2019 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). The current report provides information on the stock status for 2019 and advice for management of the 2020 fishery.

This Science Response Report results from the Science Response Process of December 11, 2019, on the Stock Status Update of Eastern Scotian Shelf Shrimp in Shrimp Fishing Areas (SFAs) 13–15.

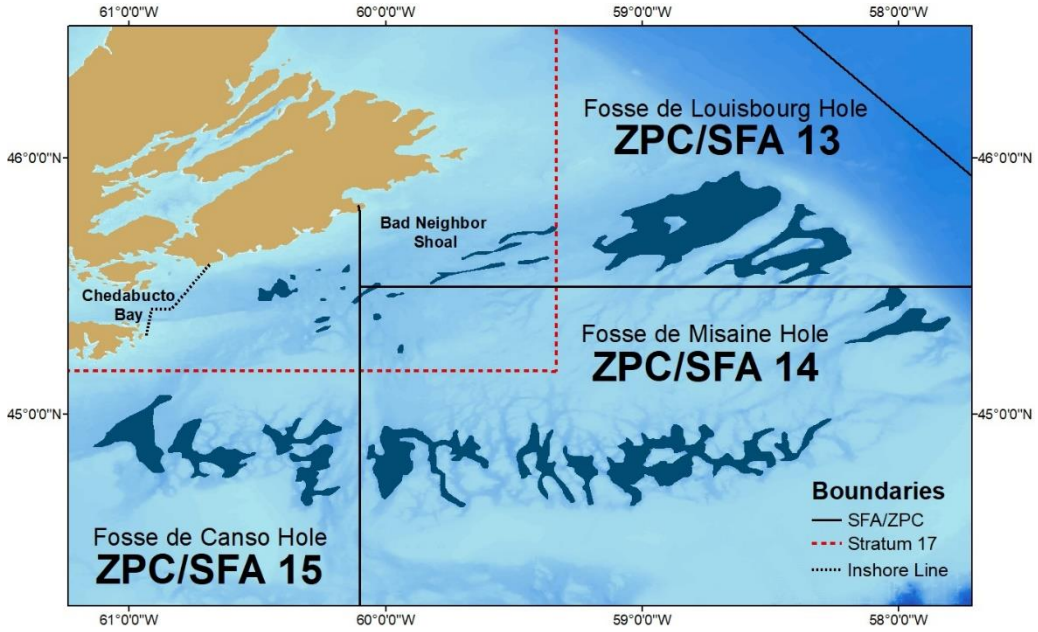

Figure 1. Shrimp Fishing Areas (SFAs) on the Eastern Scotian Shelf. The red dashed line outlines survey stratum 17, and survey strata 13–15 are the remaining portions of SFAs 13–15.

Background

As documented in recent assessments, the ESS Shrimp stock has been declining since 2014. The relatively abundant 2007– 2008 year classes reached the end of their life expectancy in 2014–2016, while the less abundant 2009–2012 year classes were expected to provide limited replenishment to the fishing stock (DFO 2015; DFO 2017; Hardie et al. 2018). Due to an increase in adult biomass, the TAC was raised from 3,800 metric tons (mt) in 2013 to 4,500 mt in 2014 and held constant in 2015. As the stock began to show signs of decline, TAC reductions were put in place. In 2016, the TAC was reduced by 28% to 3,250 mt, and in 2017 there was a further TAC reduction of 20% to 2,600 mt. A status quo TAC was implemented in 2018 and 2019 because declines in both total and spawning stock biomasses stabilized. The expectation was that the high abundance from the 2013 year class (Hardie et al. 2018), would recruit to the spawning stock biomass during this time.

Description of the fishery

The trawl fishery on the Scotian Shelf occurs in deep offshore “shrimp holes” and on the nearshore Bad Neighbor Shoal area (Figure 1), primarily during spring and early summer, with some limited fall fishing efforts. 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 (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 Gulf Region and an inshore sector consisting of vessels mainly <65' LOA based in the Maritimes Region. A trap fishery, currently consisting of 7 active licenses, is restricted to Chedabucto Bay and occurs during the fall and winter period. The allocation of quota to the Chedabucto Bay trap fishery currently is 8% of the overall 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. The annual TAC for 2017–2019 has been at the lowest level since 1992 (2,600 mt).

