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Maritimes Region

Canadian Science Advisory Secretariat
Science Advisory Report 2019/013

ASSESSMENT OF NORTHERN SHRIMP ON THE EASTERN SCOTIAN SHELF (SFAs 13-15)

(J. Domm 2006)

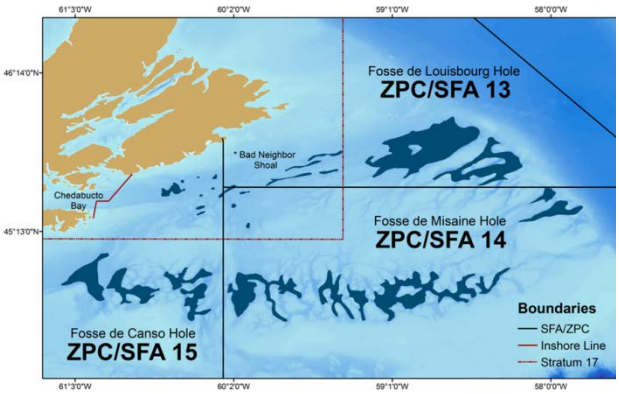

Figure 1. Shrimp Fishing Areas (SFAs) on the Eastern Scotian Shelf.

Context:

Advice on the status of the Eastern Scotian Shelf Shrimp stock is requested by DFO Resource Management to help determine a Total Allowable Catch (TAC) that is consistent with the management plan. Annual science advice is required because of rapid changes in abundance, variable recruitment to the population and fishery, and changes in the size of Shrimp available for harvest. The resource is near the southern limit of the species' distribution where it is thought to be more vulnerable to significant and rapid declines, as has been observed in the adjacent Gulf of Maine stock. The current report provides information and advice for management of the 2019 fishery.

The trawl fishery on the Scotian Shelf occurs primarily during late spring and early summer with some fishing during fall, in the deep offshore Shrimp "holes", and on an inshore area near the Bad Neighbour Shoal. 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 (about 14 active vessels) 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 vessels, is restricted to Chedabucto Bay. All licenses except traps operate under Individual Transferable Quotas (ITQs). Annual stock assessments were conducted until 2012, until a biennial assessment schedule with interim year updates was initiated in 2013. Both assessment and update processes are based upon a full analysis of Shrimp stock indicators determined from the DFO-Industry survey, commercial landings, and environmental monitoring data.

This Science Advisory Report is from the December 13, 2018, Stock Assessment of Eastern Scotian Shelf Shrimp in Shrimp Fishing Areas (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.

SUMMARY

- As of November 15, 2018, 2410 mt of the 2600 mt Total Allowable Catch (TAC) for 2018 had been landed.
- The 2018 total biomass estimate showed stability at 23,449 mt (± 4,724 mt, 95% Confidence Interval (CI)) from the 2017 estimate of 23,382 mt (± 6,376 mt, 95% CI).
- The Eastern Scotian Shelf Shrimp stock has declined since 2014, as the 2009-2012 year classes have reached the end of their expected life span.
- The 2018 Spawning Stock Biomass (SSB, females) point estimate increased 2% to 12,599 mt and it remains below the Upper Stock Reference (USR, 14,558 mt). Based on the precautionary approach the Eastern Scotian Shelf Shrimp stock is considered to be in the Cautious Zone.
- The 2017 TAC (2600 mt) was maintained in 2018 to reflect declining fishable and spawning stock biomass resulting from the low recruitment contributions from 2009-2012 year classes. The unchanged precautionary TAC helped to further reduce both total and female exploitation to values of 10% and 12%, respectively.
- Belly-bag index values for 2016 and 2017 were consistent and low, suggesting poor recruitment over the past two seasons. However, the value for 2018 shows an increase in recruitment relative to the past two years.
- The abundance index for both Age 2 and Age 4 Shrimp decreased in 2018, which is consistent with the low belly-bag Age 1 abundance index values found in 2017 (i.e. 2016 year class) and 2015 (i.e. 2014 year class), respectively.
- The 2013 year class increased the index of abundance for Age 5^+ Shrimp in 2018.
- Ecosystem indicators were primarily influenced by temperature trends as two of three sympatric species trends were not updated for 2018. The consistent decrease in temperatures and an increase in Snow Crab recruitment in the last few years, suggest that conditions are currently favourable for cold water species such as Shrimp.
- The overall mean summary indicator increased in 2018 and is in the yellow zone after being in the red zone for the past two years due to increases in indicators representing abundance, productivity, ecosystem characteristics, and a decrease in indicators representing fishing effects.
- While Age 4+ males decreased in 2018, it is uncertain whether this will translate into a decrease in the total biomass index in 2019. The 2013 year class is expected to recruit to the SSB at least until 2020.
- Continuation of a status-quo TAC will help to maintain low exploitation rates and to protect more of the 2013 year class as it recruits to the SSB.

BACKGROUND

Species Biology

The Northern or Pink Shrimp, *Pandalus borealis*, is the only Shrimp species of commercial importance in the Maritimes Region. Shrimp are crustaceans that have a hard outer shell, which they must periodically shed (molt) in order to grow. Females generally produce eggs once a year (not more) in the late summer-fall and carry them, attached to their abdomen,

until the spring when they hatch. Consequently, Shrimp bear eggs, (i.e., are "ovigerous") for about 8 months of the year. Newly hatched Shrimp spend 3 to 4 months as pelagic larvae, feeding near the surface. At the end of this period, they settle to the bottom. On the Scotian Shelf, the Northern Shrimp first matures as a male at Age 2, and generally changes sex at Age 4, to spend another 1 to 2 years as a female. However, Shrimp may live up to 8 years, depending on environmental conditions and population dynamics. Shrimp concentrate in deep "holes" (>100 fathoms) on the Eastern Scotian Shelf (ESS) (Figure 1), but nearshore concentrations along the coastline were discovered in 1995 by the DFO-Industry survey. In general, Northern Shrimp prefer temperatures of 2-6ºC and a soft, muddy bottom with a high organic content.

The Fishery

The fishery currently consists of 28 (Maritimes) licenses (9 active vessels during 2018), mostly <65' length overall (LOA), and 14 midshore (Gulf) licenses (5 active vessels during 2018) 65-100' LOA. All mobile licenses have been under Individual Transferable Quotas (ITQs) since 1998. A competitive trap fishery with 14 licenses (7 active during 2018) is largely restricted to Chedabucto Bay (Figure 1). The trap fishery allocation is currently 8% of the yearly Total Allowable Catch (TAC). The fishery operates under an "evergreen" management plan, which documents sharing agreements between fleet sectors.

Although there has been some Shrimp fishing on the Scotian Shelf since the 1960s, the Maritimes fishery began to expand toward its full potential only when groundfish bycatch restrictions were overcome with the introduction of the Nordmøre grate in 1991. The TAC was first reached in 1994 after individual Shrimp Fishing Area (SFA) quotas were combined into a single TAC (Table 1, Figure 2). Since that time, there have been some minor shortfalls associated with re-allocations of uncaught trap quotas to the mobile fleet late in the season. The gap between the TAC and catch has narrowed steadily since 2005 as problems associated with market conditions and quota reallocations have been resolved. The mobile fleet continues to prefer open access to all areas (i.e. no individual SFA quotas) because of the flexibility this offers in obtaining favourable combinations of good catch rates and counts (Shrimp sizes).

The fishing season is from January 1st to December 31st. At the time of the assessment (November 15, 2018), 2410 mt of the 2600 mt TAC had been landed. The trap fleet landed 65 mt in 2017, and 62 mt had been landed as of November 15, 2018 (fishing is ongoing).

Table 1. Recent Eastern Scotian Shelf Shrimp Total Allowable Catches (TACs) and landings ('000s mt).

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
TAC	5.0	5.0	5.0	5.0	3.5	5.0	4.6	4.2	3.8	4.5	4.5	3.2	2.6	2.6
Landings	3.6	4.0	4.6	4.3	3.5	4.6	4.4	4.1	3.6	4.3	4.4	3.0	2.4	2.4[1]

[1]Landings to November 15, 2018.

The spatial pattern of the fishery has not changed significantly since 2005 (Figure 2). In general, the bulk of the catch has been taken from SFAs 14 and 15. As of November 15th, 80% of the 2018 landings were harvested from SFA 14.

