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Maritimes Region
Canadian Science Advisory Secretariat
Science Advisory Report 2012/073

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

(J. Domm 2006)

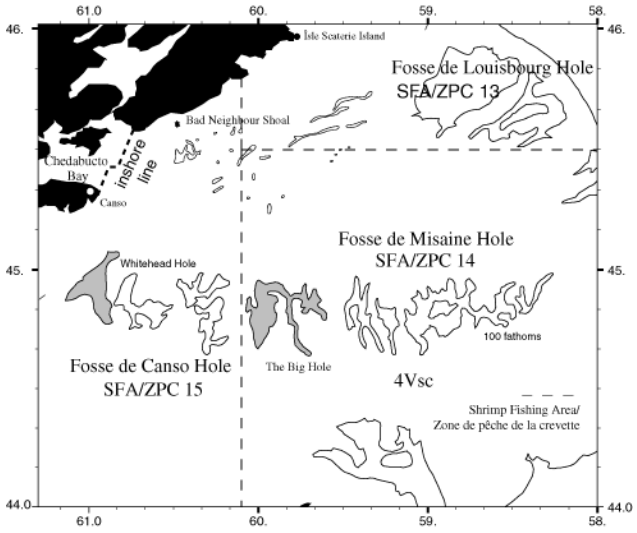


Figure 1. Shrimp fishing areas (SFAs) on the Eastern Scotian Shelf.

Context

Advice on the status of the Eastern Scotian Shelf shrimp stock is requested by DFO Fisheries and Aquaculture Management Branch and industry to help determine a Total Allowable Catch (TAC) that is consistent with the management plan. Annual assessments are 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 2013 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 (40mm), use of a Nordmøre separator grate, and a TAC. This fleet (about 17 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 8 active vessels is restricted to Chedabucto Bay. All licenses except traps operate under Individual Transferable Quotas (ITQs). Stock assessments have been conducted annually based on indicators from commercial, scientific survey, and environmental monitoring data.

This Science Advisory Report is from the December 4, 2012, Assessment of Eastern Scotian Shelf Shrimp. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

SUMMARY

- As of December 15, 2012, 4,054 mt of the 4,200 mt Total Allowable Catch (TAC) for 2012 had been landed.
- Although the standardized catch per unit effort (CPUE) index, an index of abundance, increased slightly, while the Gulf and survey CPUE indices decreased, catch rates remain relatively stable overall and slightly below average for the past decade.
- The total biomass estimate (28,028 +/- 4,560 mt) decreased by 8% in 2012 and has decreased by 38% since the peak in 2009.
- The spawning stock biomass point estimate (14,763 mt) decreased by 12% in 2012, but remains slightly above the upper stock reference of 14,558 mt (i.e., in the Healthy Zone).
- The precautionary reduction in the TAC for 2012 (9%) helped to offset decreased biomass, so female exploitation (19%) remained below the 20% removal reference.
- Recent trends in the research survey coefficient of variation index (low) and the commercial fishing area index (stable) suggest that the stock is relatively evenly distributed on the fishing grounds.
- The moderately abundant 2007-2008 year classes continue to support the fishable and spawning stock biomass in 2012 and 2013.
- Length frequency distributions from survey and commercial gear suggest that succeeding year classes (>2008) are not very abundant. This is consistent with the recent values for the belly bag index, which suggest poor recruitment to the 2009-2011 year classes.
- Total and spawning stock biomass are likely to remain relatively stable in 2013, as the 2008 year class fully undergoes sex transition to 5-year old females. Given the expected reduction in the 2007-2008 year classes, and the evidence of low abundance of succeeding year classes, biomass is expected to decline in 2014.
- Spring sea surface temperatures and survey bottom temperatures (June) remained high in 2012 relative to the long term average, which could have a negative effect on juvenile recruitment and will be a concern for the stock if these trends continue.
- Given the anticipation of the recruitment of the relatively abundant 2008 year class to spawning stock biomass in 2013, biomass is expected to remain relatively stable and a *status quo* TAC is not expected to exceed the removal reference. However, a TAC reduction would promote higher total and spawning stock biomass in 2013 realized from the full recruitment of the 2007 and 2008 year classes to the female portion of the stock, increasing the likelihood of strong recruitment if conditions are suitable.

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 move to the bottom and take up the life style of the adults. 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. They generally live up to 8 years, depending on current environmental conditions and population dynamics. Shrimp concentrate in deep "holes" (>100 fathoms) on the Eastern Scotian Shelf (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 inshore licenses (12 active vessels), mostly <65' length overall (LOA), and 14 midshore licenses (5 active vessels) 65-100' LOA. All mobile licenses have been under Individual Transferable Quotas (ITQs) since 1998. A competitive trap fishery with 14 licenses (8 currently active) is largely restricted to Chedabucto Bay. 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 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. The total allowable catch (TAC) was first reached in 1994 when 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. More substantial shortfalls occurred in 2005-2008 unrelated to resource availability. The gap between the TAC and catch has narrowed steadily since 2005 as problems associated with market conditions and quota reallocations have been resolved.

As of December 15, 2012, 4,054 mt of the 4,200 mt TAC for 2012 had been landed. Although trap fishing effort and catches had decreased to negligible amounts (e.g., 1 mt in 2010) since 2005 due to low prices, there have been considerably higher landings in 2011 (111 mt) and 2012 (130 mt as of November 20, 2012, with fishing ongoing). 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).

Table 1. Recent shrimp TACs and landings ('000s mt)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
TAC	5.0	3.0	3.0	3.5	5.0	5.0	5.0	5.0	3.5	5.0	4.6	4.2
Landings	4.8	2.9	2.8	3.3	3.6	4.0	4.6	4.3	3.5	4.6	4.4	4.1[1]

[1]Landings projected to December 31, 2012.