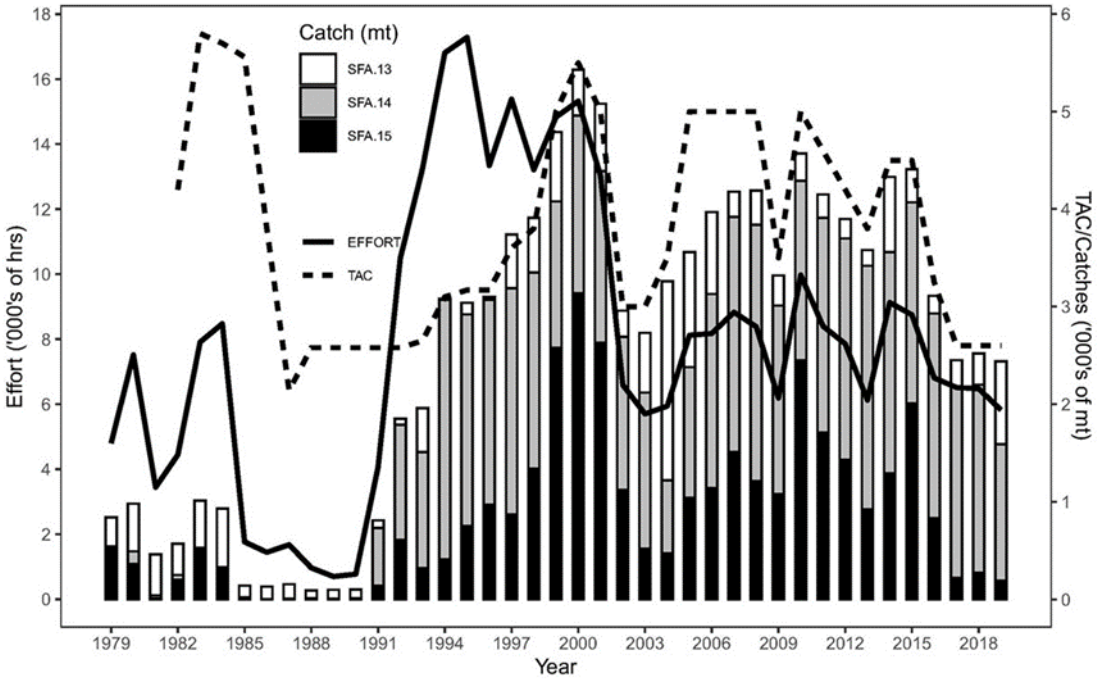

Figure 2. History of Eastern Scotian Shelf Shrimp catches per Shrimp Fishing Area (SFA) (13, 14, and 15), Total Allowable Catch (TAC) (thousands of mt) and effort (thousands of hours) from 1979–2019. Effort and catches for 2019 represent data up to November 15, 2019.

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 2019).

A precautionary approach using reference points and control rules within the context of the Traffic Light analysis has been used in recent assessments of ESS Shrimp. The Limit Reference Point (LRP) and Upper Stock Reference (USR) 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, a metric of fishing impact on the reproductive potential of the stock, 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 environmental data (Hardie et al. 2018).

Indicators of the stock status

The swept area survey biomass index increased by 21% from 23,449 mt (18,726– 28,172 mt - 95% confidence interval (CI)) in 2018 to 28,334 mt (23,173– 33,495 mt - 95% CI) in 2019. In 2019, CPUE trends from the Gulf and the standardized commercial fishery data show an increase (Figure 3A). The preliminary trap CPUE decreased by 15% for 2019; however, fishing is still ongoing. Biomass estimates also increased in all strata except for Stratum 15 (Figure 3B).