Prior to 2010, the fishing began in April and a large proportion of the catch was taken by June, at which time fishing generally stops to avoid the moulting period. Fishing has generally resumed in September-October and may continue into December if catch rates and Shrimp condition are suitable. In recent years, fishing has been starting earlier in the calendar year.

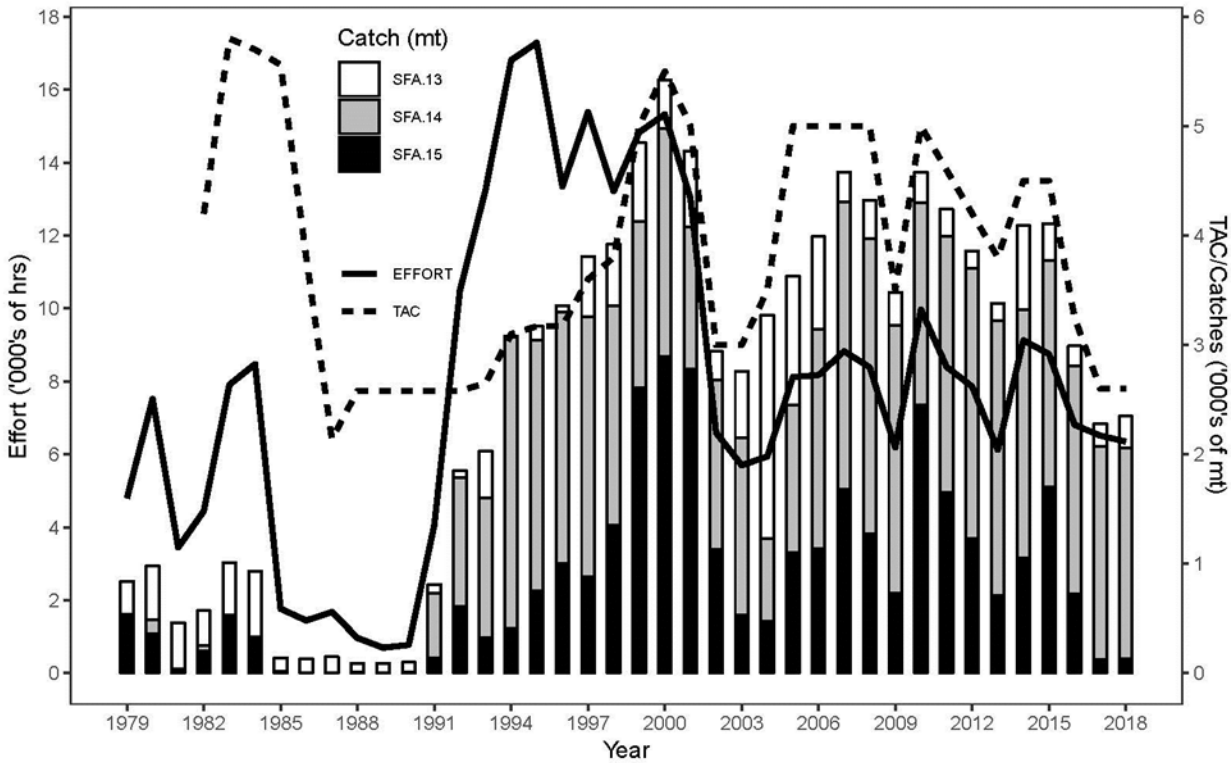

Figure 2. History of Eastern Scotian Shelf Shrimp catches per Shrimp Fishing Area (SFA) (13, 14, and 15), Total Allowable Catch (TAC) (thousands of mt), and effort (thousands of hours), from 1979-2018. Effort and catches for 2018 represent preliminary data as of November 15, 2018.

ASSESSMENT

Stock Trends and Current Status

A Traffic Light Analysis (TLA) has been used to assess the status of the ESS Shrimp stock for the provision of science advice since 1999 (Koeller et al. 2000). This holistic multiple indicator approach considers the current value of each indicator relative to its time series and summarizes individual indicators into four “characteristics”, as well as in an overall mean summary indicator. Indicators always represent summary data for the entire area (i.e. all SFAs combined, according to the current practice of managing the fishery as one stock). The TLA is used to display, summarize, and synthesize a large number of relevant yet disparate data sources into a consensus opinion on the state of the Shrimp stock.

The 2018 ESS Shrimp total biomass estimate showed some stability (increased by <1%) at 23,449 mt (± 4,724 mt, 95% Confidence Interval (CI)) from the 2017 estimate of 23,382 mt (± 6,376 mt, 95% CI) (DFO 2018a). This total biomass had been declining (2015-2017) as the 2009-2012 year classes reached the end of their expected life span. The Spawning Stock Biomass (SSB) estimate also increased by 2% (18,346 mt) in 2018. The 2013 year class contributed to both the total biomass and SSB increases as it has now entered the 5^+ age class in 2018 (Table 2, Figures 6-8). The DFO-Industry survey Catch Per Unit Effort (CPUE) increased by 1% and is within the 95% confidence intervals (Figure 3).

The standardized CPUE and the Gulf vessel CPUE decreased by 4% and 16%, respectively (Figure 3). As of November 15, 2018, the trap catch index decreased by 1% relative to 2017.

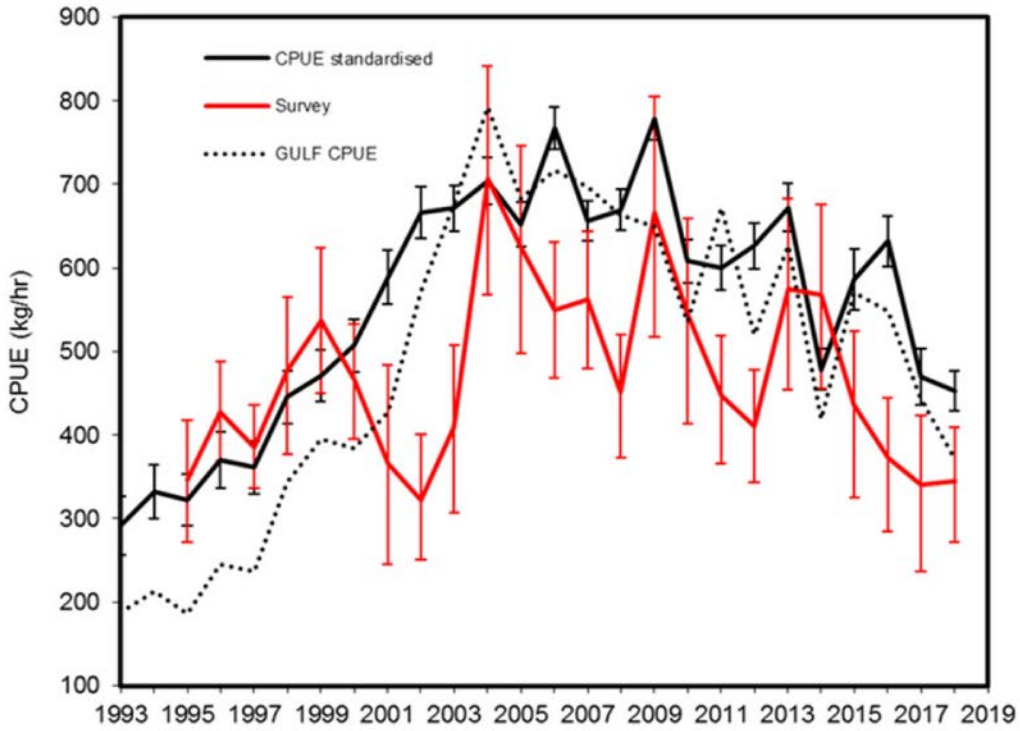

Figure 3. DFO-Industry survey stratified Catch Per Unit Effort (CPUE), standardized commercial CPUE with 95% confidence intervals, and unstandardized Gulf vessel CPUE. from 1993-2018.

Commercial CPUE indices may not always reflect overall abundance changes in the short term, due to changes in the spatial distribution of the resource and fishing effort. The current divergence is likely indicative of changing spatial distribution patterns associated with the decline of the 2009-2012 year classes at the end of their lifespan, and the 2013 year class entering the SSB of the fishing population. The increase in the DFO-Industry survey CPUE in 2018 is corroborated by the distribution of commercial catch areas, where increases have occurred in all catch rate categories. The 2017 TAC was reduced by 20% (from 3250 mt in 2016 to 2600 mt), and this TAC value was maintained in 2018 to reflect the declining fishable and spawning stock biomass resulting from the loss of the formerly less abundant 2009-2012 year classes. The adoption of this precautionary TAC value (2600 mt) has served to limit the fishing effort and reduce overall pressure on a declining resource.