The spatial pattern of the fishery has changed significantly over the years (Figure 2), reflecting changing distributions of biomass and size frequencies. In general, the bulk of the catch is taken from SFAs 14 and 15, although a large part of the TAC (57%) was taken in SFA 13 in 2004. In the past 5 years, effort has shifted back to SFAs 14 and 15.

Historically (up to 2009), 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 generally resumes in September-October and continues until December if catch rates and shrimp condition are suitable. In recent years, fishing has been starting earlier in the calendar year (as early as late-January in 2012), although it continues to cease in July-August and resume in the fall.

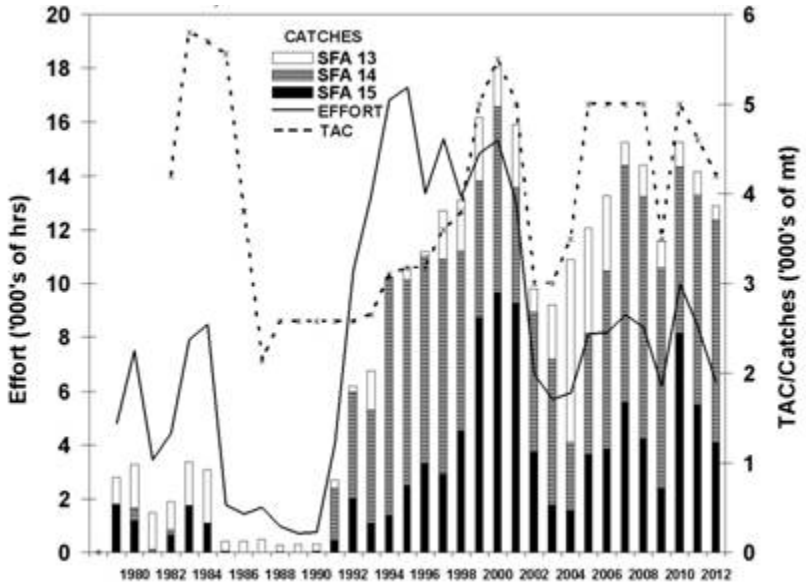


Figure 2. Landings, TACs, and Effort.

ASSESSMENT

Stock Trends and Current Status

After a sustained long-term increase, commercial Catch Per Unit Effort (CPUE) indices leveled off and have been fluctuating at a high level since 2002 (Figure 3A-B). The DFO-Industry trawl survey has shown two divergences from CPUE trends (Figure 3A). The first, between 2000-2003, was attributed to changing spatial distribution patterns of the relatively large 1994-1995 year classes as these moved through the population and died off, and the second (2005-2008) was at least partly due to a problem with the attack angle of the Nordmøre grate in the survey trawl. In 2012, the three CPUE-based indicators provided fairly congruent results. Although the standardized CPUE index, an index of abundance, increased slightly, while the Gulf and survey CPUE indices decreased, catch rates remain relatively stable overall and slightly below average for the past decade.

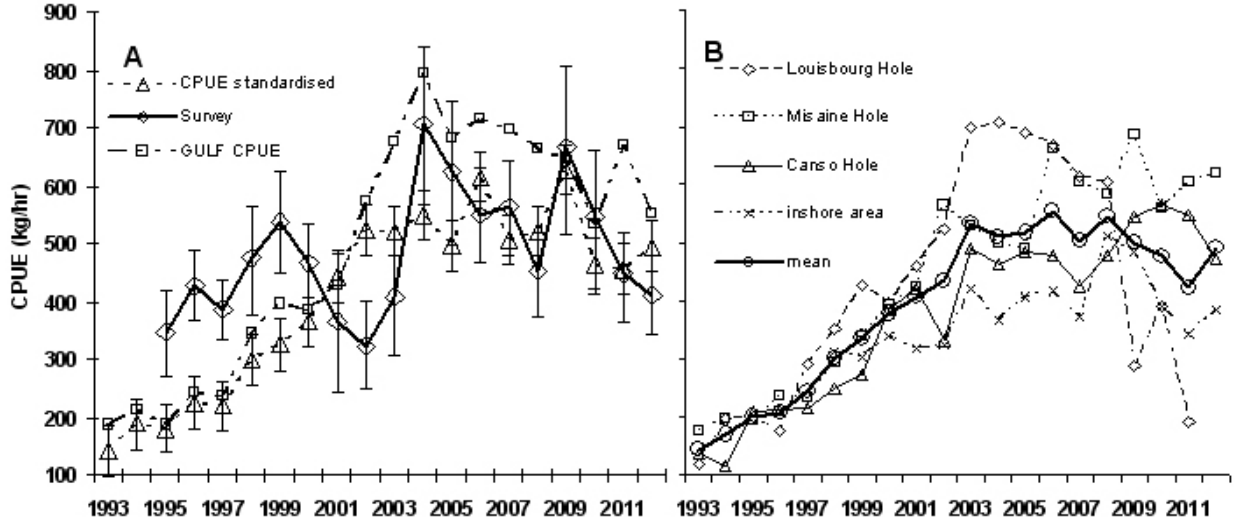


Figure 3. A – Commercial and survey CPUEs and B – unstandardised commercial CPUEs by stratum.

Based on the survey indices, the total biomass estimate (28,028 +/- 4,560 mt) decreased by 8% in 2012 and has decreased by 38% since the peak in 2009. Although the spawning stock biomass (SSB, females) point estimate (14,763 mt) decreased by 12% in 2012 (Figure 4A), it remains slightly above the upper stock reference (USR) of 14,558 mt (i.e., in the Healthy Zone, Figure 5). Although confidence limits around the SSB point estimate are not quantified, there is some uncertainty around this index, so the close proximity of the SSB estimate to the USR suggests that there is some likelihood (approximately 40% chance) that the true value falls within the Cautious Zone. The precautionary reduction in the TAC for 2012 (9%) helped to offset decreased biomass, so both total and female exploitation indices remained relatively stable at 15% and 19%, respectively (Figure 4B), slightly below the 20% removal reference for SSB (Figure 5).

