Fisheries and Oceans Canada | Pêches et Océans Canada
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Maritimes Region

Canadian Science Advisory Secretariat
Science Response 2021/014

2020 STOCK STATUS UPDATE OF EASTERN SCOTIAN SHELF NORTHERN SHRIMP (SFAS 13–15)

Context

Advice on the status of the Eastern Scotian Shelf (ESS) Shrimp (*Pandalus borealis*) stock is requested annually by Fisheries and Oceans Canada (DFO) Fisheries Management Branch and industry to help determine a Total Allowable Catch (TAC) that is consistent with the Integrated Fishery Management Plan (IFMP). Science advice for the management of the ESS Shrimp stock is provided as a fully peer-reviewed stock assessment at an inclusive Regional Advisory Process (RAP) meeting on a biennial basis. In interim years, science advice is provided as a stock status update and published as a Science Response. The most recent RAP took place in December 2018 (DFO 2019) and the most recent framework review took place in April 2015 (Hardie et al. 2018). Due to the impact of COVID-19 on work plans, and the plan to conduct a Framework review and Assessment in the fall of 2021, the stock status for 2020 and advice for management of the 2021 fishery is provided as a Science Response Process for this year.

This Science Response Report results from the Science Response Process of December 09, 2020, on the Stock A of Eastern Scotian Shelf Shrimp in Shrimp Fishing Areas (SFAs) 13–15. Additional publications from this meeting will be posted on the DFO Science Advisory Schedule as they become available.

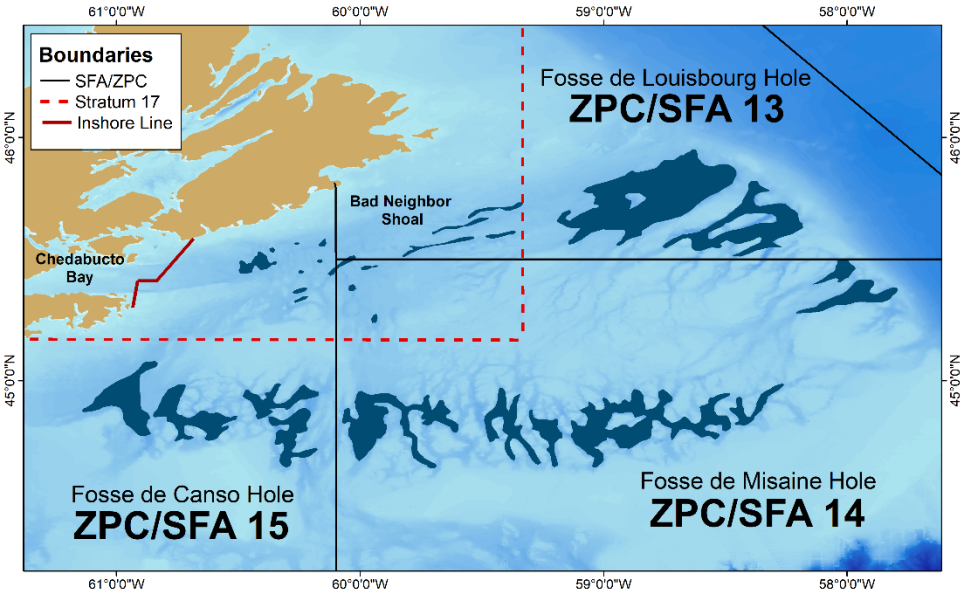

Figure 1. Shrimp Fishing Areas (SFAs) on the Eastern Scotian Shelf. The area within the dashed red line depicts survey stratum 17 (inshore area); survey strata 13–15 are the remaining portions of SFAs 13–15.

Background

As documented in recent assessments, the ESS Shrimp stock has been able to recover from a 4-year decline (2014–2017), as positive changes to biomass were noticeable in 2018. A steady biomass increase has been observed for the last two years, and the current 2020 estimate is above the biomass in 2015. The abundant recruitment events of the 2013–2014 year-classes are at the end of their life expectancy in 2020–2021, while the less abundant 2015–2016 year-classes are expected to provide limited recruitment to the fishing stock (DFO 2019, DFO 2020). Since 2017, Shrimp recruitment has been consistent, and it is anticipated to begin contributing to the adult biomass in 2022. In 2016, after two years of biomass declines, TAC reductions were put in place. The TAC was reduced by 28% to 3,250 mt in 2016, with a further TAC reduction of 20% to 2,600 mt in 2017. Since 2018, a status quo TAC has remained in place with positive total and spawning stock biomass responses throughout that time.

Description of the Fishery

The trawl fishery on the Scotian Shelf occurs primarily during spring and early summer, with some fishing during fall. It occurs in the deep offshore Shrimp “holes” and in an inshore area near Bad Neighbor Shoal (Figure 1). The main management tools are limits on the number of licenses and size of vessels used, minimum codend mesh size (40 mm), use of a Nordmøre separator grate, and a TAC. This fleet (currently about 15 active licenses) is divided into two sectors: a midshore sector consisting of vessels 65–100' Length Over All (LOA) based in New Brunswick in the DFO Gulf Region, and an inshore sector consisting of vessels mainly < 65' LOA based in the DFO Maritimes Region. A trap fishery, currently consisting of 7 active licenses, is restricted to Chedabucto Bay. The quota allocated to the trap fishery is currently 8% of the TAC.

