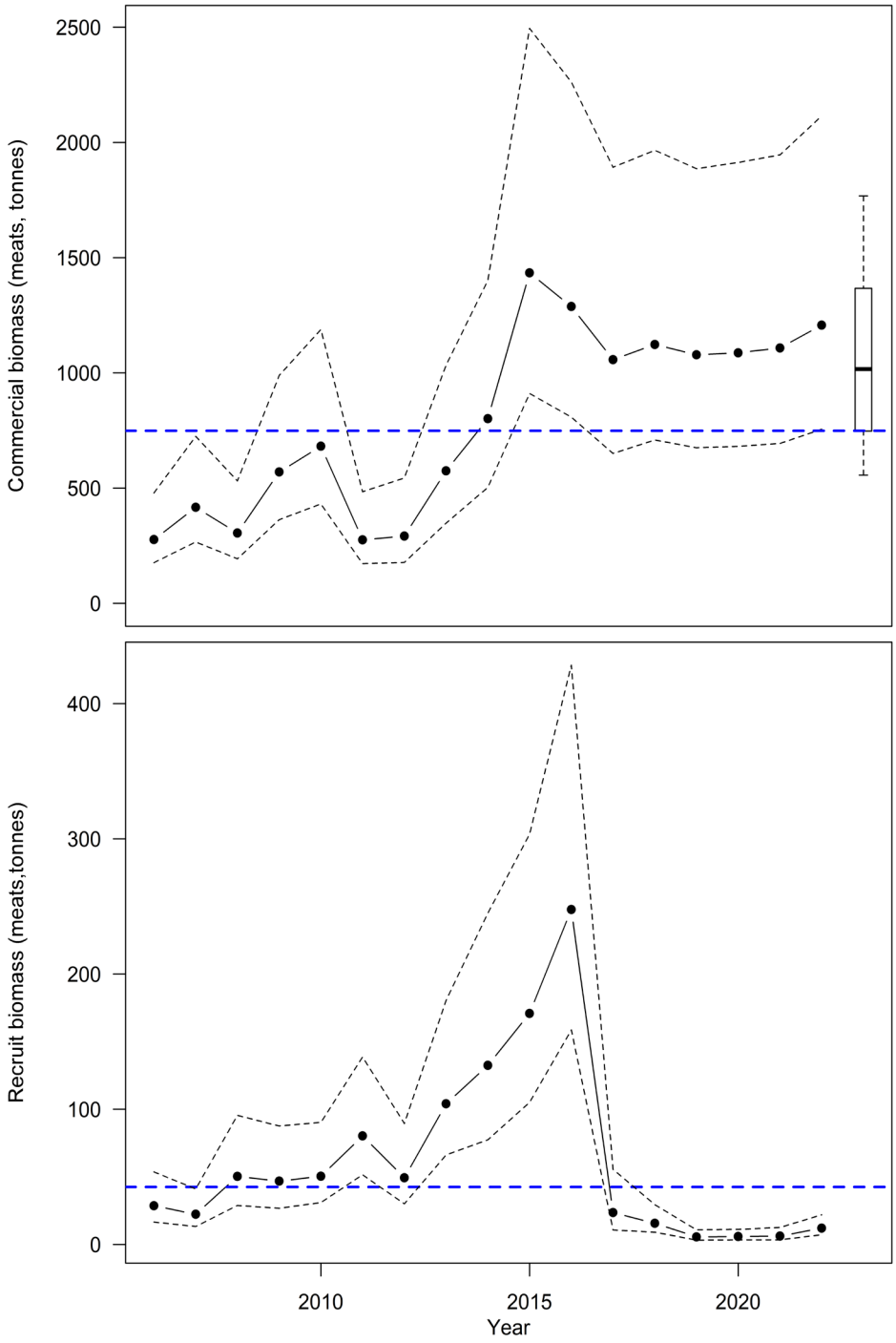

Figure 6. Median biomass estimates (solid line) in the SPA 6 modelled area for commercial (top panel) and recruit (bottom panel) size Scallops in meat weight (tonnes) from the assessment model fit to the survey and commercial data. Dashed lines are the upper and lower 95% credible limits on the estimates. The predicted commercial size biomass for 2023, assuming a catch of 180 t in 2023, is displayed as a box plot with median, 50% credible limits (box) and 80% credible limits (whiskers). The blue horizontal dashed lines represent the long-term median (2006–2021) biomasses.

Table 5. Harvest scenario table for the SPA 6 modelled area to evaluate 2022–23 catch levels in terms of resulting exploitation (e), expected changes in commercial biomass (%), probability (Pr) of commercial biomass increase. The probability that after removal the stock will be above the Candidate Upper Stock Reference (C.USR; 471 t), and above the Candidate Limit Reference Point (C.LRP; 236 t); grey shaded columns. Corresponding catch levels for the whole area of SPA 6 are conditional on the proportion of catch from the modelled area staying the same in 2023 as in 2022 (64%).

2022–23 Fishing Season						
Modelled Area						*Whole Area*
Catch (t)	***e***	**% Change**	**Pr Increase**	**Pr > C.LRP**	**Pr > C.USR**	**Catch (t)**
100	0.08	−12	0.35	> 0.99	0.96	156
120	0.10	−13	0.33	> 0.99	0.96	188
140	0.12	−14	0.32	> 0.99	0.95	219
160	0.13	−16	0.30	> 0.99	0.95	250
180	0.15	−17	0.28	> 0.99	0.95	281
200	0.17	−19	0.26	> 0.99	0.94	312
220	0.18	−20	0.24	> 0.99	0.94	344

Ecosystem Considerations

Currently, there is no DFO requirement for observer coverage in SPAs 1–6. Refer to Sameoto and Glass (2012) for past analysis of discards from the Inshore Scallop fishery.