Since the end of the long-lived 2001 year class the population age-length evenness index has been fluctuating at a relatively high value, which is indicative of a stock composed of several year classes. Recent trends in the research survey coefficient of variation index (low) and the commercial fishing area index (stable), both indicators of dispersion of the resource, suggest that the stock is relatively evenly distributed on the fishing grounds with no evidence of aggregation that might suggest a declining resource or “clumping” that can maintain artificially high CPUEs from a shrinking stock. These, coupled with positive abundance indicators, provide a positive picture of a stock that is relatively abundant, evenly distributed over the fishing grounds, and supported by a number of year classes.

The interpretation of year class strength and longevity is 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 dependant influences. Furthermore, the tendency of a single year class, especially large ones such as 2001, to change sex over a number of years, makes it difficult to distinguish them from adjacent year classes. Nonetheless, the recruitment pulses of 2001 and 2007-2008 coincide with the maturation of strong year classes, i.e., 1993-1995 and 2001, respectively. This is evidence that strong year classes have produced large spawning stock biomasses.

The moderately abundant 2007-2008 year classes continue to provide a detectable signal in the trawl survey (Figure 6, 7) and commercial catches (Figure 8), and continue to support the fishable and spawning stock biomass in 2012 and 2013. As predicted (DFO 2012), the onset of the recruitment of these year classes to the fishable biomass and to the female component (2007 year class as 5 year old females) of the population has contributed to the maintenance of relatively high total and spawning stock biomass. The moderately high abundance of the 2008 year class is also corroborated by the stability of the age 4 shrimp abundance index for 2012 (Table 2). This year class is expected to begin sex transition in 2013, which should contribute to the continuation of relatively high spawning stock and total biomass. However, length frequency distributions from survey (belly-bag and main trawl; Figures 5-6) and commercial gear (Figure 7) suggest that succeeding year classes (>2008) are not very abundant. This is consistent with the recent values for the belly bag index, which suggest poor recruitment to the 2009-2011 year classes (Table 2). Based on these data, total and spawning stock biomass are likely to remain relatively stable in 2013, as the 2008 year class fully undergoes sex transition to 5-year old females. Given the expected reduction in the 2007-2008 year classes, and the evidence of low abundance of succeeding year classes, biomass is expected to decline in 2014.

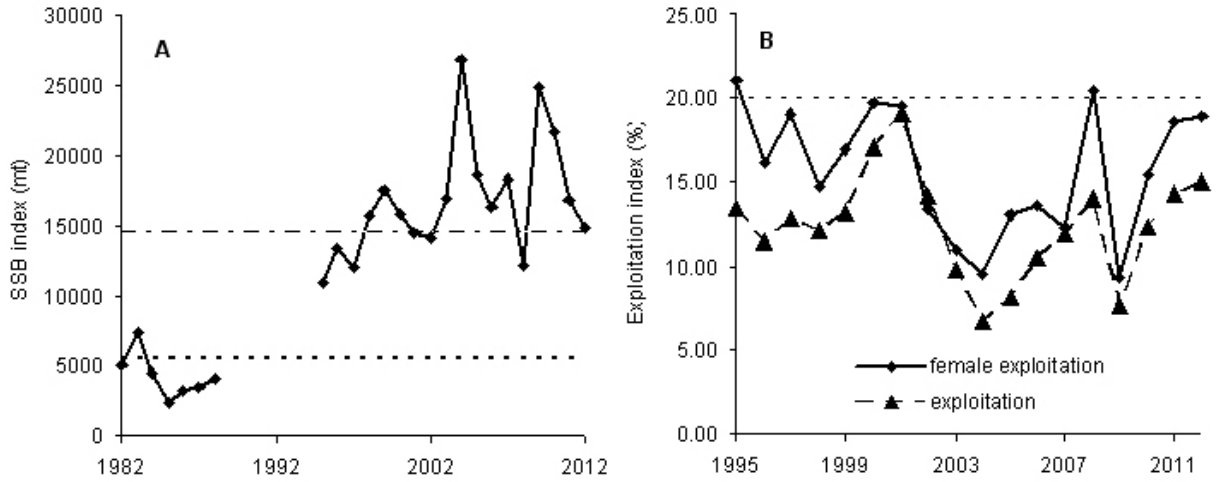


Figure 4. A - Changes in the spawning stock biomass index for the Eastern Scotian Shelf shrimp population. The dashed lines show the upper and lower limit reference point. B - Changes in the exploitation index for the Eastern Scotian Shelf shrimp fishery. The dashed line shows the limit reference point of 20% for the exploitation index.