Although there has been some Shrimp fishing on the Scotian Shelf since the 1960s, the Nova Scotia fishery began to expand toward its full potential only when groundfish bycatch restrictions were overcome with the introduction of the Nordmøre grate in 1991 (Figure 2). The TAC was first reached in 1994, when individual SFA quotas were removed. Since that time, the TAC has fluctuated between 3,100–5,500 mt, mostly in response to the influence of strong recruitment events (large year classes) on spawning stock and fishable biomass. In 2017, the TAC was decreased to the lowest level since 1992 (2,600 mt), and has been maintained at this level for the last three years (2018–2020).

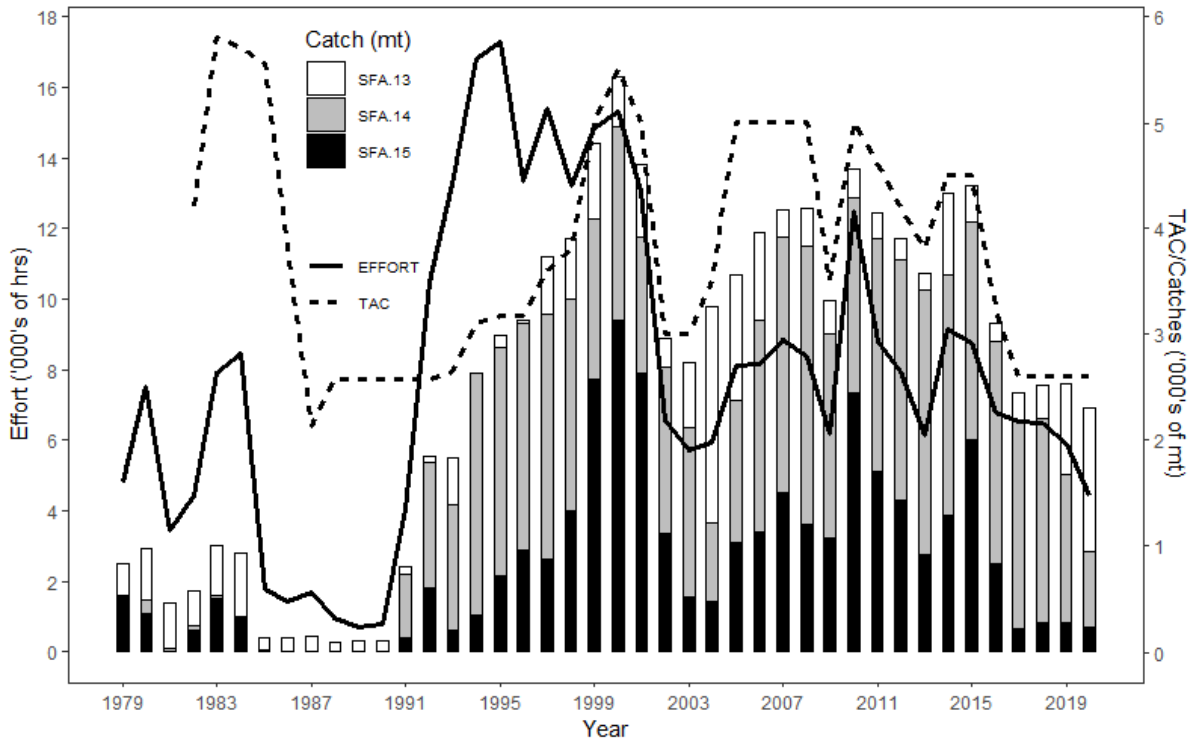

Figure 2. History of Eastern Scotian Shelf Shrimp catches per Shrimp Fishing Area (SFA) (13, 14, and 15), Total Allowable Catch (TAC) (thousands of mt), and effort (thousands of hours), from 1979–2020. Effort and catches for 2020 represent data available as of November 25, 2020.

Analysis and Response

The stock assessment for ESS Shrimp is based on a “Traffic Light” analysis (Koeller et al. 2000) that uses a multiple indicator diagnostic approach, with discussion of individual indicators grouped under headings representing four characteristics: Abundance, Productivity, Fishing Effects, and Ecosystem (see DFO 2020).

A precautionary approach using reference points and control rules within the framework of the Traffic Light analysis has been used in recent assessments for this stock. The precautionary application of reference points for ESS Shrimp includes a Limit Reference Point (LRP) and Upper Stock Reference (USR), which are 30% and 80%, respectively, of the average Spawning Stock Biomass (SSB) maintained during the high productivity period of the modern fishery (2000–2010). A maximum removal reference point of 20% female exploitation is used to help guide management decisions (Hardie et al. 2018).

Data used in this assessment include commercial catch data, survey Catch Per Unit Effort (CPUE) data (expanded to total biomass using the swept area method), detailed Shrimp biological data (commercial and survey samples), survey data for other marine species, and various environmental data (Hardie et al. 2018).

Indicators of the Stock Status

The swept area survey biomass index increased by 6% from 28,098 +/- 5,161 mt (95% confidence interval) in 2019 to 29,875 +/- 4,956 mt (95% confidence interval) in 2020. CPUE trends from the Gulf vessels and the standardized commercial fishery data also show an increase in 2020 (Figure 3A). The trap CPUE is 2.32 kg Catch per Trap Haul (CPTH) and similar to the last four years, with fishing still ongoing. Although Figure 3B shows CPUEs increasing for all strata, biomass estimates showed an increase in Stratum 15 only.