The Precautionary Approach (PA) uses two indicators, SSB (Production characteristic) and female exploitation (Fishing Effects characteristic), as reference points. The 2018 SSB (females) point estimate increased by 2% to 12,599 mt and it remains below the Upper Stock Reference (USR, 14,558 mt). Based on the PA, the ESS Shrimp stock is considered to be in the Cautious Zone (Figure 4A and Figure 5). The 2018 precautionary TAC helped to further reduce total and female exploitation values to 10% and 12%, respectively (Figure 4B and Figure 5).

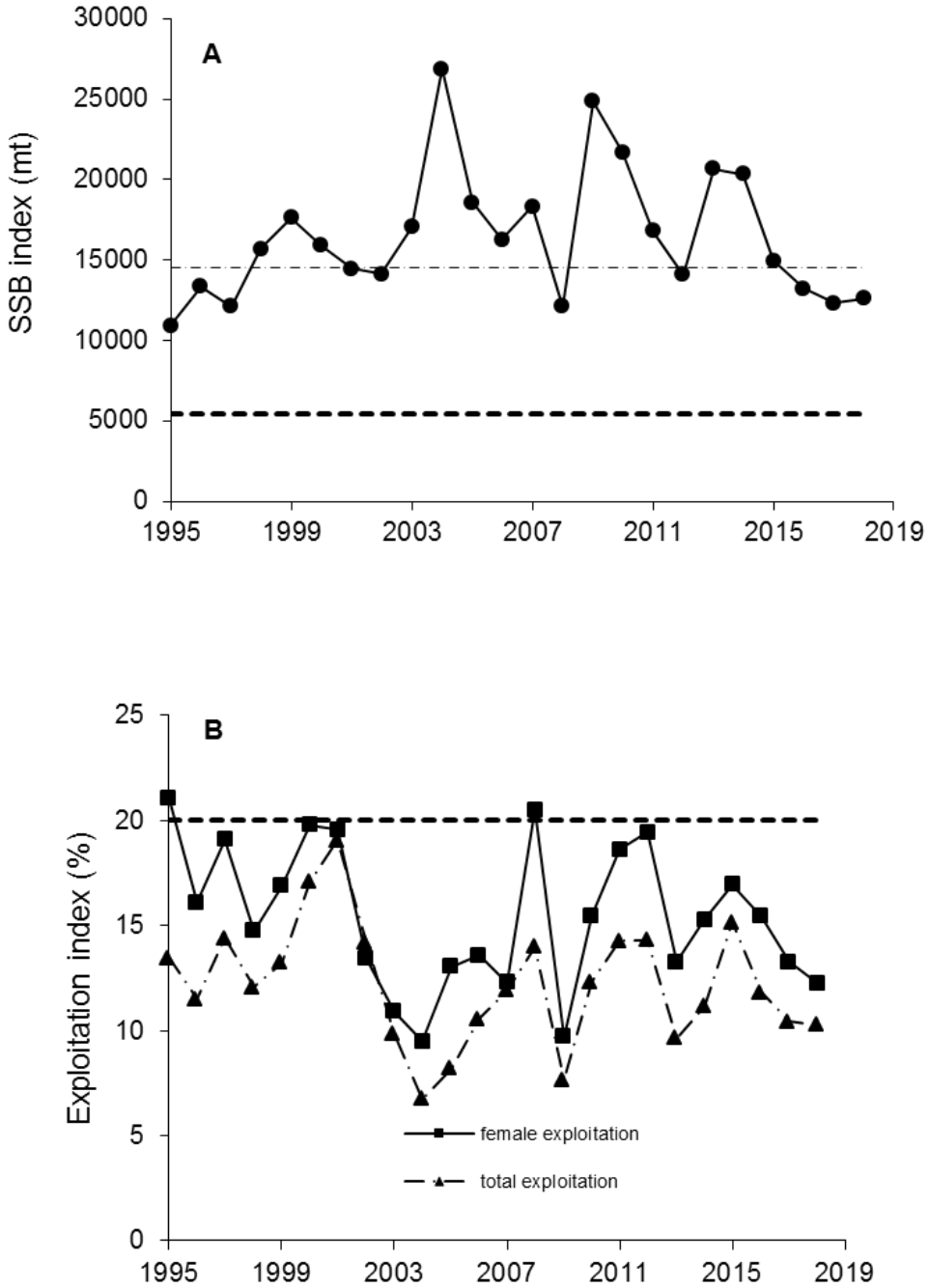

Figure 4. A-Changes in the Spawning Stock Biomass (SSB) index for the Eastern Scotian Shelf Shrimp population. The dashed lines show the Lower Reference Point (LRP) at 30% and Upper Stock Reference (USR) at 80% of the mean SSB during the 2000-2010 high-productivity period. B-Changes in the exploitation indices for the Eastern Scotian Shelf Shrimp fishery. The dashed line shows the removal reference of 20% for the female exploitation index when in the Healthy Zone.

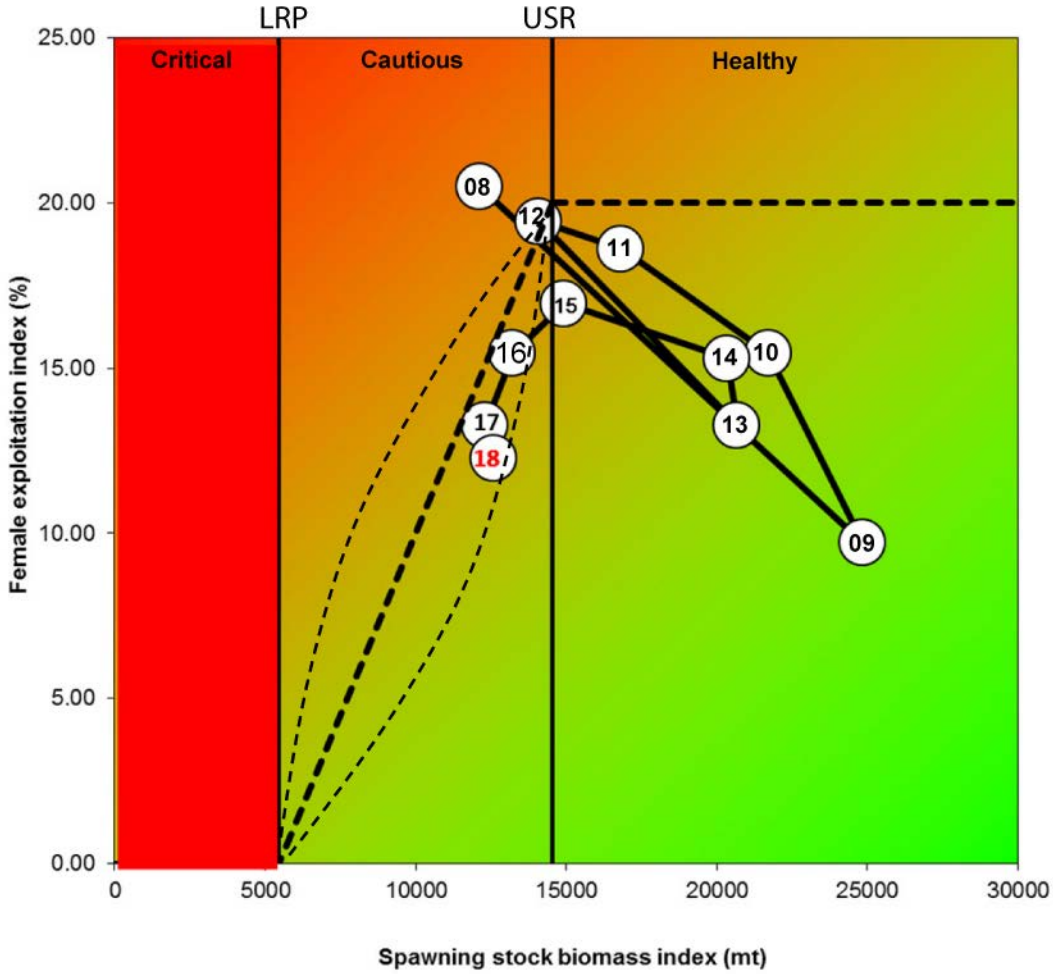

Figure 5. Graphical representation of the precautionary approach for Eastern Scotian Shelf Shrimp. The dotted lines in the Cautious Zone represent a range of possible management actions, depending on whether the stock is stable, increasing or decreasing, or on trends in other indicators of stock or ecosystem health. The horizontal dashed line in the Healthy Zone represents the Removal Reference (20%). Values within the circles represent calendar year.