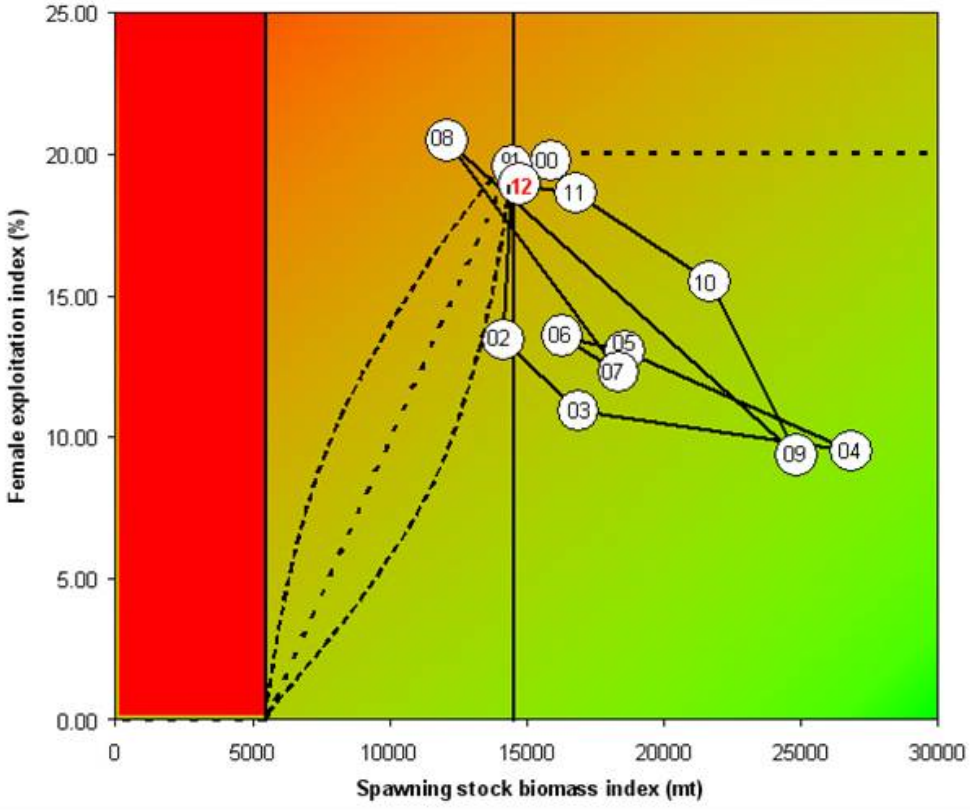


Figure 5. *Graphical representation of the precautionary approach for Scotian Shelf shrimp. The dotted lines in the cautious zone represent a range of management actions possible, depending on whether the stock is stable, increasing or decreasing, or on trends in other indicators of stock or ecosystem health.*

Table 2. Minimum survey population numbers at age from modal analysis. Numbers x 10^6.

	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	Average
1[4]								980	196	316	198	61	194	484	567	263	97	125	316
2	359	307	129	40	166	280	175	134	616	354	187	121	39	114	304	188	85	273	215
3	1046	276	1159	785	27	757	362	383	312	3118	652	880	506	396	267	1020	752	879	754
4	876	1248	1257	1884	3010	0[3]	1184	399	1506	839	4502	0[3]	0[3]	1190	463	1036	1044	976	1428
5+	1702	2162	1539	2047	1952	3374	2110	1847	1727	3324	2224	5106	5506	3017	6020	4109	2488	1791	2891
TOTAL	3983	3993	4084	4755	5155	4412	3831	2763	4161	7636	7763	6169	6244	5201	7622	6616	4467	4044	5161
4+ males[1]	1369	1971	1578	2243	3235	1784	1771	938	1526	1549	4956	3916	2804	3317	4263	3454	1755	1208	2424
primiparous[2]	649	777	709	889	736	728	817	678	551	870	786	771	1739	892	1492	1324	930	279	868
multiparous	560	661	509	647	991	863	706	630	1188	1698	1183	480	1157	482	1295	630	945	1405	890
total females	1209	1438	1218	1535	1727	1591	1523	1308	1739	2568	1969	1251	2896	1374	2787	1954	1875	1684	1758

[1] total population less ages 2,3 males, transitionals and females
i.e. males that will potentially change to females the following year

[2] includes transitionals

[3] 4 year olds of the 1996 and 2002, 2003 yc were not distinguishable in the MIX analysis.
these yc appear to be small and are contained in the age 3 or 5+ categories