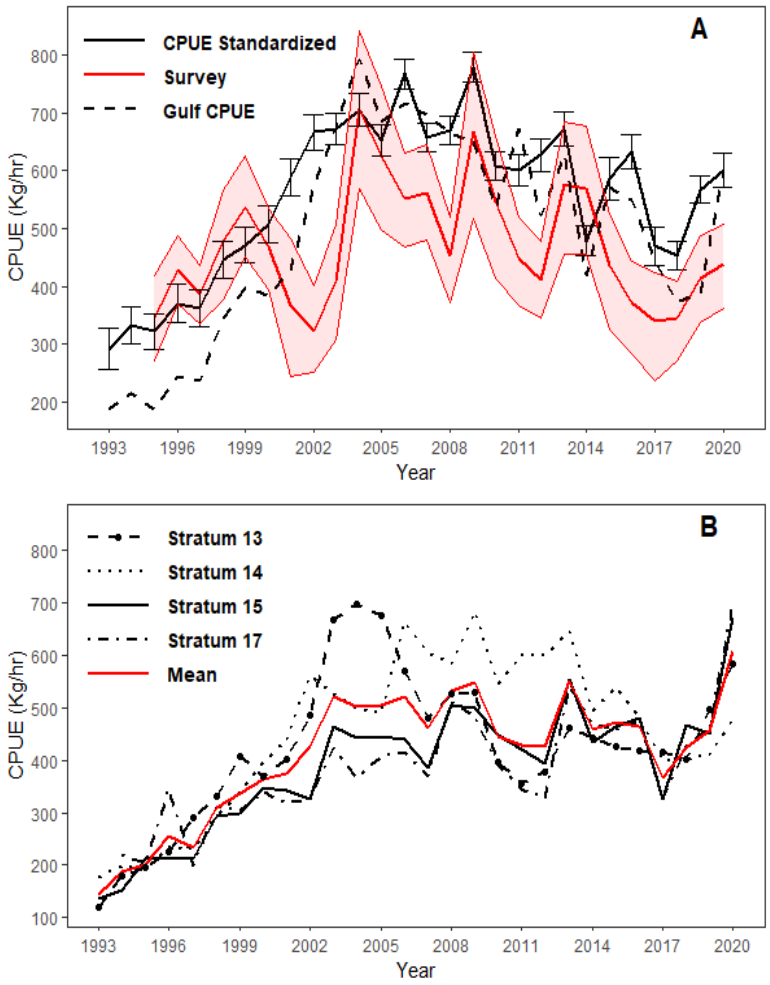

Figure 3. (A) DFO-Industry survey stratified Catch Per Unit Effort (CPUE), standardized commercial CPUE with 95% confidence intervals, and unstandardized Gulf vessel CPUE; and (B) Unstandardized commercial CPUE for each fishing area, from 1993–2020.

Spawning stock biomass is the accepted Precautionary Approach stock health indicator for Scotian Shelf Shrimp (Smith et al. 2012). As depicted in Figure 4, the SSB point estimate decreased 10% from 20,398 mt in 2019 to 18,403 mt in 2020, but the stock remains in the Healthy Zone (Figure 4) and above the USR (14,558 mt). The status quo TAC since 2017 has resulted in reductions in the total and female exploitation. In 2020, both total and female preliminary exploitation indices are under 10%, an all-time low (Figure 4).