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 2001, 2007-2008, and 2013, to change sex over a number of years makes it difficult to distinguish them from adjacent year classes. Nonetheless, these recruitment pulses have coincided with the maturation of strong year classes, providing evidence that strong year classes have produced large spawning stock biomasses.

As evidenced in the 2015 to 2017 DFO-Industry survey (Figure 6 and Figure 7) and commercial catches (Figure 8), the 2009-2012 year classes have reached the end of their expected lifespan; the remaining fishable and spawning stock biomass has not been well supported by subsequent recruitment; cohort tracking through length frequency distributions from the DFO-Industry survey and commercial samples also corroborate the low belly-bag (Age 1 abundance) index from 2010-2013 and predict low contributions to fishable and spawning stock biomass from the 2009-

2012 year classes (Table 2). Belly-bag Age 1 abundance index values for 2014 was the second highest in the 17-year time series, suggesting good recruitment from the 2013 year class. Belly-bag index values for 2016 and 2017 were consistent and low, suggesting poor recruitment over the past two seasons; however, the value for 2018 shows an increase from 83 to 267 million of Shrimp and is near the long-term average (289 million; Table 2). The abundance index for Age 2 and Age 4 Shrimp decreased in 2018, which is consistent with the lower belly-bag index values found in 2017 (i.e. 2016 year class) and 2015 (i.e. 2014 year class), respectively (Table 2). The moderate overall abundance of Age 1 and Age 2 Shrimp observed in the 2018 DFO-Industry survey is consistent with the stabilizing SSB and decreasing temperature indices observed since 2017.

The 2013 year class has been closely monitored and continues to provide a strong signal in the DFO-Industry survey (Table 2; Figure 6 and Figure 7) and commercial fishery data (Figure 8).

Table 2. Minimum survey population numbers-at-age from modal analysis. Numbers x 10^6. Shaded portion of the table represents numbers updated to include all SFAs.

Age	2011	2012	2013	2014	2015	2016	2017	2018	Avg. (1995-17)	Median (1995-17)
1[1]	88	94	22	796	288	112	83	267	289	198
2	58	43	211	26	495	17	166	37	187	157
3	513	348	302	119	501	193	581	361	619	501
4	1105	1018	1157	613	690	1304	1468	822	1373	1133
5+	2694	2688	4091	4673	2956	3076	1734	2231	2856	2694
TOTAL	4458	4191	5783	6227	4930	4702	4032	3718	5112	4755
Age 4+ males[2]	2003	2241	2960	3831	2270	2931	1859	1966	2555	2270
Primiparous[3]	947	371	699	706	521	664	453	433	812	736
Multiparous[4]	937	1188	1611	1545	1143	897	973	921	933	937
Total females	1884	1559	2310	2251	1664	1561	1426	1354	1745	1591

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. Transitional/primiparous Shrimp are the group of females entering the SSB.
[4] Multiparous Shrimp identifies the group of females that are already contributing to the SSB

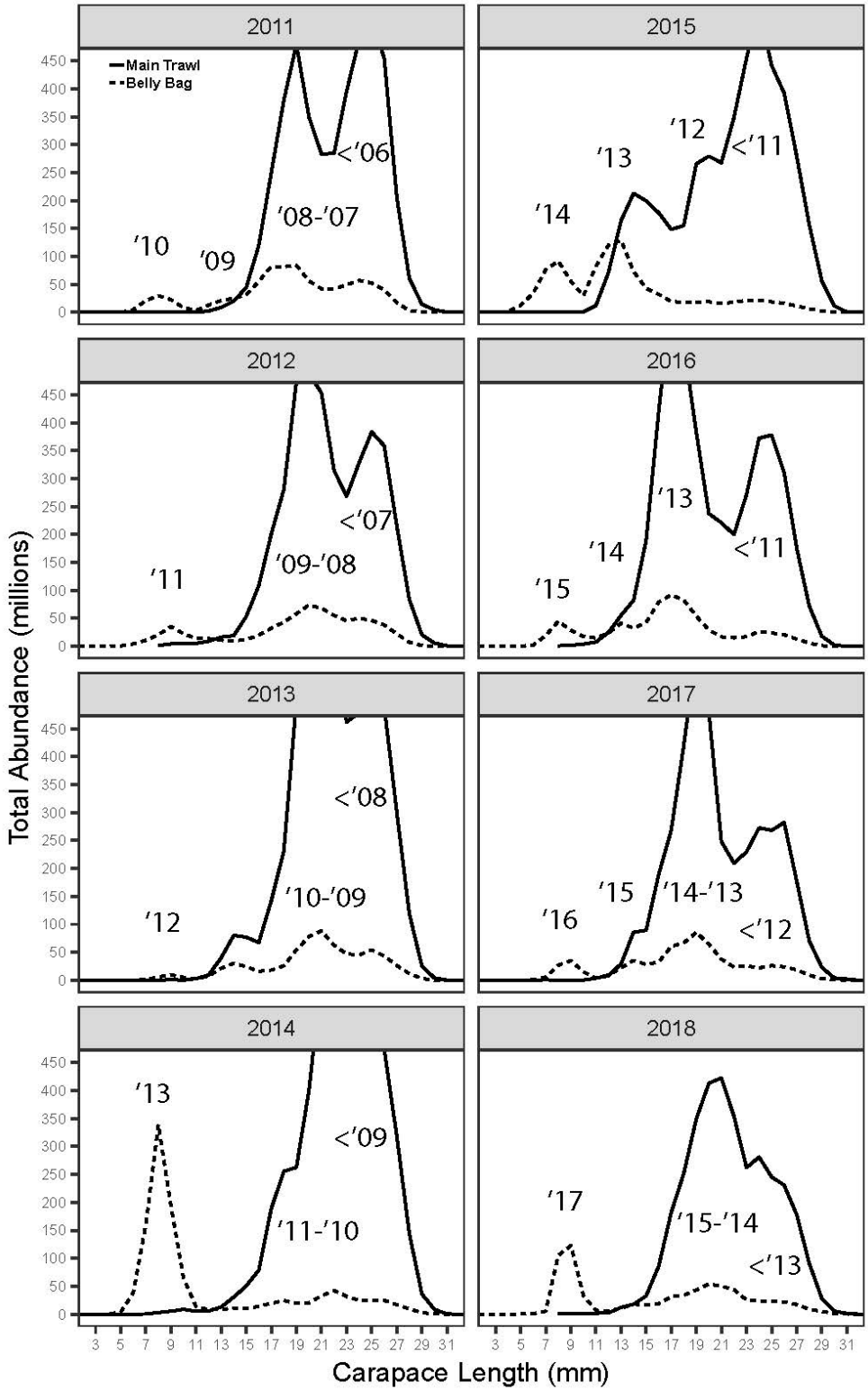

Figure 6. Population estimates from belly-bag and main trawl catches for 2011-2018 DFO-Industry surveys.