[4] belly bag

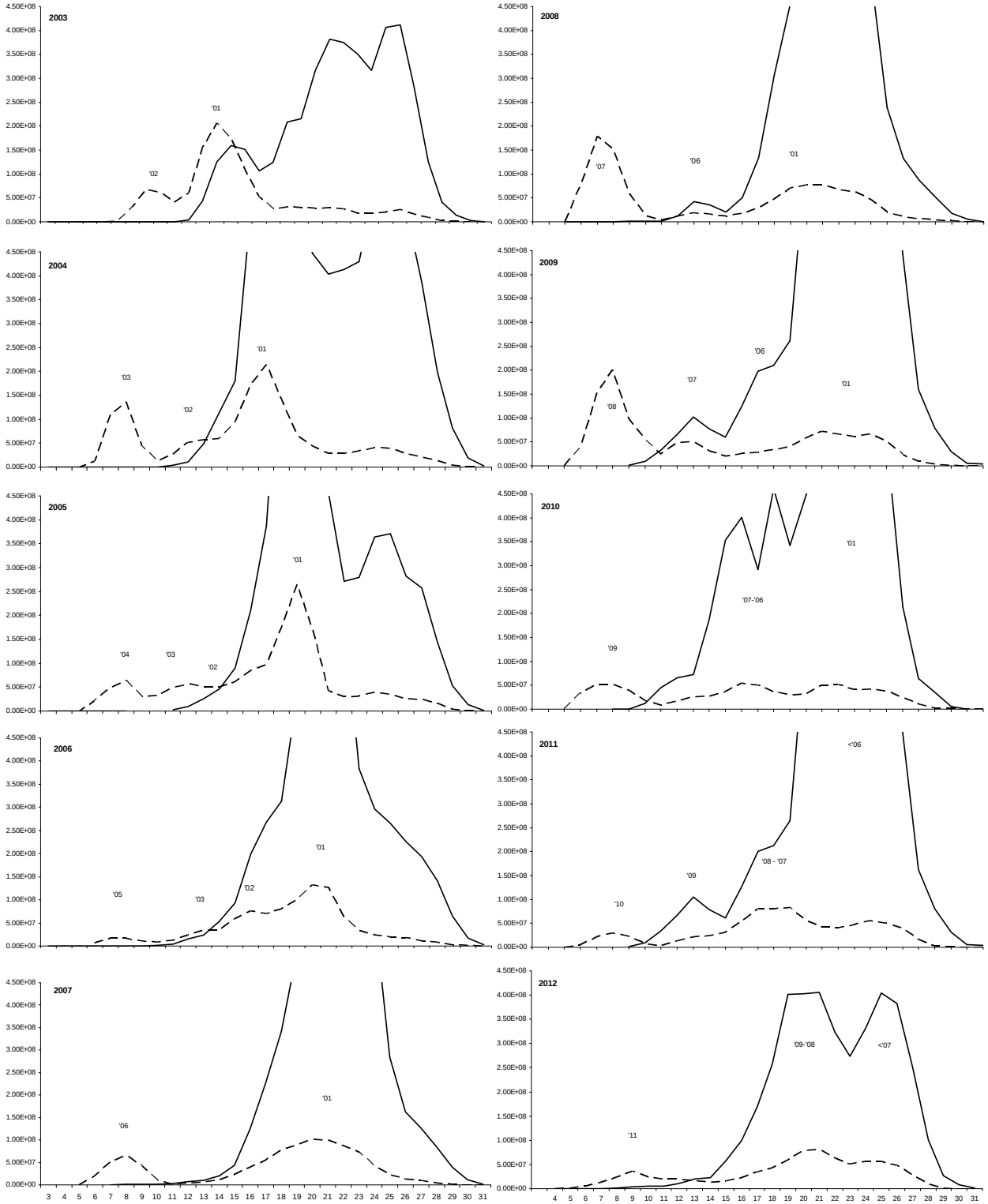


Figure 6. Population estimates from belly-bag and main trawl catches for the 2003-2012 survey.

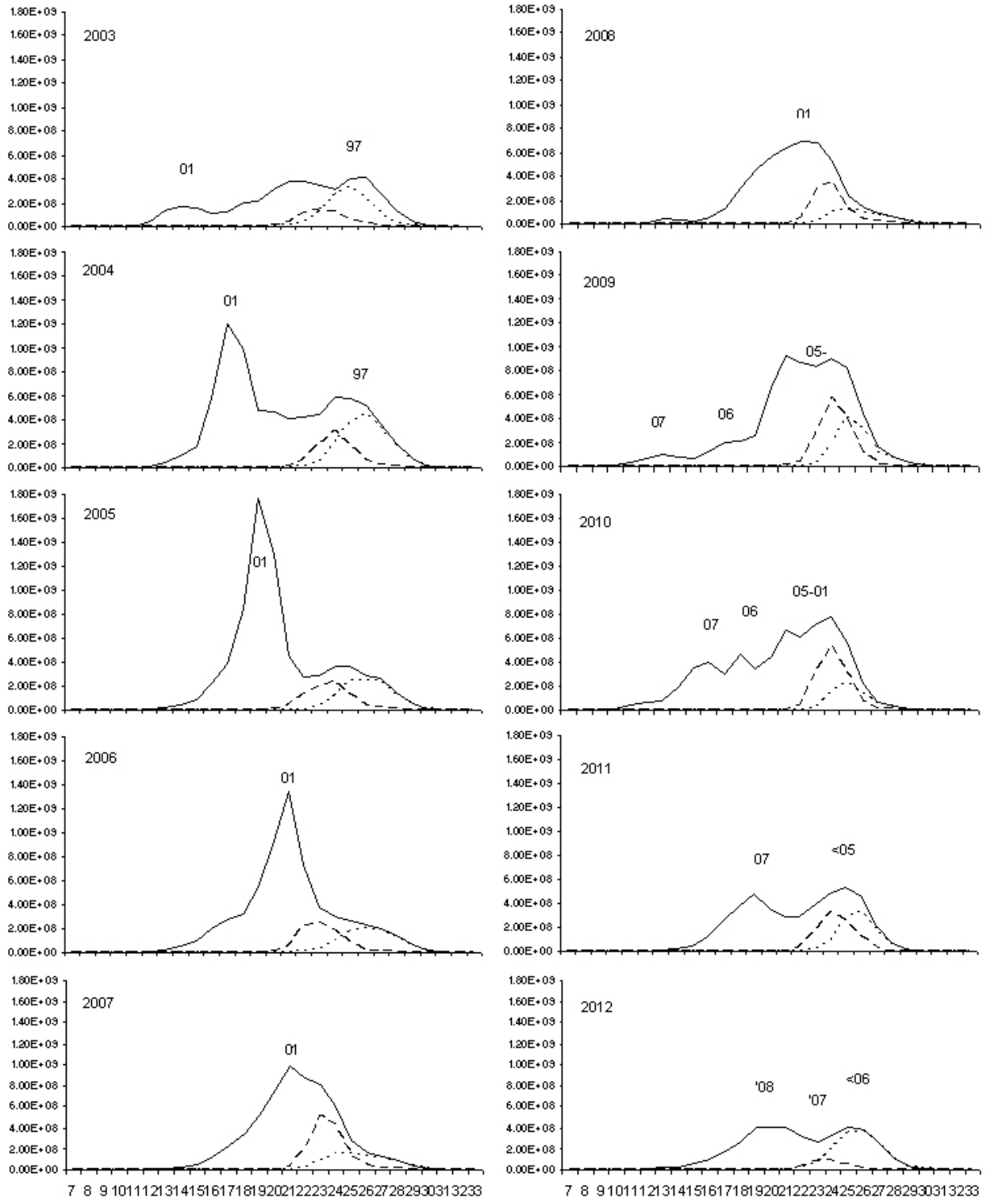


Figure 7. Population estimates at length from DFO-industry surveys 2003-2012 (solid line). The heavy dotted line in each figure represents transitional and primiparous shrimp, and the stippled line represents multiparous shrimp