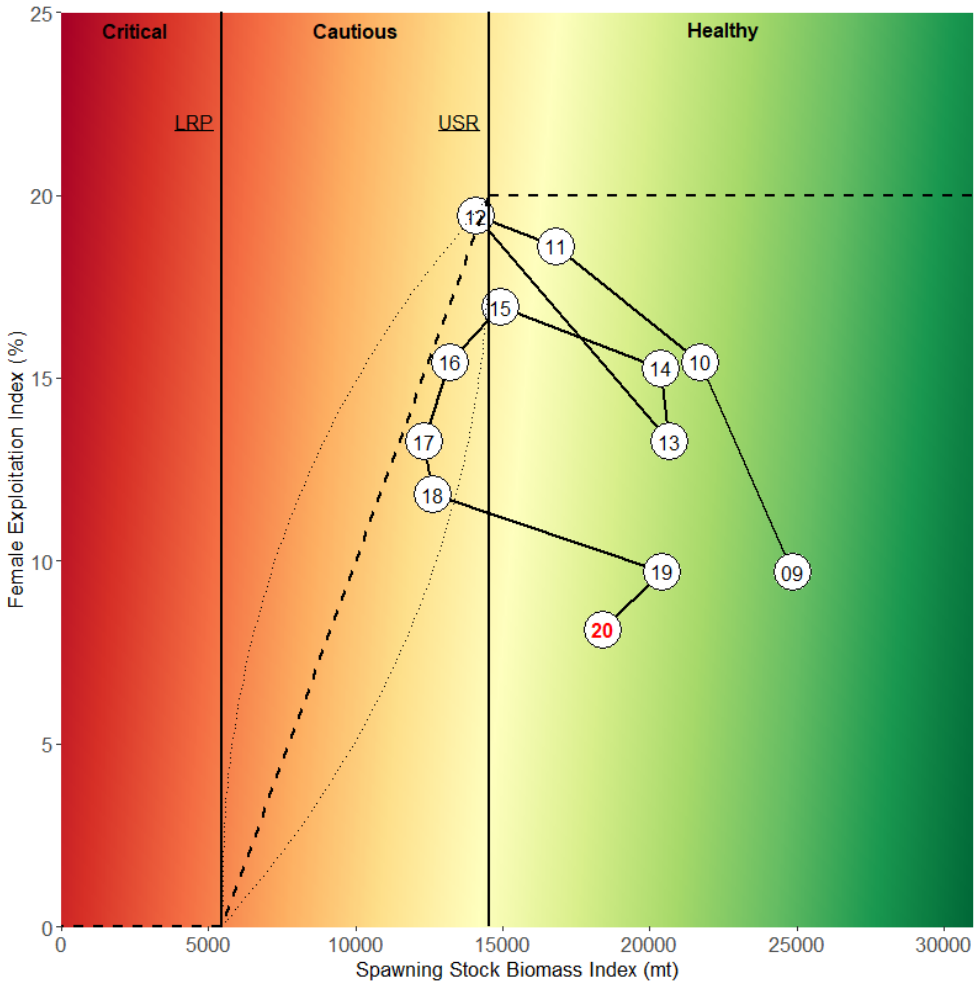

Figure 4. Graphical representation of the precautionary approach for Eastern Scotian Shelf Shrimp. The dotted lines in the Cautious Zone represent a range of management actions possible, depending on whether the stock is stable, increasing or decreasing, or on trends in other indicators of stock or ecosystem health.

The interpretation of year-class strength and longevity can be complicated by a number of factors, including: the low catchability of Shrimp younger than Age 4; the strong influence of growth rate on the catchability of Age 4 Shrimp; difficulty in distinguishing and assessing year-classes after Age 3; and changing longevities and natural mortalities associated with environmental and/or density-dependent influences. The tendency of a single year-class (especially larger ones, such as 2007–2008 and 2013) to change sex over a number of years makes it difficult to distinguish them from adjacent year-classes. Nonetheless, the recruitment pulses of 2007–2008, and most recently 2013, have resulted in the maturation of large spawning stock biomasses.

The relatively abundant 2013–2014 year-classes are reaching the end of their life expectancy in 2020–2021. With the less abundant 2015–2016 year-classes reaching commercial sizes, their contribution is expected to provide limited recruitment to support the remaining fishable and spawning stock biomasses as represented at age 5+ (Table 2). This is evidenced in the 2020 DFO-Industry survey (Figure 5) and commercial catch (Figure 6) length frequencies. Cohort tracking through length frequency distributions from the DFO-Industry survey and commercial

samples corroborate the lower belly-bag (Age 1 abundance) index in 2016 and 2017 in predicting lower contributions to fishable and spawning stock biomass than from the 2013–2014 year-classes (Table 2).

Belly-bag Age 1 abundance index values for 2016 and 2017 were among the lowest in the 18-year time-series, suggesting poor recruitment from the 2015 and 2016 year-classes. The abundance indices for Age 2 and Age 4 increased in 2020, which is consistent with the associated belly-bag index values found in 2019 (i.e., 2018 year-class). However, 2017 (i.e., 2016 year-class) is the lowest recruitment event in recent years, so the Age 4 index value was expected to decrease for 2020 (Table 2). As previously mentioned, several factors complicate the tracking of an age-class throughout the modal analysis. In this case, there is a possibility that Age 4 Shrimp actually contains multiple year-classes. The overall abundance of Age 1 and Age 2 Shrimp observed in the 2020 DFO-Industry survey is consistent with the increases in SSB and reduced temperature indices observed since 2016.

Table 1. Minimum survey population numbers-at-age from modal analysis. Numbers x 10^6. Average and median are based on data from 1999–2020. Shaded portion of the table represents numbers updated to include all SFAs.

Age	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Avg.	Median
1[1]	205	311	198	61	191	479	541	197	88	94	22	796	288	112	83	267	272	279	286	205
2	616	354	187	121	39	114	304	188	58	43	211	26	495	17	166	37	68	72	166	123
3	312	3118	652	880	506	396	267	1020	513	348	302	119	501	193	581	361	195	368	540	365
4	1506	839	4502	0[4]	0[4]	1190	463	1036	1105	1018	1157	613	690	1304	1468	822	392	522	1270	1105
5+	1727	3324	2224	5106	5506	3017	6020	4109	2694	2688	4091	4673	2956	3076	1734	2231	3155	3000	3028	3038
TOTAL	4161	7636	7763	6169	6244	5201	7622	6616	4458	4191	5783	6227	4930	4702	4032	3718	4082	4241	5127	4816
Age 4+ males[2]	1526	1549	4956	3916	2804	3317	4263	3454	2003	2241	2960	3831	2270	2931	1859	1966	2273	2137	2635	2296
Primiparous[3]	551	870	786	771	1739	892	1492	1324	947	371	699	706	521	664	453	433	435	573	777	717
Multiparous	1188	1698	1183	480	1157	482	1295	630	937	1188	1611	1545	1143	897	973	921	1111	1091	1009	1041
Total females	1739	2568	1969	1251	2896	1374	2787	1954	1884	1559	2310	2251	1664	1561	1426	1354	1546	1664	1787	1664

Notes:

[1] Belly-bag. Time series began in 2002.