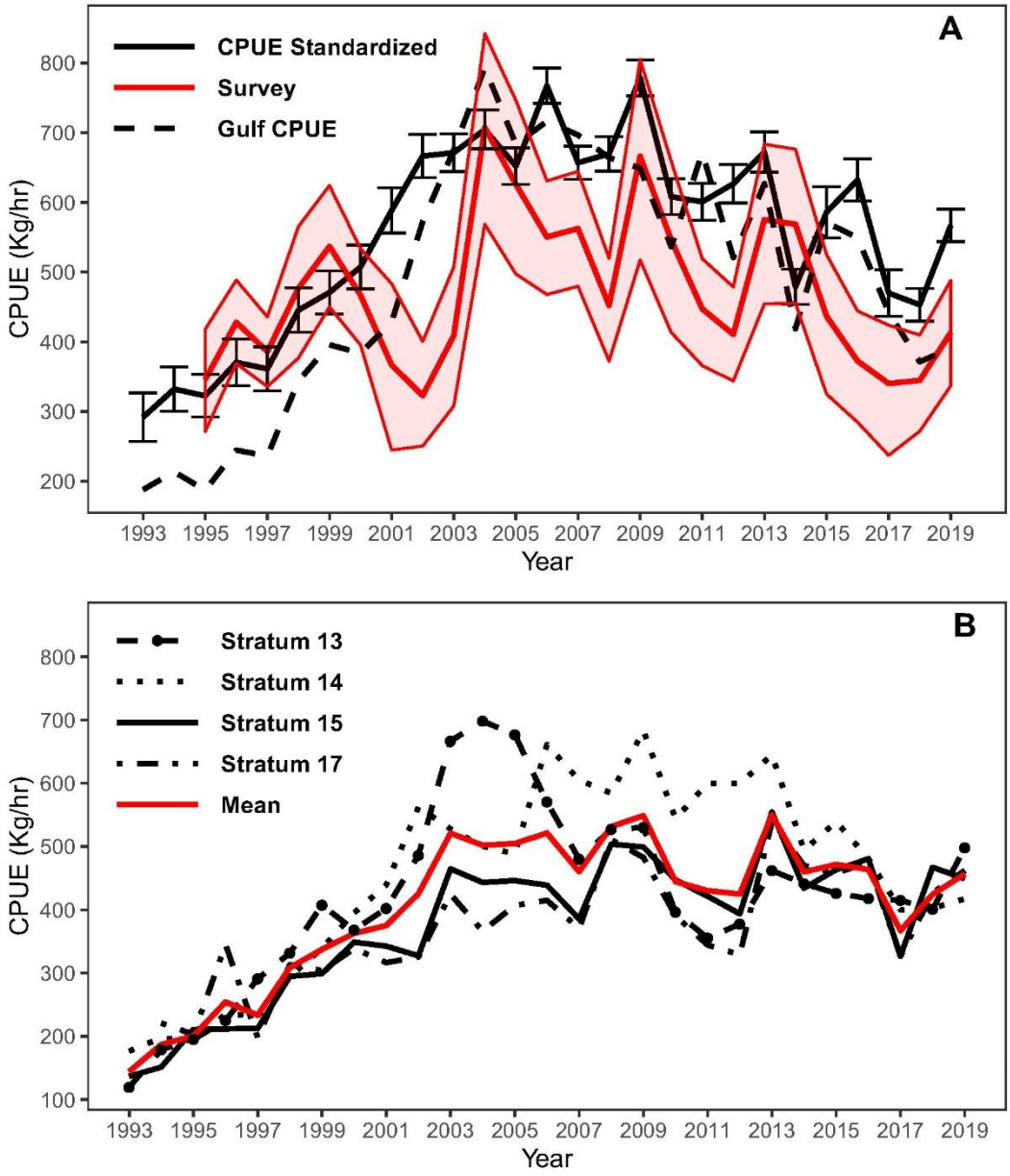

Figure 3. Panel A: DFO-Industry survey stratified Catch Per Unit Effort (CPUE), standardized commercial CPUE with 95% confidence intervals, and unstandardized Gulf vessel CPUE; Panel B: unstandardized commercial CPUE for each fishing area, from 1993–2019.

Spawning stock biomass is the accepted Precautionary Approach indicator (Smith et al. 2012). The LRP and USR are defined as 30% and 80% of the average SSB from 2000–2010. As depicted in Figure 4, the point estimate of the SSB increased 53% from 13,515 mt in 2018 to 20,737 mt in 2019. This places the stock in the Healthy Zone (Figure 4) and above the USR (14,558 mt) after being three years in the Cautious Zone. The status quo TAC implemented since 2017 has decreased the total and female exploitation. In 2019, 20% and 34% reductions were observed in the total and female exploitation, respectively (Figure 4).