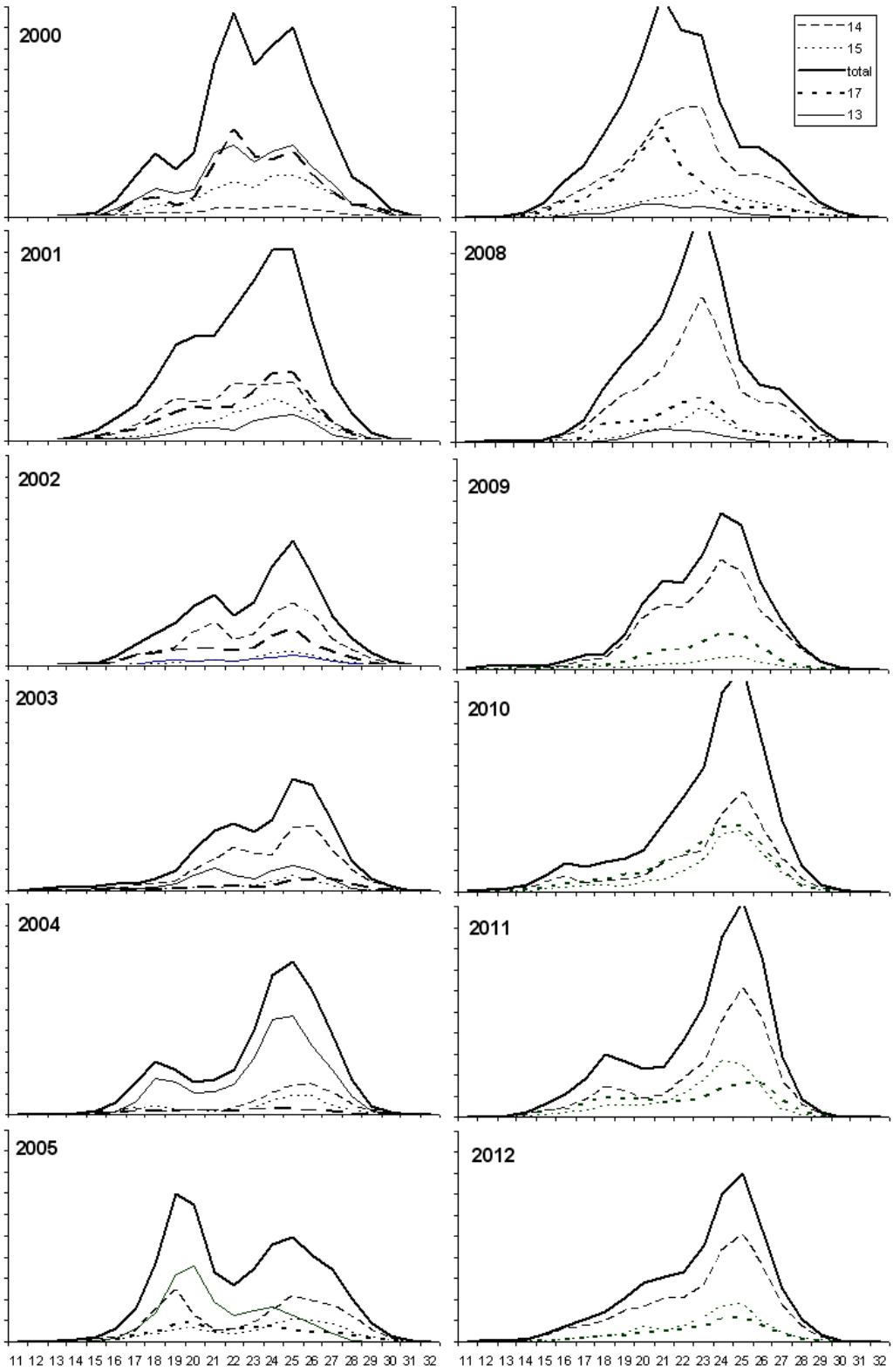


Figure 8. Catch at length from commercial sampling, 2000-2012.

Commercial count estimates (numbers of shrimp per pound) increased in 2005-2007 as abundant males from the 2001 year class recruited to the fishing gear (Figure 9A). Counts then decreased starting in 2007 as these shrimp changed sex and continued to grow as females.

The increase in the 2011 commercial count index was likely due to recruitment of the 2007 cohort to the fishery as smaller age 4 males, while spawning stock biomass (large shrimp) decreased. Commercial counts decreased slightly in 2012, probably because the relatively abundant 2007-2008 year classes account for a large proportion of the catch as age 4 and age 5 shrimp, relative to much less abundant succeeding year classes (i.e., few small shrimp).