[2] Total population less Ages 2 and 3 males, transitionals (i.e., males that will potentially change to females the following year), and females.

[3] Includes transitionals.

[4] Four-year olds of the 2002, 2003, and 2010 year-classes were not distinguishable in the MIX analysis. These year-classes appear to be small and are contained in the Ages 3 or 5+ categories.

The 2013 year-class, first observed in 2014 as the second highest belly-bag index in the time series (Table 2), has been closely monitored and has provided a strong signal in the DFO-Industry survey (Table 2; Figure 5) and commercial fishery (Figure 6) data until now. The Age 5+ females and the Age 4+ males decreased, which coincides with lower maturing contributions from 2015–2016 year-classes (Figure 7, A and B). The survey length frequencies of transitional/primiparous Shrimp have increased in 2020; however, the abundance of multiparous Shrimp decreased and supports the decrease observed in the SSB index (Figure 7, B). The 2015 year-class is expected to recruit to the SSB in 2020 and despite its low belly-bag index, a positive contribution is observed as primiparous Shrimp in Figure 5 and 7B.

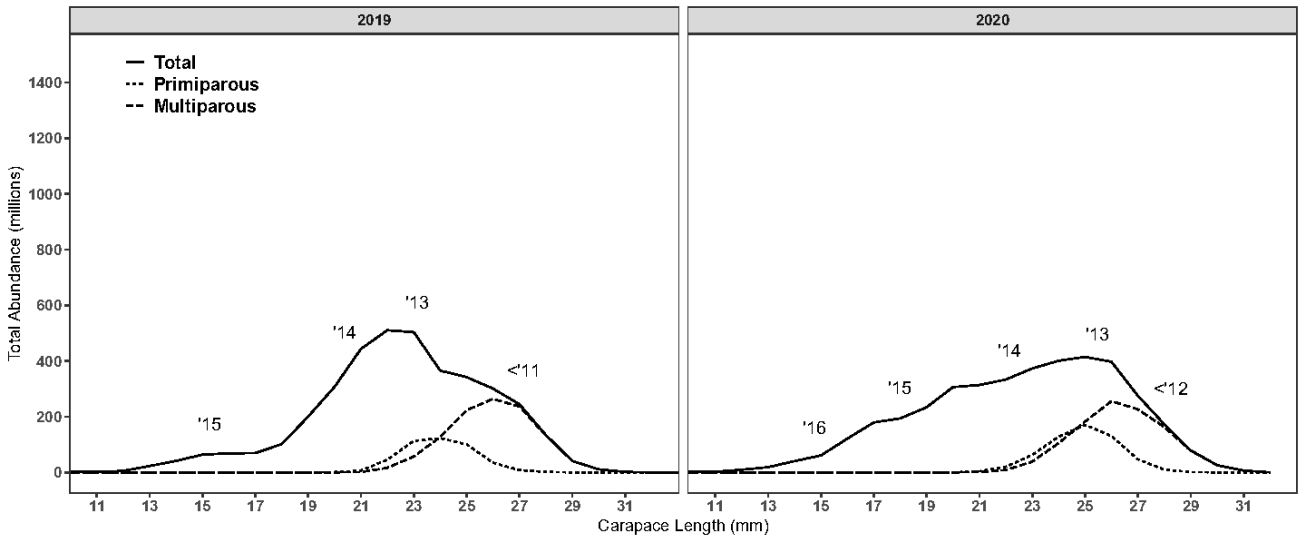

Figure 5. Population estimates of number of Shrimp-at-length from the 2019 and 2020 DFO-Industry surveys (solid line). The dotted line in each figure represents transitional and primiparous Shrimp, and the dashed line represents multiparous Shrimp. Year-classes associated with Shrimp at given carapace lengths are indicated. See DFO, 2019 for complete time-series of survey length-frequencies.

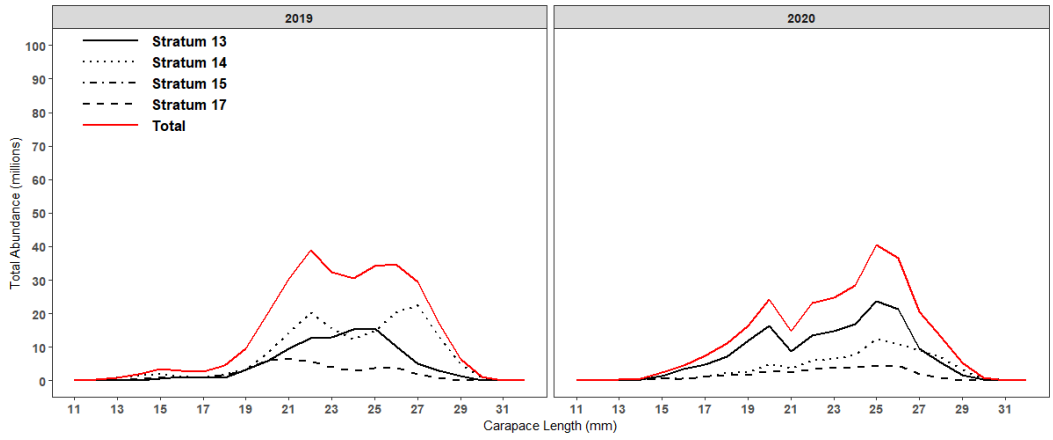

Figure 6. Catch-at-length from commercial sampling by stratum, 2019–2020.