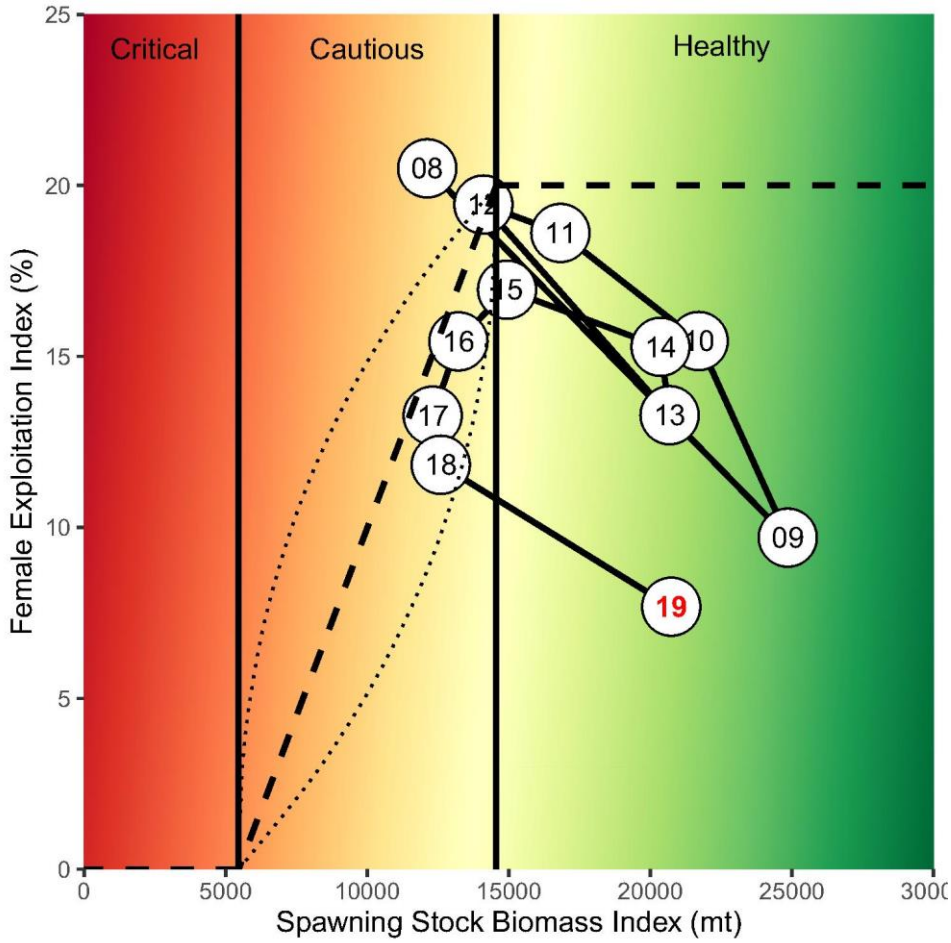

Figure 4. Graphical representation of the precautionary approach for Eastern Scotian Shelf Shrimp. The dotted lines in the Cautious Zone represent a range of possible management actions, depending on whether the stock is stable, increasing or decreasing, or on trends in other indicators of stock or ecosystem 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 or density dependent influences. The tendency of a single year class (especially relatively large 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 2002, 2007– 2008, and most recently 2013, have coincided with their maturation to produce large spawning stock biomasses.

With the 2013 year class having now reached commercial sizes, its contribution is well represented at Age 5+ in 2019 (Table 2), and it currently supports the remaining fishable and spawning stock biomasses. This is evidenced in the 2019 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 higher belly-bag (Age 1 abundance) index in 2014, 2015 and more recently in 2018– 2019 in predicting higher contributions to fishable and spawning stock biomass than from the 2009–2012 year classes (Table 2). Belly-bag Age 1 abundance index values for 2016 and 2017 were among the

lowest in the 17-year time series, suggesting poor recruitment from the 2015 and 2016 year classes. The abundance indices for Age 2 increased, while Age 4 shrimp decreased in 2019, which is consistent with the associated belly-bag index values found in 2018 (i.e., 2017 year class) and 2016 (i.e., 2015 year class), respectively (Table 2). The overall abundance of Age 1 and Age 2 shrimp observed in the 2019 DFO-Industry survey is consistent with the increases in SSB and reduced temperature indices observed since 2017. 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 continues to provide a strong signal in the DFO-Industry survey (Table 2; Figure 5) and commercial fishery data (Figure 6). The 2013 year class increased the index of abundance for Age 5+ female shrimp to the highest it has been since 2014. While Age 4+ males increased in 2019, it is uncertain whether this will translate into an increase in the total biomass index in 2020. The survey length frequencies of transitional/primiparous shrimp have relatively remained unchanged from 2018 to 2019; however, the abundance of multiparous shrimp increased and supports the increases observed in the biomass indices (Figure 7). The 2013 year class was expected to recruit to the SSB in 2018; however due to the inability to track this cohort consistently, a larger proportion of its age class may be recruiting to the SSB this year rather than last year. As a result, the SSB increased significantly in 2019.

Table 2. Minimum survey population numbers at age from modal analysis. Numbers x 10^6. Average and median are based on data from 1999–2019. Shaded portion of the table represents numbers updated to include all SFAs.

Age	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avg.	Median
1[1]	957	205	311	198	61	191	479	541	197	88	94	22	796	288	112	83	267	264	286	202
2	134	616	354	187	121	39	114	304	188	58	43	211	26	495	17	166	37	68	171	134
3	383	312	3118	652	880	506	396	267	1020	513	348	302	119	501	193	581	361	195	549	362
4	399	1506	839	4502	0[4]	0[4]	1190	463	1036	1105	1018	1157	613	690	1304	1468	822	392	1307	1105
5+	1847	1727	3324	2224	5106	5506	3017	6020	4109	2694	2688	4091	4673	2956	3076	1734	2231	3155	3029	3076
TOTAL	2763	4161	7636	7763	6169	6244	5201	7622	6616	4458	4191	5783	6227	4930	4702	4032	3718	4074	5169	4930
Age 4+ males[2]	938	1526	1549	4956	3916	2804	3317	4263	3454	2003	2241	2960	3831	2270	2931	1859	1699	1971	2632	2319
Primiparous[3]	678	551	870	786	771	1739	892	1492	1324	947	371	699	706	521	664	453	433	435	787	728
Multiparous	630	1188	1698	1183	480	1157	482	1295	630	937	1188	1611	1545	1143	897	973	921	1111	1005	991
Total females	1308	1739	2568	1969	1251	2896	1374	2787	1954	1884	1559	2310	2251	1664	1561	1426	1354	1546	1793	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.