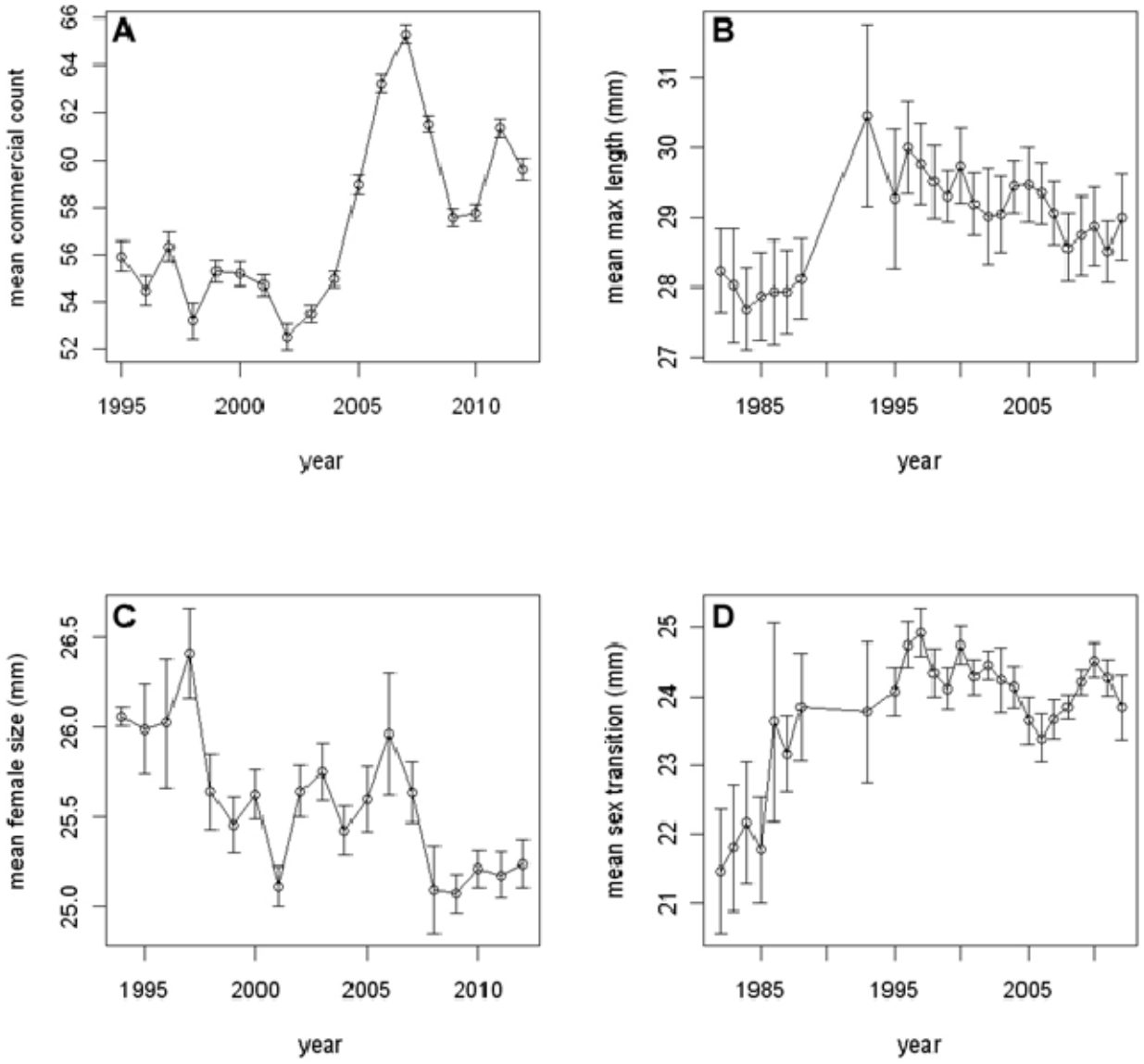


Figure 9. Average: commercial count (A), maximum length (B), female size (C) and size at sex transition (D) for all SFAs combined for 1995-2012 with 95% confidence intervals.

Mean female size and mean maximum size show a decreasing trend since the mid 1990s overall, although both indices have been relatively stable for the past 5 years (Figure 9 B-C). The possibility that the observed long-term decreasing trend in both indicators is a cumulative fishing effect that may be having a negative impact on the population's reproductive capacity bears consideration.

Decreases in average length at sex change (L_t) in shrimp stocks can contribute to population downturns due to decreased female fecundity (smaller shrimp produce fewer eggs). On the Scotian Shelf, length at sex change began to decrease when monitoring began in the mid 1990s

(Figure 9D). Length at sex change increased from 2006-2010, probably due to late sex change of 2001 year class males, some of which had an additional year(s) to grow. Size at sex transition has been decreasing back toward an average level (for the high-productivity period, 2000-present) for this stock, as the moderately abundant cohorts that currently make up the adult shrimp biomass are likely undergoing sex transition after age 4.

Predator feeding studies have shown that shrimp are important prey for many finfish species, and significant negative correlations between shrimp and finfish abundance have been demonstrated from the Gulf of Maine to Greenland. The sharp increase in the predation index for 2011 has returned to a very low level for 2012 (Figure 10). Given that many groundfish stocks remain at low levels on the Eastern Scotian Shelf, and the continued low value of the cod recruitment index, natural mortality of shrimp due to predation is expected to continue to be low.