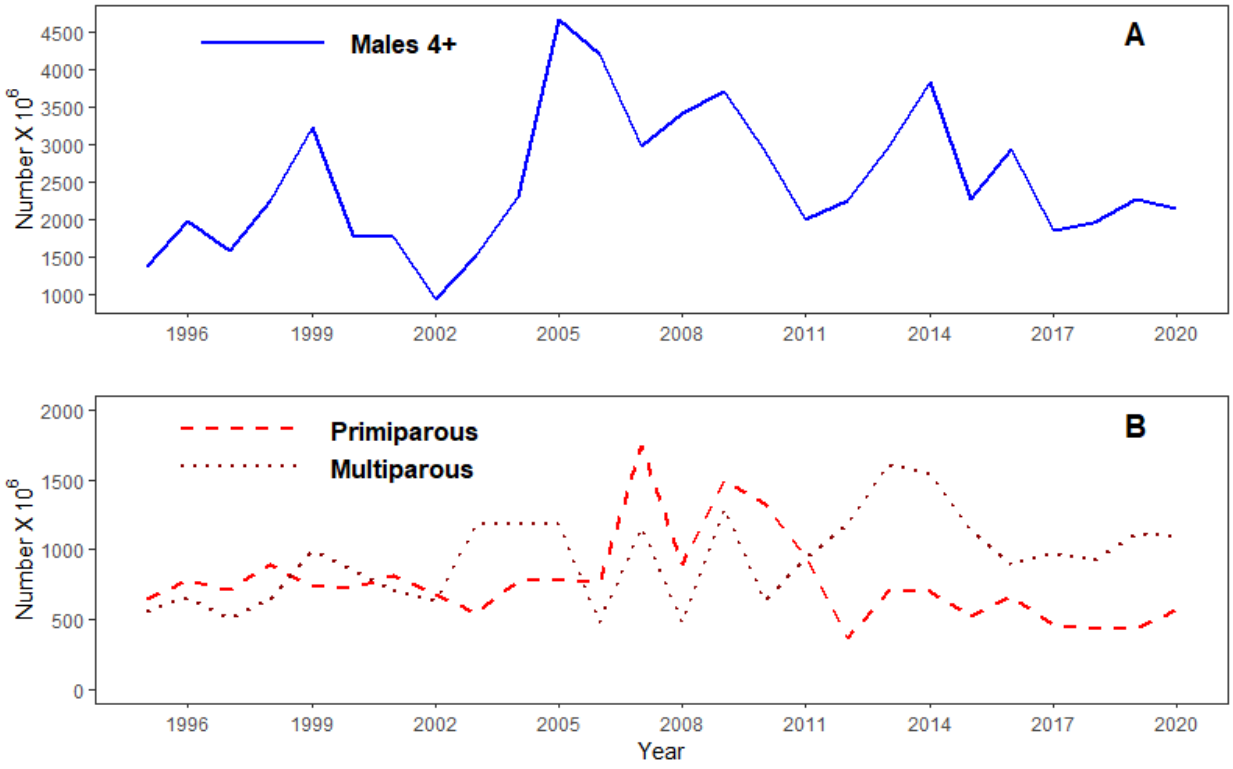

Figure 7. (A) Modal analysis population estimates of Age 4 and older male, and (B) Primiparous female and Multiparous female, Shrimp from the survey.

The suite of available indicators of stock health are grouped into four summary characteristics: Abundance, Productivity, Fishing Effects, and Ecosystem characteristics (Figure 8). All summary characteristics increased except for Ecosystem in 2020. The Abundance characteristic increased but remains in the red zone due to a gradual increase of all the indicators while counteracted by a decrease in commercial catch rate areas. The Productivity characteristic also increased and is nearing the green zone, primarily because of increases in the abundance of young Shrimp associated with sustained stronger juvenile recruitment (higher belly-bag Age 1). The Fishing Effects characteristic is nearing the green zone as a result of continued declines in total and female exploitation. The Ecosystem characteristic decreased and is in the red zone as both bottom and spring sea-surface temperatures are rising. The relative contribution of the individual indicators to the four summary indicators are shown in Figure 9. The overall mean summary indicator decreased in 2020 and remains in the yellow zone due to positive responses in 16 out of the 24 indicators across all four characteristics.