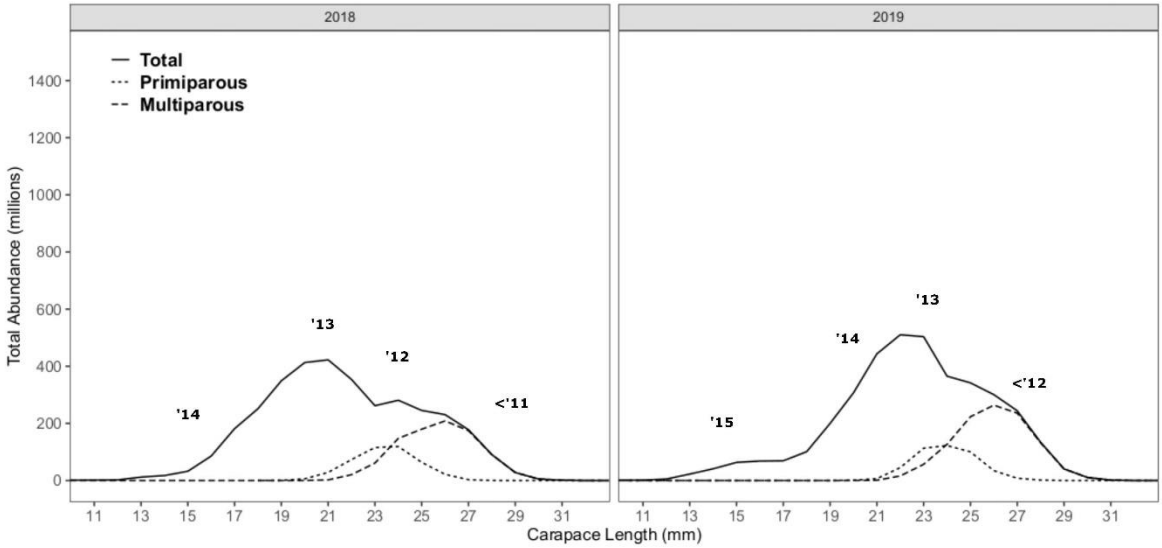

Figure 5. Population estimates of number of shrimp at length from the 2018 and 2019 DFO-Industry surveys (solid line). The dotted line in each figure represents transitional and primiparous shrimp, and the dash line represents multiparous shrimp. Year classes associated with shrimp at given carapace lengths are indicated. See DFO 2019 for complete time-series of survey length-frequencies.

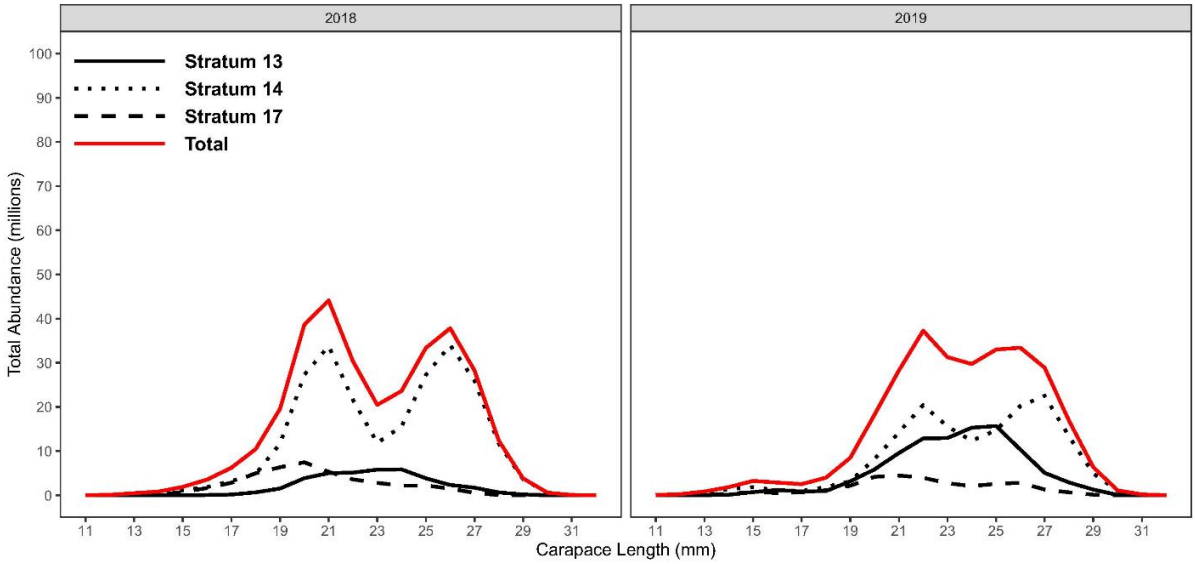

Figure 6. Catch-at-length from commercial sampling by stratum, 2018– 2019. Note: No samples were collected in Stratum 15 in 2018– 2019.