Conclusions

In 2022, all SPAs remained in the Healthy Zone. The biomass estimates of commercial Scallop for SPAs 1A, 1B, 4, and 6 were above their long-term medians, whereas for SPA 3 it was below its long-term median. The biomass estimates of recruit Scallops for SPAs 1A, 3, 4, and 6 were below their respective long term medians, whereas for SPA 1B it was above the long-term median.

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Appendix

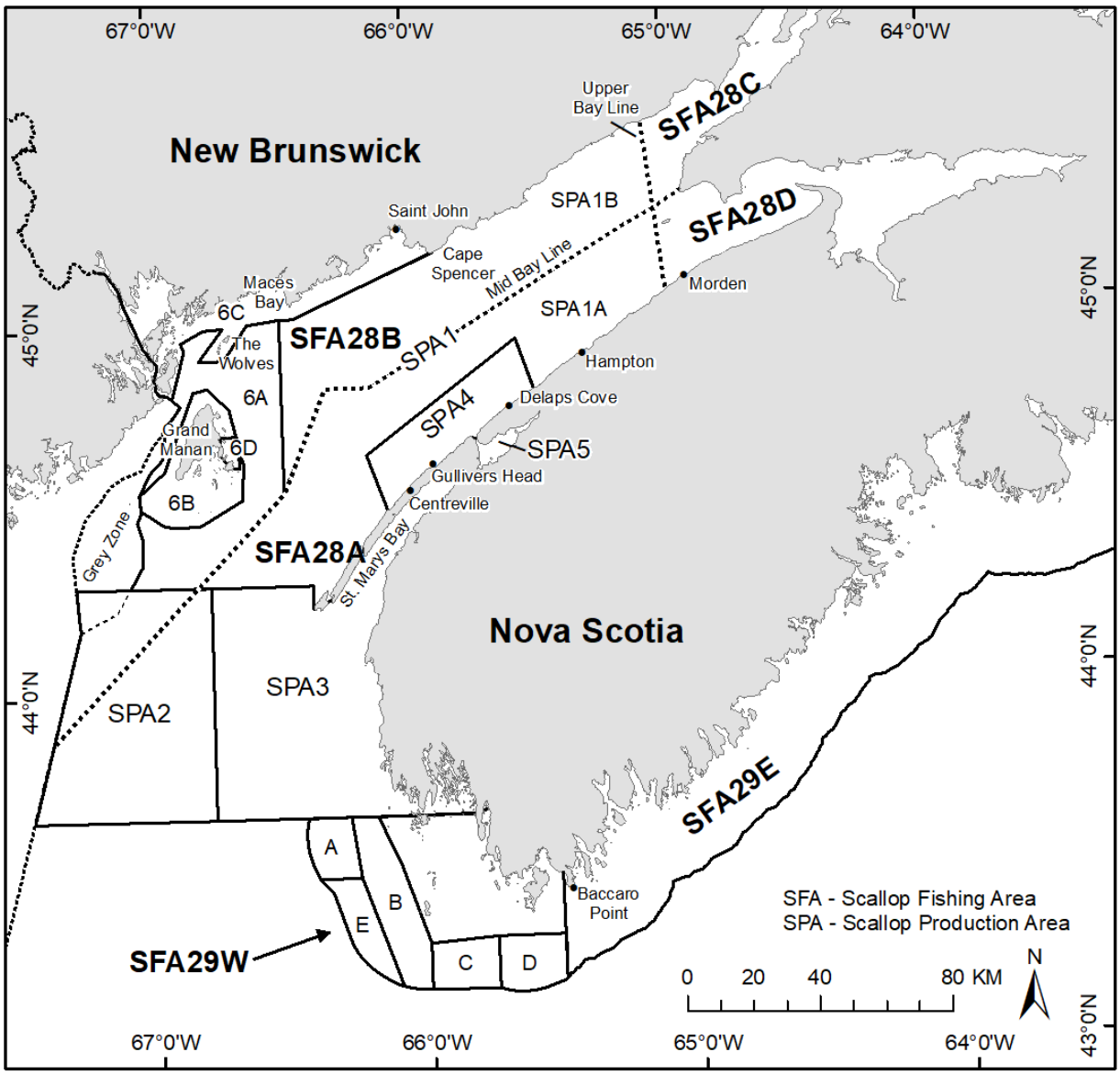

Figure A1. Map of Scallop Production Areas (SPAs) and Scallop Fishing Areas (SFAs) in the Bay of Fundy and approaches.

*Table A1. Commercial Scallop fishery landings, Total Allowable Catch (TAC), and landings for Food, Social and Ceremonial purposes (FSC) by First Nations (meats, t) for Scallop Production Areas (SPAs) in the Bay of Fundy from 2020 to 2022. TAC values are pre-quota reconciliation. Landing values in 2022 are preliminary (as of October 31, 2022). Dash (-) indicates no catch. * indicates preliminary data.*

Year	SPA	TAC (t)	Landings (t)	FSC (t)	Total Landings (t)
2020	1A	415	415.3	-	415.3
	1B	600	544.9	-	544.9
	3	175	107.6	-	107.6
	4&5	135	128.0	-	128.0
	6	200	215.9	-	215.9
2021	1A	270	271.7	-	271.7
	1B	400	417.1	-	417.1
	3	200	249.2	-	249.2
	4&5	175	168.5	-	168.5
	6	210	190.5	-	190.5
2022*	1A	350	350.2	-	350.2
	1B	450	441.3	-	441.3
	3	200	201.1	-	201.1
	4&5	200	189.7	-	189.7
	6	265	283.9	-	283.9

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