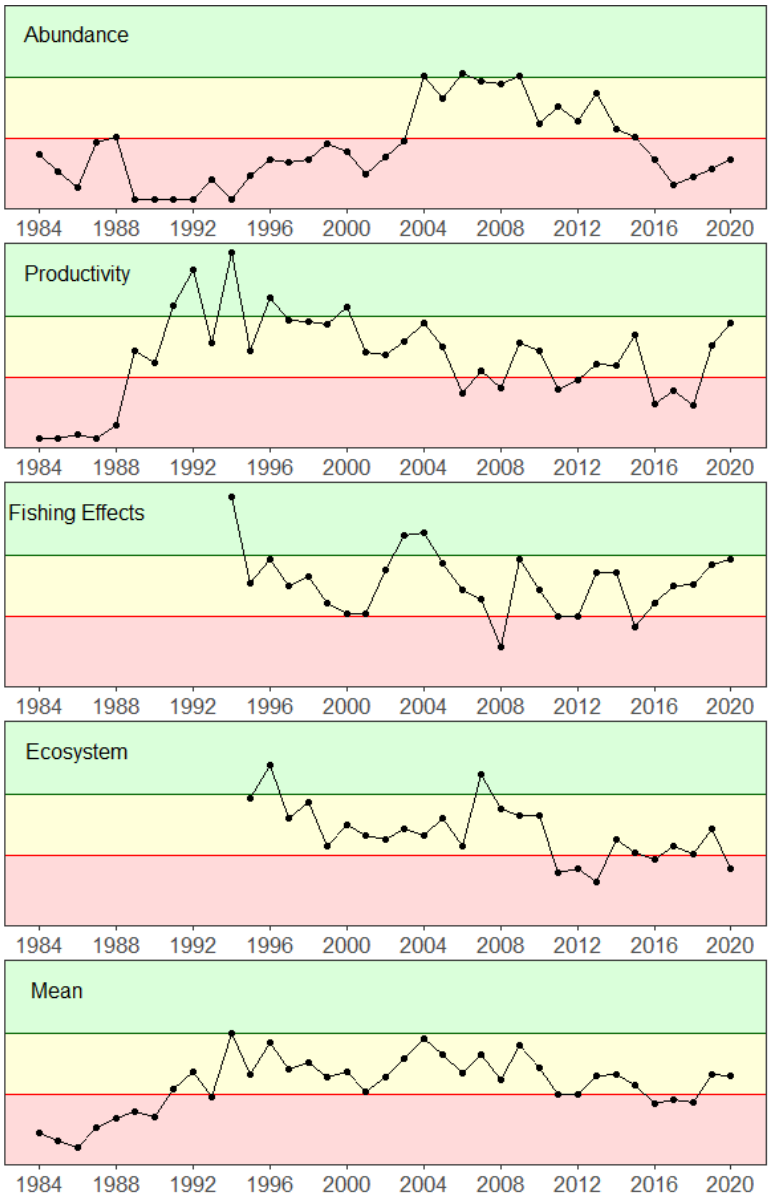

Figure 8. Time series of all available indicators grouped into four characteristics (top four panels) and the mean (overall) indicator (bottom panel) from 1984–2020. Thresholds between red, yellow, and green are at the 33rd and 66th percentile of the 2000–2010 data series for each indicator. Not all indicators in the summary above are discussed in the text. See Hardie et al. (2018) for a detailed description of indicators.