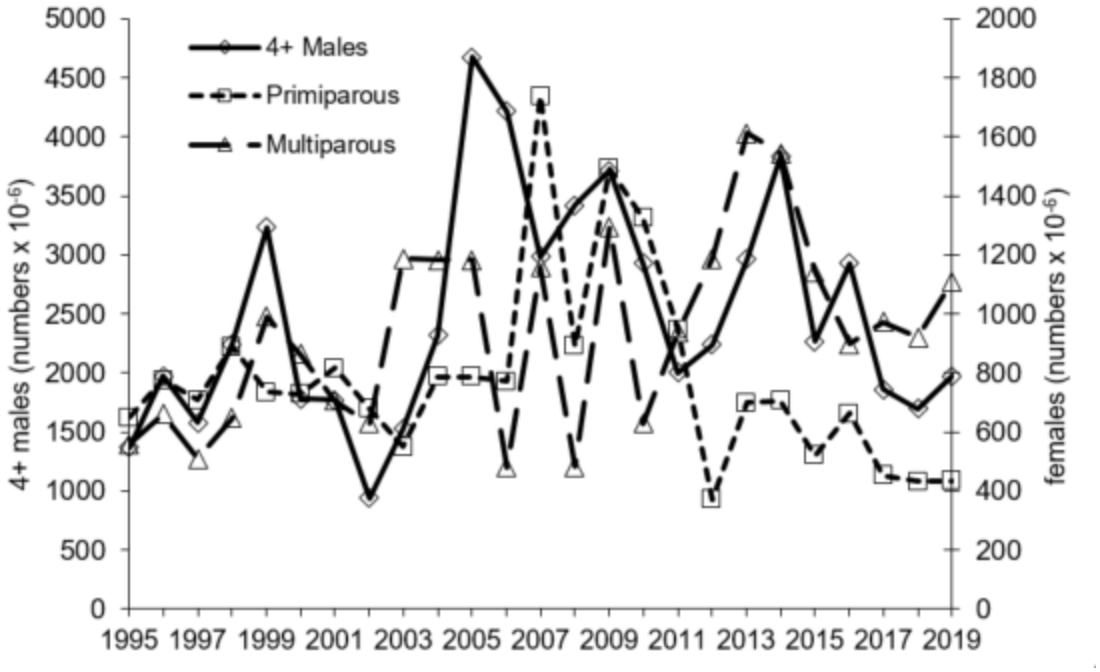

Figure 7. Modal analysis population estimates of Age 4 and older male, primiparous female, and multiparous female shrimp from the survey

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 in 2019. The abundance characteristic remains in the red zone. The productivity characteristic is now in the yellow zone, primarily because of increases in the abundance of young shrimp associated with stronger juvenile recruitment (low belly-bag Age 1) and a surge in SSB. Fishing effects are now in the green zone as a result of continued declines in total and female exploitation. The ecosystem characteristic remains in the yellow zone with continued lower bottom and spring sea-surface temperatures. The relative contribution of the individual indicators to the four summary indicators are shown in Figure 9. The overall mean summary indicator increased in 2019 and is now in the yellow zone due to positive responses in 19 out of the 24 indicators across all four characteristics.