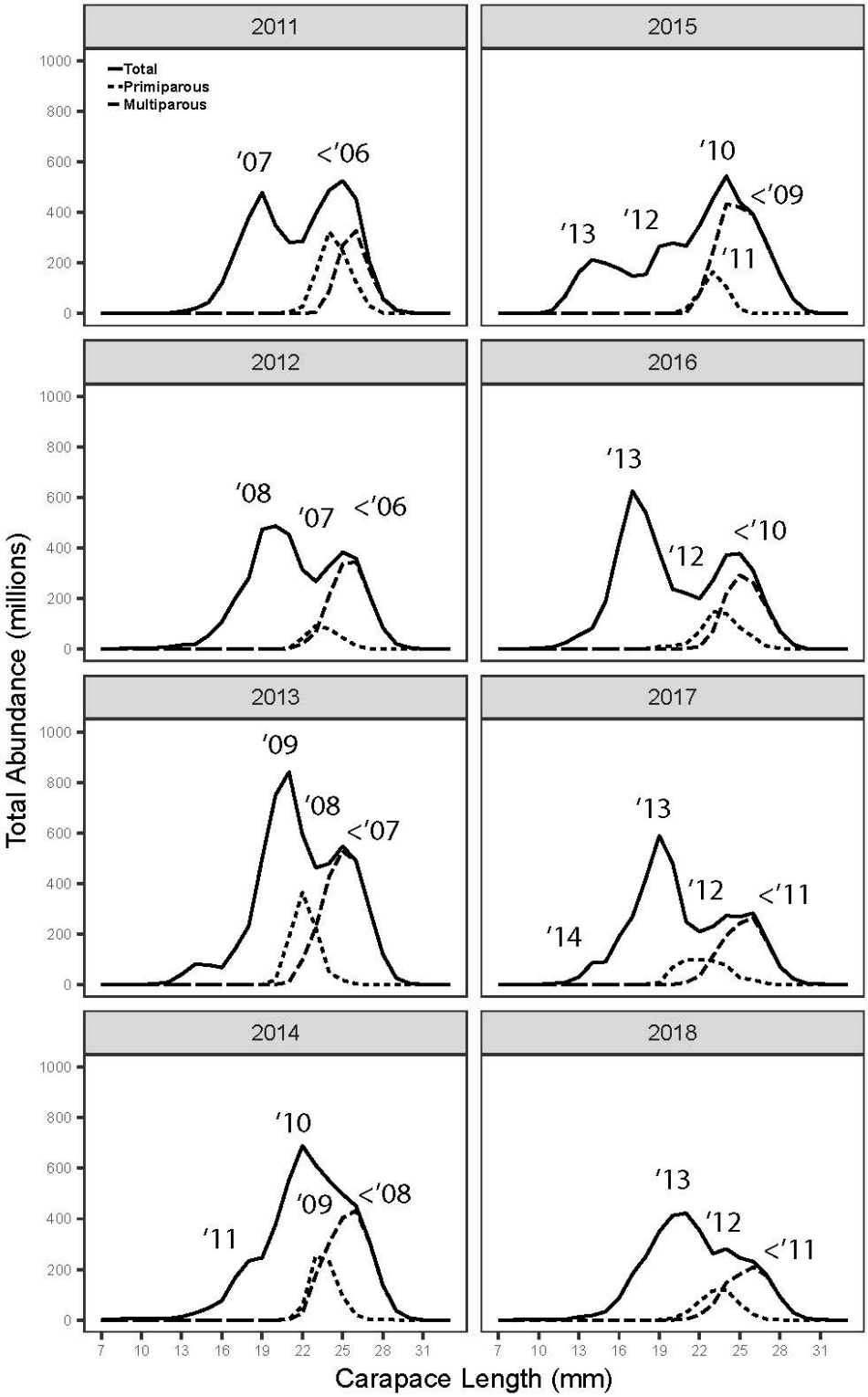

Figure 7. Population estimates-at-length from DFO-Industry surveys 2011-2018 (solid line). The heavy dotted line in each figure represents transitional and primiparous Shrimp, and the stippled line represents multiparous Shrimp.

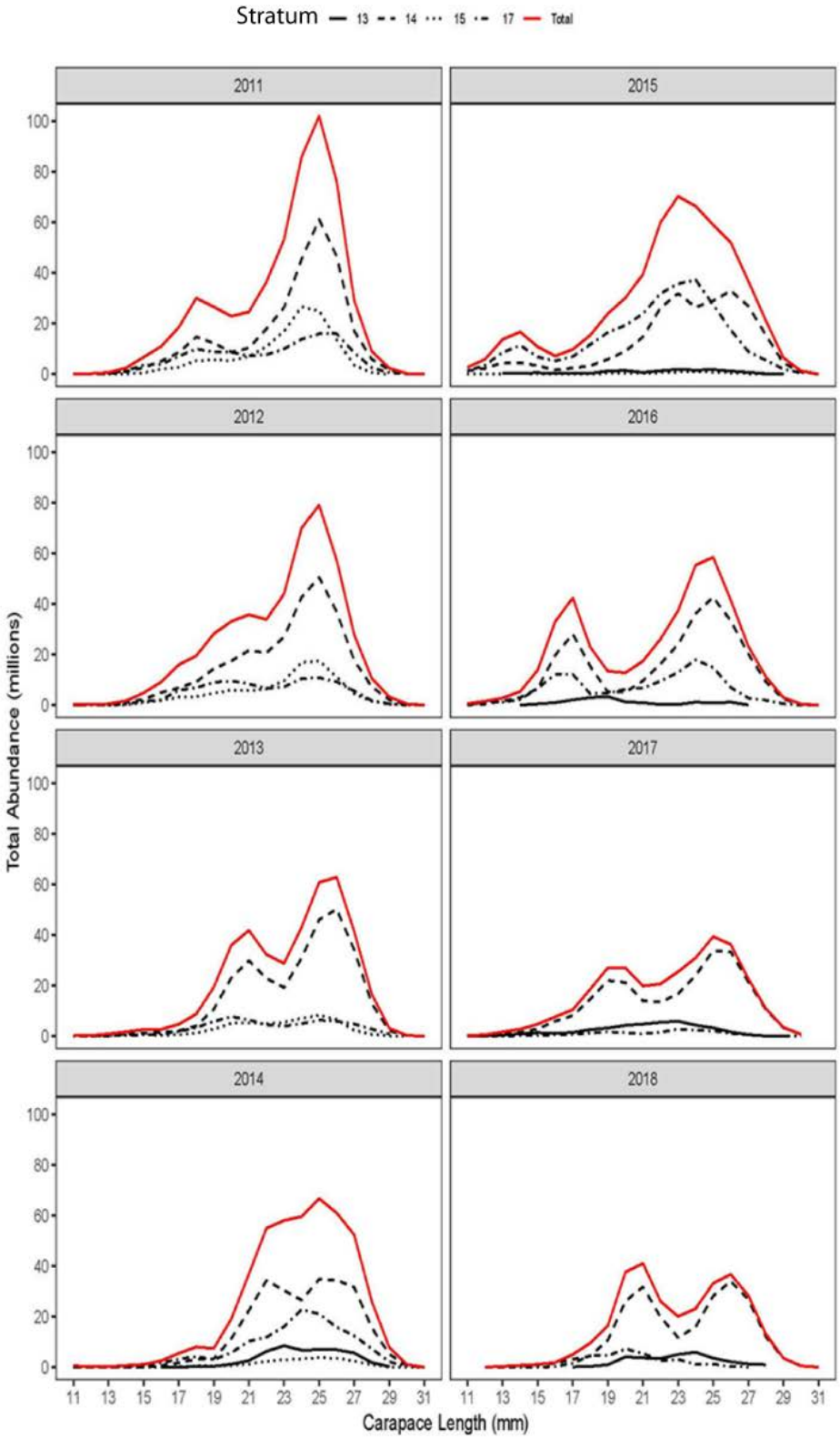

Figure 8. Catch-at-length from commercial sampling by stratum, 2011-2018.

Commercial count estimates (numbers of Shrimp per pound) decreased in 2017 and again in 2018 (Figure 9A). The decreased count index in 2017-2018 relative to 2014 is likely indicative of residual female Shrimp from the 2009-2012 year classes at the end of their lifespan. Mean female size and mean maximum size indices have been variable but, overall, have shown a decreasing trend since the mid-1990s (Figure 9B-C). The increase in the mean female size indicator from 2016 to 2018 can be attributed to a sustained abundance of large females from the 2009-2012 year classes relative to smaller females from succeeding year classes.

Decreases in mean length-at-sex transition in Shrimp stocks may contribute to population downturns through decreased female fecundity (i.e. smaller Shrimp produce fewer eggs). Length at sex transition can be influenced by large year classes, which can delay the timing of sex transition, allowing additional year(s) of growth potential. Size at sex transition has been trending in a slow decline toward an average level (for the high-productivity period, 2000-2010) for this stock; however in 2018, it is the lowest value in the time series around 23.5 mm (Figure 9D).