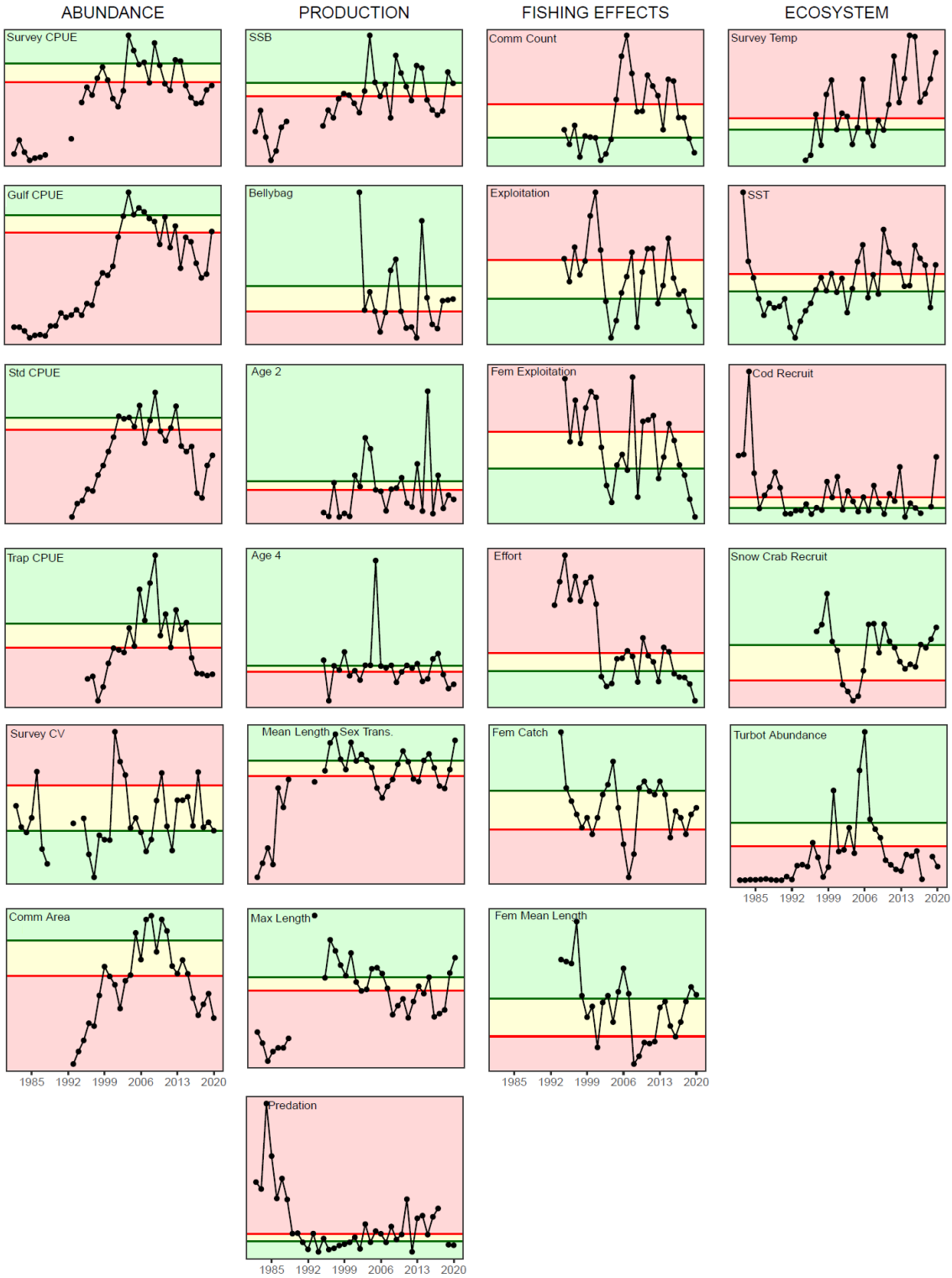

Figure 9. Time series of individual Shrimp indicators. Note: not all indicators are discussed in the text. Refer to past CSAS Research Documents for detailed description of indicators (e.g., Hardie et al. 2018).

Bycatch

Introduction of the Nordmøre grate in 1991 substantially reduced bycatch and allowed the fishery to expand to its present size. Bycatch information from observer coverage of 44 commercial sets from 2019 (3 trips) and 2020 (1 trip) suggests that the fleet's trawl configurations, including the use of the Nordmøre grate, continue to ensure low total bycatch (< 1%) by weight. Total bycatch by weight from observed trips in 2019–20 is similar to that reported in past assessments. The single observed trip in 2020 (out of a 6-trip target) took place during the spring-summer and covered SFAs 13 and 14. The ESS mobile Shrimp fishery currently poses little risk to other marine species in terms of bycatch amount or species composition.

Conclusions

The anticipated 2020 stock assessment was replaced by an update due to impacts of COVID-19 and a change in timing of the upcoming CSAS Framework Review and Assessment process. There were several notable impacts that affected this fishery in 2020. The DFO-Industry survey was delayed by a month, with a different vessel, new captain and crew conducting the survey to meet COVID-19 requirements. Commercial fishing was also limited and delayed, resulting in a later season with less fishing in SFA 14 than in previous years. This directly affected port sample collection and distribution among SFAs, with a larger portion of samples coming from SFA 13. Observer coverage was impacted as there was a suspension of monitoring activities in the spring. Delays also occurred in administrative pathways (commercial log processing, quota transfers, etc.). Despite these impacts, the resulting stock analysis was able to be completed with confidence that it is representative of ESS Shrimp stock in 2020.

The DFO-Industry survey stratified mean biomass estimate increased by 6%, to 29,875 (+/- 4,956 mt, 95% CI) in 2020 from 2019 levels. The point estimate of the 2020 SSB (18,403 mt) decreased by 10% from 2019. This SSB point estimate is still above the USR (14,558 mt), indicating the stock is still in the Healthy Zone. Additionally, commercial CPUEs remained at a high level (standardized CPUE increased 6%, Gulf-based vessel CPUE by 54%).

Belly-bag Age 1 abundance indices for the last three years (2018–2020) highlight sustained recruitment from the 2017–2019 year-classes, consistent with the expectation that lower temperature conditions lead to better recruitment. The abundance indices for Age 2 and Age 4 Shrimp increased in 2020, consistent with the associated belly-bag index values found in 2019 (i.e., 2018 year-class). However, 2017 (i.e., 2016 year-class) is the lowest recruitment event in recent years; from this information the Age 4 index value was expected to decrease for 2020.

Size-based indicators (mean size at sex transition, mean maximum size, mean count) demonstrate that the size of Shrimp has been increasing in recent years; however, in 2020 female mean length decreased. This coincides with the addition of smaller Shrimp to the 2013–2014 year-classes that have been supporting the overall Shrimp abundance.

Temperature-based ecosystem indicators show a gradual increase in the last few years, but they are still at lower temperatures than in 2016. Trends in the abundance of sympatric species are contradictory for 2019, suggesting that favorable conditions for coldwater species are fluctuating.

The overall mean summary indicator, condensing the 24 indicators, decreased and is still in the yellow zone in 2020 due to three out of four summary characteristics showing positive responses. The Fishing Effects characteristic saw a continued decrease in 2020 and is at an all-time low, benefitting the Shrimp stock.

Increases in abundance and production are counteracted by increasing bottom and sea-surface temperatures, adding a more challenging dynamic to the interpretation of the 2021 population. The 2014–15 year-classes are now contributing to the SSB and are expected to provide commercial stock support for the next few years. Continuation of similar catch levels from 2020 would help maintain low exploitation rates and protect more of the 2016–2017 year-classes until they can recruit to the SSB.

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Sources of Information

This Science Advisory Report is from the December 9, 2020, Stock Assessment of Eastern Scotian Shelf Northern Shrimp (SFAs 13–15). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

DFO. 2019. Assessment of Northern Shrimp on the Eastern Scotian Shelf (SFAs 13–15). DFO Can. Sci. Advis. Sec. Sci. Resp. 2019/013.

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