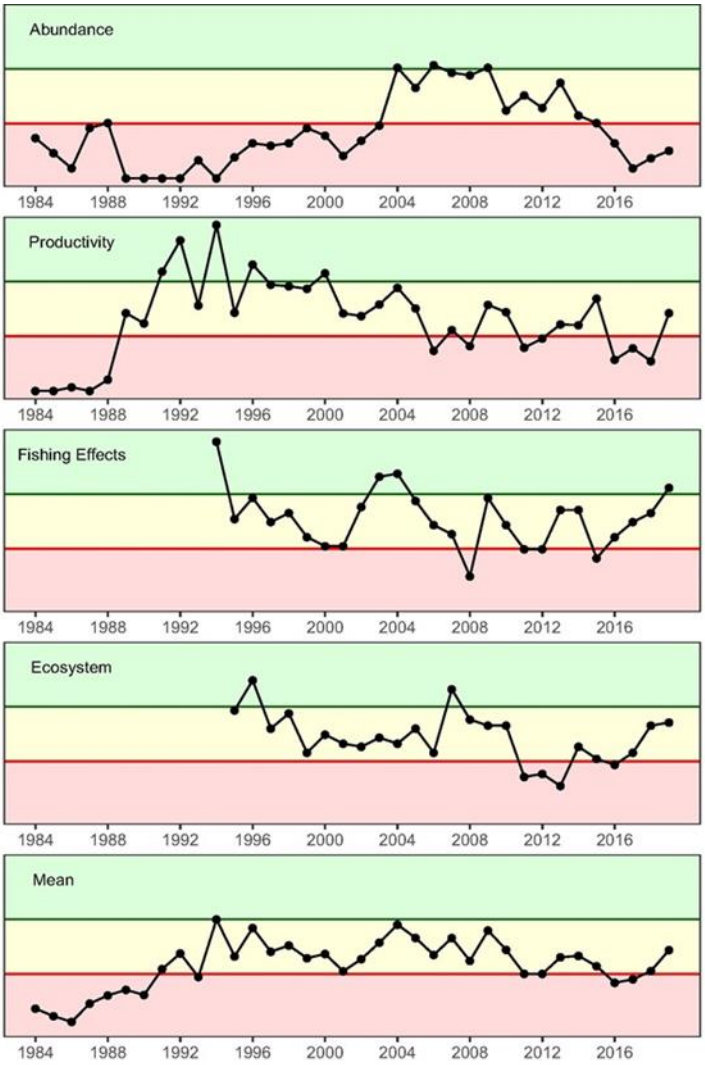

Figure 8. Time series of all available indicators grouped into four characteristics (top four panels) and the mean (overall) indicator (bottom panel) from 1984– 2019. Thresholds between red, yellow and green are at the 33rd and 66th percentile of the 2000– 2010 data series for each indicator. See Hardie et al. 2018 for a detailed description of indicators.