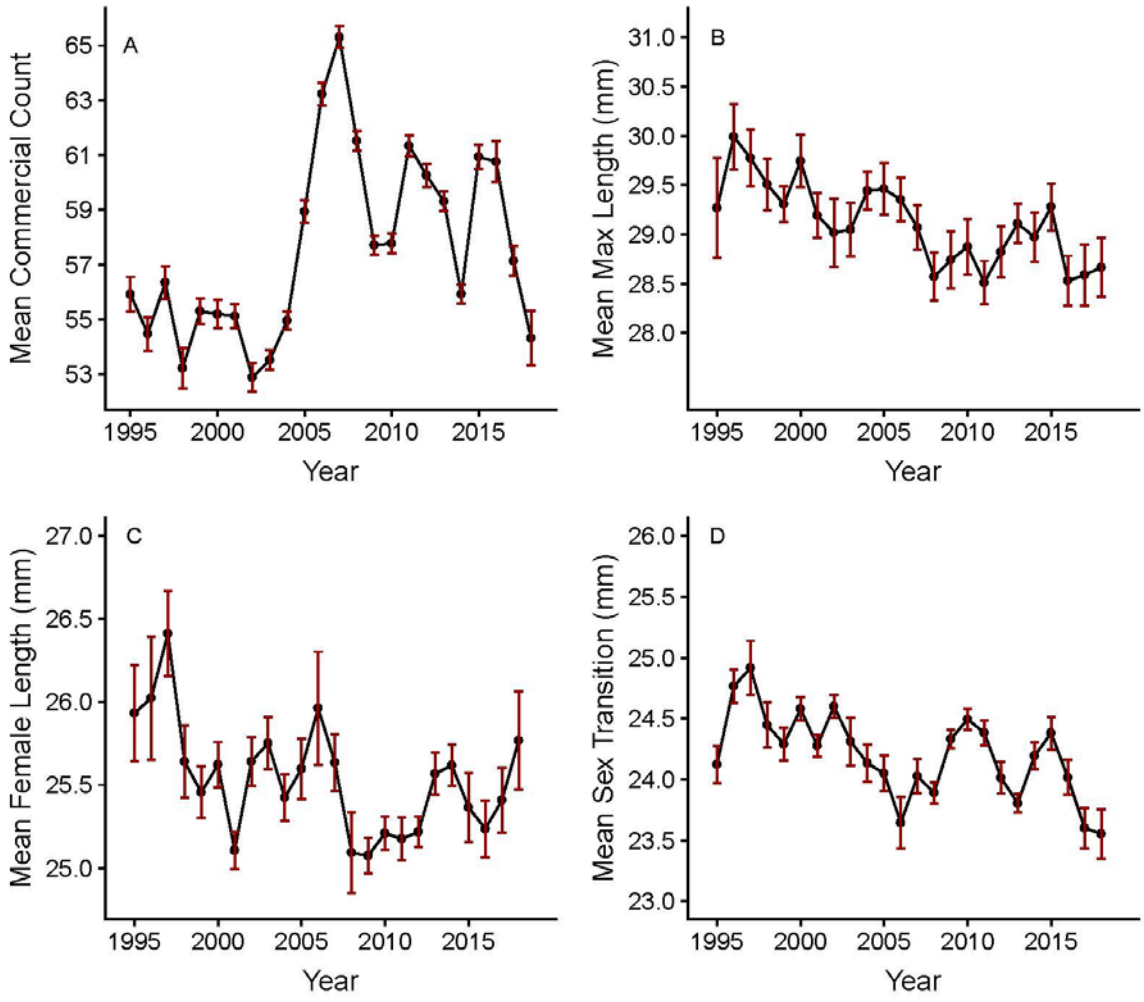

Figure 9. Mean: (A) commercial count, (B) maximum length, (C) female size, (D) size-at-sex transition for all Shrimp Fishing Areas (SFAs) combined for 1995-2018 with 95% confidence intervals.

Predator feeding studies have shown that Shrimp are important prey for many finfish species. Significant negative correlations between Shrimp and finfish abundance have been demonstrated from the Gulf of Maine to Greenland (Parsons 2005). Over the recent high-productivity period, the predation index has been variable but remains at a low level relative to the early 1980s, when Shrimp abundance was low. Cod recruitment remained low in 2017. The general index of Shrimp finfish predator abundance increased from 2016 to 2017 (Figure 10). In 2018, advice on predation and trends in cold water sympatric species could not be incorporated into the TLA as they are unavailable from the DFO Summer Research Vessel (RV) Survey, which experienced operational limitations, and were not able to provide information to update these trends.

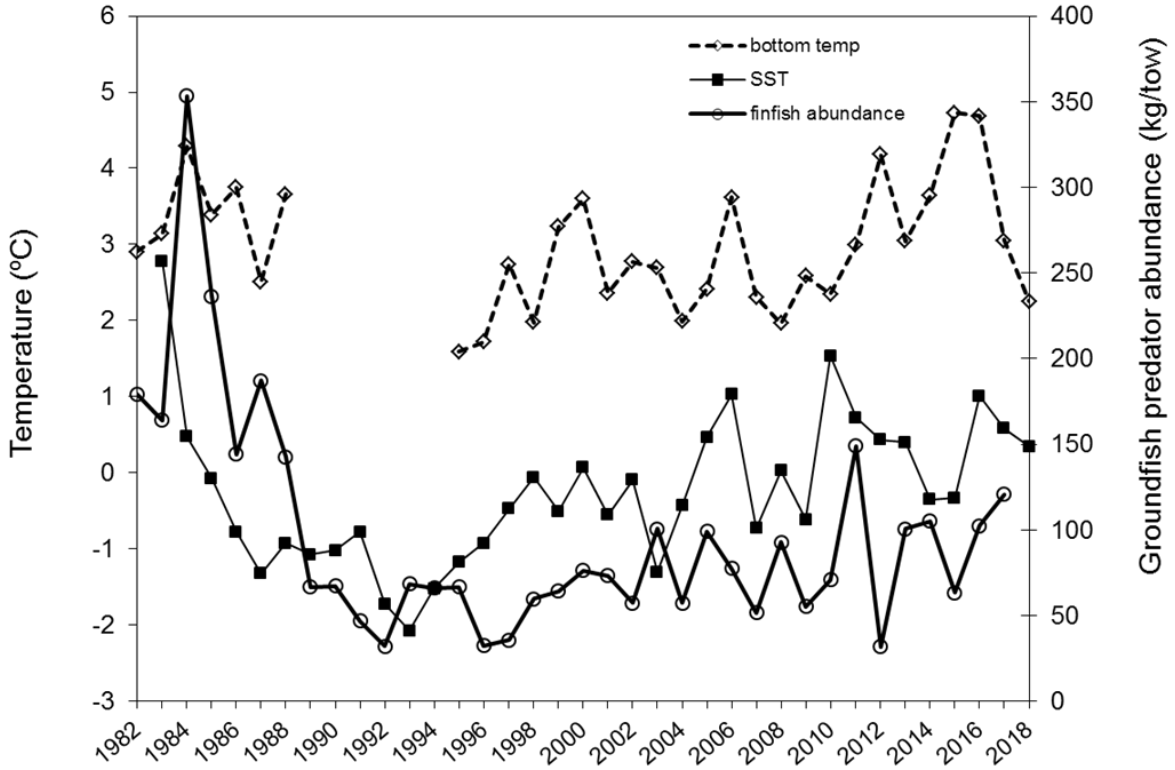

Figure 10. Average bottom and late winter Sea Surface Temperatures (SSTs) and predator abundance on the Eastern Scotian Shelf Shrimp grounds

For some Northern Shrimp stocks near the southern limit of the species' range, abundance is negatively correlated with water temperatures (Shumway et al. 1985). On the ESS, the large population increase that occurred from the mid-1980s to the mid-1990s is associated with colder surface and bottom water temperatures. Colder temperatures can increase the length of the egg incubation period, resulting in later egg hatchings that are closer to the spring phytoplankton bloom and warming of the surface layers where larvae feed and grow (Shumway et al. 1985). Large fluctuations in bottom water temperatures (Figure 10) may also be associated with the cyclical recruitment pattern experienced since the early 1990s (i.e. 1993-1995, 2001, 2007-2008, and 2013 year classes). Spring sea surface temperatures decreased in 2018, and June survey bottom temperatures decreased considerably since 2016 and were in a favorable range from 2017 to 2018 (Shumway et al. 1985). These indices highlight the decreased temperature conditions currently found on the ESS.

Colder water conditions, which are within a level of thermal preference for Shrimp, are thought to have a positive influence on juvenile recruitment. This is supported by the higher recruitment observed in the belly-bag Age 1 abundance index for 2018 (Table 2). Further, the abundance of Snow Crab, a cold water indicator species, has increased in 2017 and 2018 relative to previous warmer water years (DFO 2018b).

The 24 indicators relating to the health of the ESS Shrimp stock are summarized in Figure 11. Each indicator was assigned a color for every year data was available according to its percentile value relative to the fixed high-productivity 2000-2010 period. Default boundaries between traffic lights for individual indicators, i.e., transition from green to yellow and from yellow to red, were arbitrarily taken as the 0.66 and 0.33 percentiles (i.e. >0.66 percentile=green; 0.66-0.33 percentile=yellow; and <0.33 percentile=red). However, if an increase in the indicator was considered bad for stock health the transition between boundaries was reversed. Individual indicators were then grouped into categories of Abundance, Production, Fishing Effects and Ecosystem characteristics, as well as an overall mean summary indicator (Figure 12). Note that indicators are not weighted in terms of their importance, these categories and overall mean summary indicator are determined as a simple average of individual contributing indicators.

The abundance characteristic increased and remains in the red zone due to declines in all three commercial CPUE indices even though survey CPUE and commercial catch rate areas increased (Figure 12). The production characteristic also increased and remains in the red zone. This is a result of declines in Age 2 and Age 4 abundance indices counteracting the increase in the abundance of young Shrimp associated with good juvenile recruitment (higher belly-bag Age 1), and increased SSB. The fishing effects characteristic has been improving and is now in the green zone. The improvement can be attributed to declines in total and female exploitation due to the precautionary reductions/maintenance of TAC since 2016 and fishing effort that was adopted in response to predicted declines in total and spawning stock biomass. The ecosystem characteristic increased and is in the yellow zone due to lower bottom and spring sea surface temperatures, and good/increasing indices for sympatric cold water species (Snow Crab). Due to increases in all characteristic summaries in 2018, the overall mean summary indicator increased as well, and is in the yellow zone after being in the red zone for the last two years.

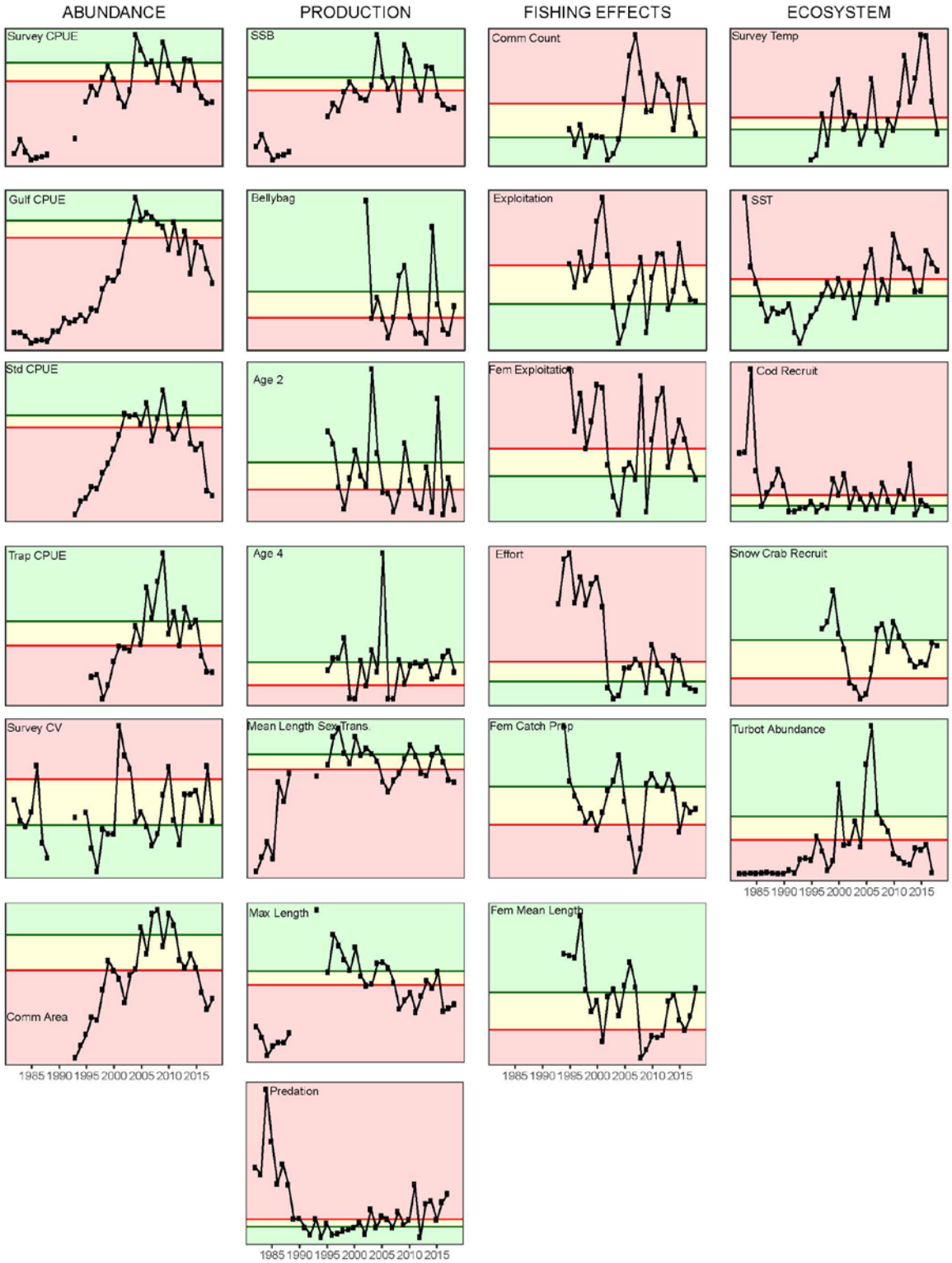

Figure 11. Time series of individual Shrimp indicators. Note: Not all indicators are discussed in the text. Please consult past CSAS Research Documents for detailed description of indicators (e.g. Hardie et al. 2013). Note that the Predation indicator (Production), the Cod Recruitment (Ecosystem), and the Turbot Abundance (Ecosystem) cannot be updated for 2018.