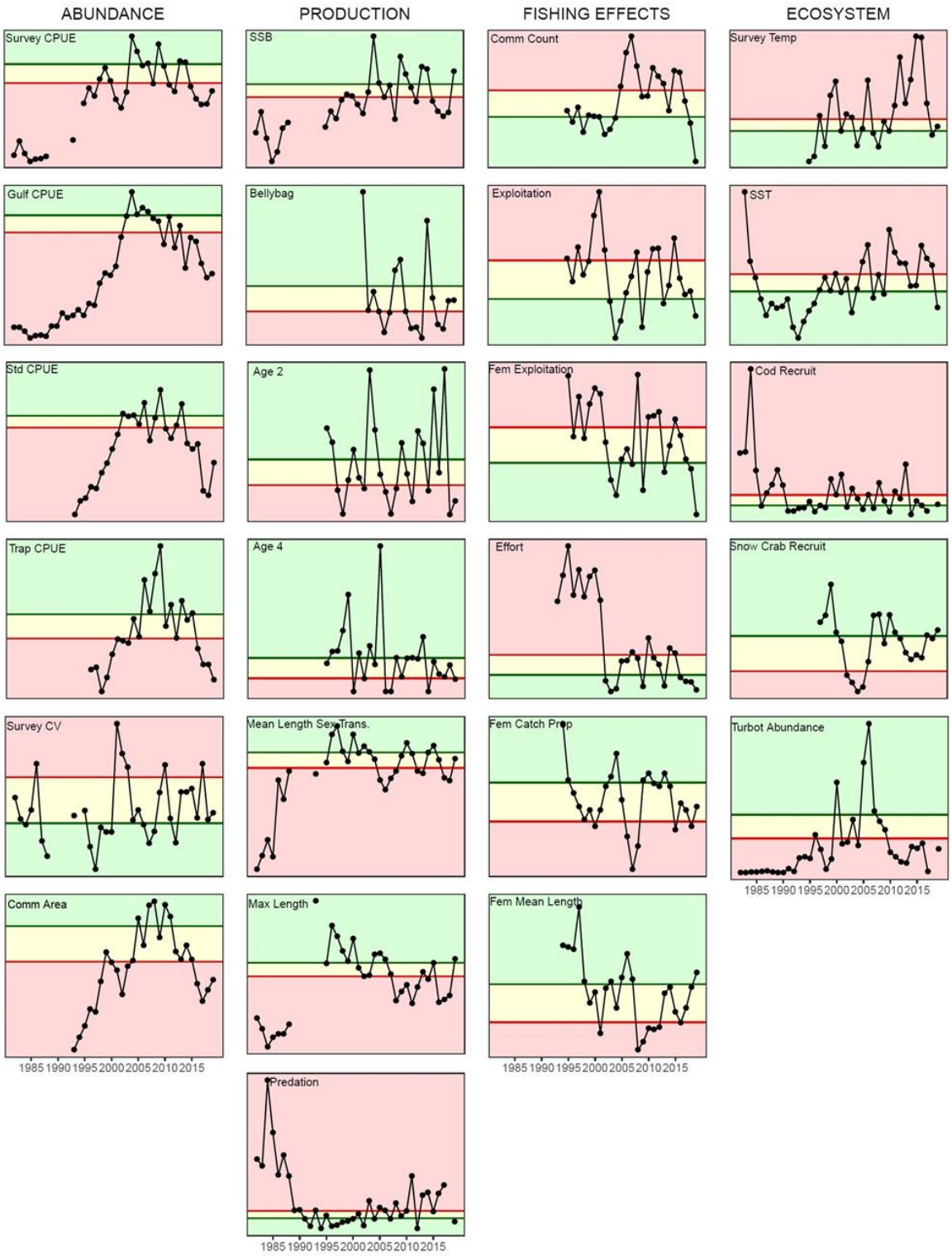

Figure 9. Time series of individual shrimp indicators. Note: not all indicators are discussed in the text. Refer to past CSAS Research Documents for detailed description of indicators (e.g., Hardie et al. 2018).

Bycatch

Introduction of the Nordmøre grate in 1991 reduced bycatch and allowed the fishery to expand to its present size. Bycatch information from observer coverage of 63 commercial sets from 2018 (2 trips – 1.8% coverage) and 2019 (3 trips – 3.2% coverage) suggests that the fleet's trawl configurations, including the use of the Nordmøre grate, continue to ensure low total bycatch (<1%) by weight. This value is likely over-estimated due to the minimum 1 kg weight recorded by the observers (e.g., a single fish would be recorded as 1 kg even if weighing only a few grams). Total bycatch by weight from observed trips in 2018– 2019 is similar to that reported in past assessments. The observed trips in 2019 took place during the spring, summer, and fall and covered all SFAs. From this representation, the ESS mobile shrimp fishery currently poses little risk in terms of bycatch amount or species composition.

Conclusions

The 2019 DFO-Industry survey stratified mean biomass estimate increased by 21% to 28,334 mt (± 5,161 mt, 95% CI). The point estimate of the 2019 SSB (20,737 mt) increased 53%, rising above the USR of 14,558 mt, placing this stock within the Healthy Zone. As predicted by recent assessments, these increases are consistent with the expectation of the 2013– 2014 year classes to enter the mature commercial female shrimp stock, and stronger recruitment of 2017– 2018 year classes.

In addition to increases in the survey abundance index, commercial CPUEs remained at a high level (standardized CPUE increased 24%, Gulf-based vessels increased by 6%). The distribution of areas representing various catch rate levels have all increased in 2019, which in combination with increases in the survey abundance index, suggests a reversal from a previously declining resource.

Belly-bag Age 1 abundance indices in 2018 and 2019 highlight better recruitment from the 2017 and 2018 year classes, respectively, which is consistent with the expectation that low temperature conditions lead to better recruitment. The abundance of Age 2 increased, while Age 4 shrimp decreased in 2019, which is consistent with the higher belly-bag index in 2018 (representing the 2017 year class), and the lower index in 2016 (representing the 2015 year class). The abundant 2013 year class increased the index of abundance of Age 5+ female shrimp in 2019. Assuming continued growth and survival, this age class is expected to provide increasing support to the SSB in 2020.

Size-based indicators (mean size at sex transition, mean maximum size, mean female size, mean count) demonstrate that the size of shrimp has been increasing in recent years. This is consistent with the addition of the expected 2013– 2014 year classes that matured as larger than average females supporting the overall shrimp abundance.

Ecosystem indicators, including sustained lower temperatures and increases in the abundance of sympatric species, suggest that conditions are currently favorable for coldwater species such as shrimp.

The overall mean summary indicator (consolidating the 24 indicators) increased and is now in the yellow zone in 2019 due to all four summary characteristics showing positive responses. The fishing effects characteristic saw a decrease in 2019 based on the status quo TAC, which in turn reduced overall effort and generated declines in both total and female exploitation indices relative to 2017– 2018.

Increases in abundance, production, and ecosystem characteristics, in combination with the SSB increasing above the USR in 2019, provides a favorable outlook for 2020. While Age 4+ males increased in 2019, it is uncertain whether this will translate into an increase in the total

biomass index in 2020. The 2013– 2014 year classes are contributing to the SSB, and they are expected to provide commercial stock support until 2020– 2021. Continuation of similar catch levels in 2020 could help maintain low exploitation rates and protect more of the 2015– 2017 year classes until they can also recruit to the SSB.

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Sources of Information

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