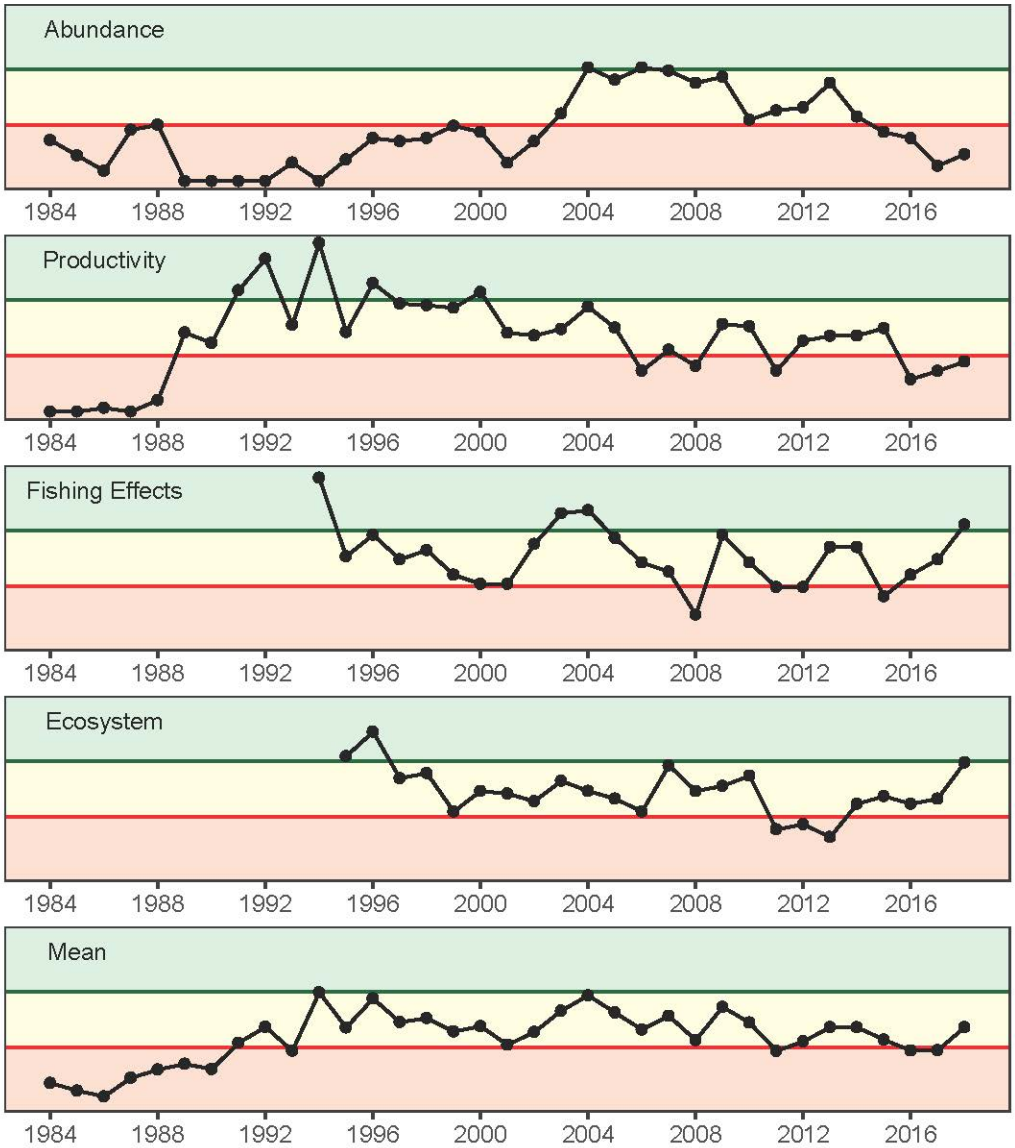

Figure 12. Time series of the characteristic summaries and overall mean summary Eastern Scotian Shelf Shrimp indicator. Note that the Productivity and Ecosystem summary characteristic have missing indicators in 2018, and this will affect their overall mean differently than in previous years.

Bycatch

Introduction of the Nordmøre separator grate in 1991 reduced bycatch and allowed the fishery to expand to its present size. Bycatch estimates are extrapolated from at-sea observer sampling during commercial trips. Target coverage is 6 trips annually (6% coverage based on trips). Low bycatch amounts (1.5 and <1%, 2017 and 2018, respectively) from at-sea observer coverage of 55 commercial sets from 2017 (2 trips) and 2018 (2 trips) suggest that the fleet's trawl configurations, including the use of the Nordmøre separator grate, continue to ensure low total bycatch by weight. Since 2015-16, total bycatch by weight from observed trips has been reportedly decreasing while sampling has remained at a similar frequency. The 2018 observed trips took place during the spring/summer and covered portions of SFAs 13 (1 set only), 14 (28 sets), and 15 (3 sets). Observer coverage of SFA 13 has been minimal to none for a

number of years. Nonetheless, the ESS mobile Shrimp fishery currently poses little risk in terms of bycatch amount or species composition.

Sources of Uncertainty

The reliance on external sources to provide essential information into our analysis assumes the risk that if there are interruptions in that time-series we would not be able to update our indicators for one or more years. There are two identifiable sources of information under this criterion: the Snow Crab and the Summer RV Surveys. In 2018, three indicators were unable to be updated due to the reduced coverage of the DFO Summer RV Survey. The operational limitations experienced by the Summer RV Survey created a break in a 36-year time-series.

The DFO-Industry Shrimp survey results are associated with high variances and biases associated with survey gear changes. Spatial and temporal variability in the distribution of Shrimp is a source of uncertainty with regard to the accuracy of survey estimates; the survey is conducted consistently during early June to try to mitigate this effect. In 2007-2008, problems with NETMIND distance sensors and data logging required the use of historical average instead of actual wing spread data to calculate swept areas and abundance.

Given the inability to accurately age Shrimp, modal groups are assigned to age classes; a process that is subjective, particularly for larger individuals. Growth rates can change dramatically due to density dependence, as happened with the strong 2001 and 2007-2008 year classes. Consequently, recruitment to the fishery can be delayed and spread over two to three years.

Commercial abundance indices are susceptible to logistic, economic, analytical, and other factors that influence index values in ways that may be unrelated to Shrimp abundance. For example, periods of bad weather or abundant sea ice can cause low CPUEs, as can fishing areas targeting large Shrimp for market reasons. The standardised commercial CPUE index subsamples the data for vessels that meet certain criteria, which can also result in particularly successful or particularly unsuccessful vessels influencing this index in ways that may be unrelated to Shrimp abundance in any given year.

Unforeseen changes in the ecosystem (specifically predator abundance) and the environment (specifically water temperature) increase the difficulty of making long-term projections for this stock. This is particularly challenging when increased predator abundance and water temperature co-occur.

Finally, because of the timing of the Shrimp assessment relative to the collection and analysis of commercial samples, advice provided during past assessment processes (prior to 2012) may have been based on only a portion of the samples. However, steps have been taken to expedite the analysis of samples such that for 2018, all 120 survey samples and 29 commercial samples were included.

CONCLUSIONS AND ADVICE

The 2018 DFO-Industry survey stratified mean biomass estimate shows some stability at 23,449 mt (± 4,724 95% CI). The point estimate of the 2018 SSB (12,599 mt) increased by 2%, remaining below the USR point of 14,558 mt, placing this stock within the Cautious Zone for the third year. As predicted by recent assessments, these declines are consistent with the expectation of a lag between the complete mortality of the long-lived 2009-2012 year classes, and the recruitment of the 2013 year class.

Despite a marginal increase in the survey abundance index, commercial CPUEs remained at a low level (standardized CPUE decreased 4%, Gulf-based vessels declined by 16%). The

distribution of areas representing various catch rate categories has increased for 2018; in combination with the increase in the survey abundance index, is consistent with a stabilizing resource.

Belly-bag Age 1 abundance indices in 2017 and 2018 highlight poor recruitment from the 2016- and moderate recruitment for the 2017 year classes and is consistent with the expectation that lower temperature conditions is promoting favorable recruitment. The abundance of Age 2 and Age 4 Shrimp also decreased in 2018 and is consistent with the low belly-bag index in 2017 (representing the 2016 year class), and 2015 (representing the 2014 year class). The abundant 2013 year class increased the index of abundance of Age 4 male Shrimp in 2017 and Age 5+ Shrimp in 2018. Assuming continued growth and survival, this age class has been recruiting to the spawning stock biomass during 2018-2019.

Size-based indicators (size at sex-transition, average maximum size, female size, count) demonstrate that the size of Shrimp has been decreasing in recent years. This is consistent with the end of the expected lifespan of the 2009-2012 year classes, which matured as larger than average females and were replaced by smaller, less abundant, Shrimp when the 2013 year class entered the fishing population.

Ecosystem indicators were primarily influenced by temperature trends as two of three sympatric species trends were not updated for 2018. The consistent decrease in temperatures and an increase in Snow Crab recruitment in the last few years suggest that conditions are currently favourable for cold water species such as Shrimp.

The overall mean indicator, summarizing the 24 stock health indicators, increased and is now in the yellow zone after 2 years of being in the red zone. The fishing effects characteristic saw a sustained decrease in 2018 based on an unchanged precautionary TAC, which in turn kept overall effort at a low level and encouraged inclines in both total and female exploitation indices relative to 2017.

Increases in abundance, production, and ecosystem indicators, in combination with decreases in exploitation indices in fishing effects, provides a favorable outlook for 2019. While Age 4+ males decreased in 2018, it is uncertain whether this will translate into an decrease in the total biomass index. The 2013 year class is expected to contribute to the SSB at least until 2020. Continuation of a status quo TAC will help to maintain low exploitation rates and to protect more of the 2013 year class recruiting to the SSB.

SOURCES OF INFORMATION

This Science Advisory Report is from the December 13, 2018, Stock Assessment of Eastern Scotian Shelf Shrimp in Shrimp Fishing Areas (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. 2018a. Stock Status Update of Eastern Scotian Shelf Shrimp (*Pandalus borealis*) in Shrimp Fishing Areas 13-15. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/014.

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