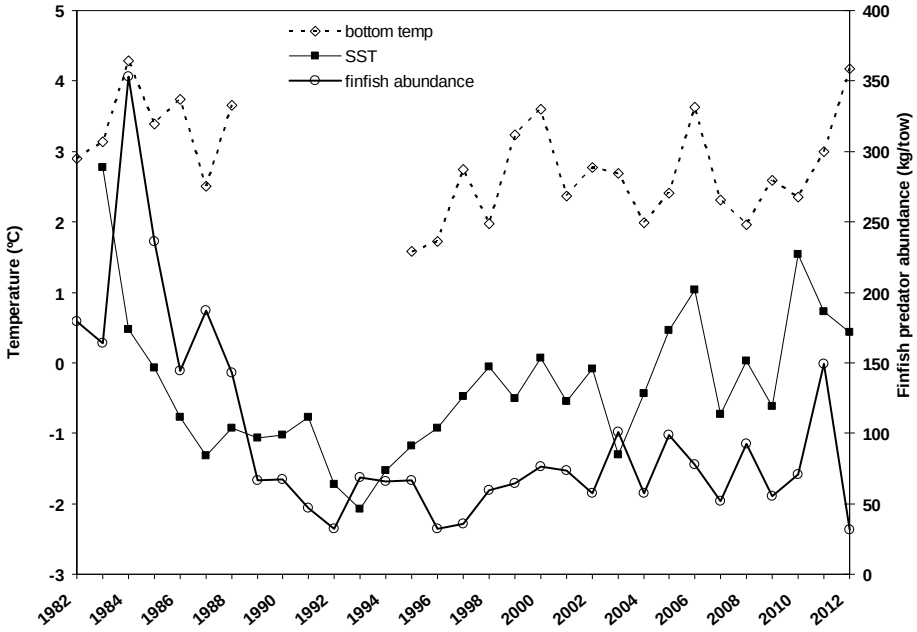
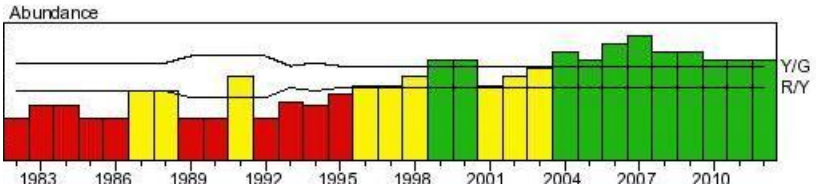


Figure 10. Bottom and spring sea surface temperatures and predator abundance on the Eastern Scotian Shelf shrimp grounds.

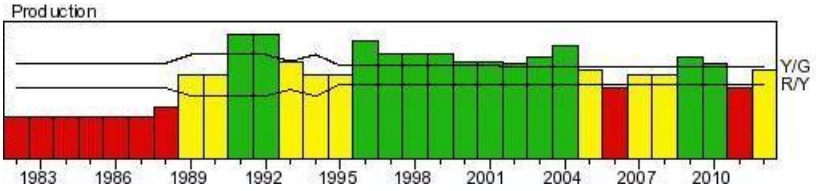
For some Northern Shrimp stocks near the southern limits of the species' range, abundance is negatively correlated with water temperatures. On the Eastern Scotian Shelf, the large population increase that occurred from the mid 1980s to the mid 1990s is associated with colder surface and bottom water temperatures. This is at least partly because colder temperatures 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. 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 and 2007-2008 year classes). Spring sea surface temperatures and survey bottom temperatures (June) remained high in 2012 relative to the long term average, which could have a negative effect on juvenile recruitment and will be a concern for the stock if these trends continue. The abundance of cold water indicator species (capelin and Greenland halibut) both remain low, suggesting that current environmental conditions are not optimal for coldwater species such as shrimp. By contrast, however, the snowcrab recruitment index remains at a relatively high level, although it declined for the third consecutive year.

Figure 11 provides a summary of 24 indicators related to the health of the Eastern Scotian Shelf shrimp stock. Each indicator was assigned a color for every year there is data according to its percentile value in the series (i.e., >0.66 percentile = green ⊕ or healthy, 0.66-0.33 percentile = yellow ○ or cautious, and <0.33 percentile = red ⊖ or critical). Indicators have been grouped into stock characteristics of Abundance, Production, Fishing Effects and Ecosystem. Note that indicators are not weighted in terms of their importance, and the summary given at the top of the figure was determined as a simple average of individual indicators.

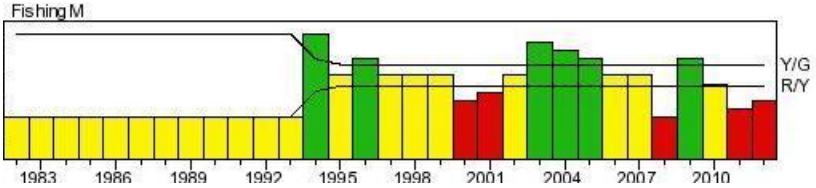
The summary indicator for 2011 remained red after the complete 2011 data were updated from all sources. In 2012, the Traffic Light analysis of preliminary survey and commercial data improved slightly relative to the 2011 summary, although it remained red. In general, the Abundance characteristics remained green and the Production characteristic improved from red to yellow, while Fishing Effects and Ecosystem characteristics remained red.



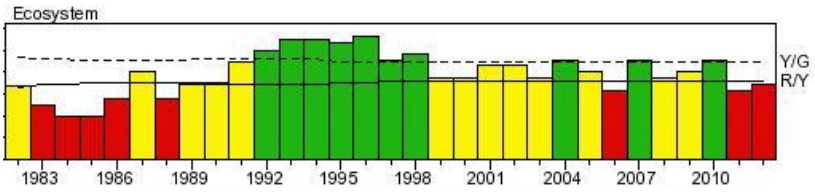
The Abundance characteristic has remained favourable (green) for the last nine years due to the influence of the commercial CPUE indices, which remained strong throughout the downturn in the survey index from 2005-2008. In 2012, the survey and commercial CPUE indices remained relatively stable, with minor downturns in the survey and Gulf CPUE data offset by improvements in to the coefficient of variation of survey catches and relative stability in the area of moderate commercial catch rates.



The Production characteristic improved in 2012 due mostly to increased abundance of age 2 shrimp and a reduced finfish predator abundance index. Spawning stock biomass remains at a healthy level and the relatively abundant age 4 shrimp are expected to recruit to the female portion of the population in 2013.



The Fishing Effects characteristic remained relatively unchanged (red) for 2012. Total and female exploitation remain relatively high, although stability was achieved because total and spawning stock biomass downturns were met with precautionary TAC reductions. Changes in most other indicators are minor.



The 2012 Ecosystem characteristic remained red because of unfavourable (high) temperature indices and low indices of some sympatric coldwater species abundance.

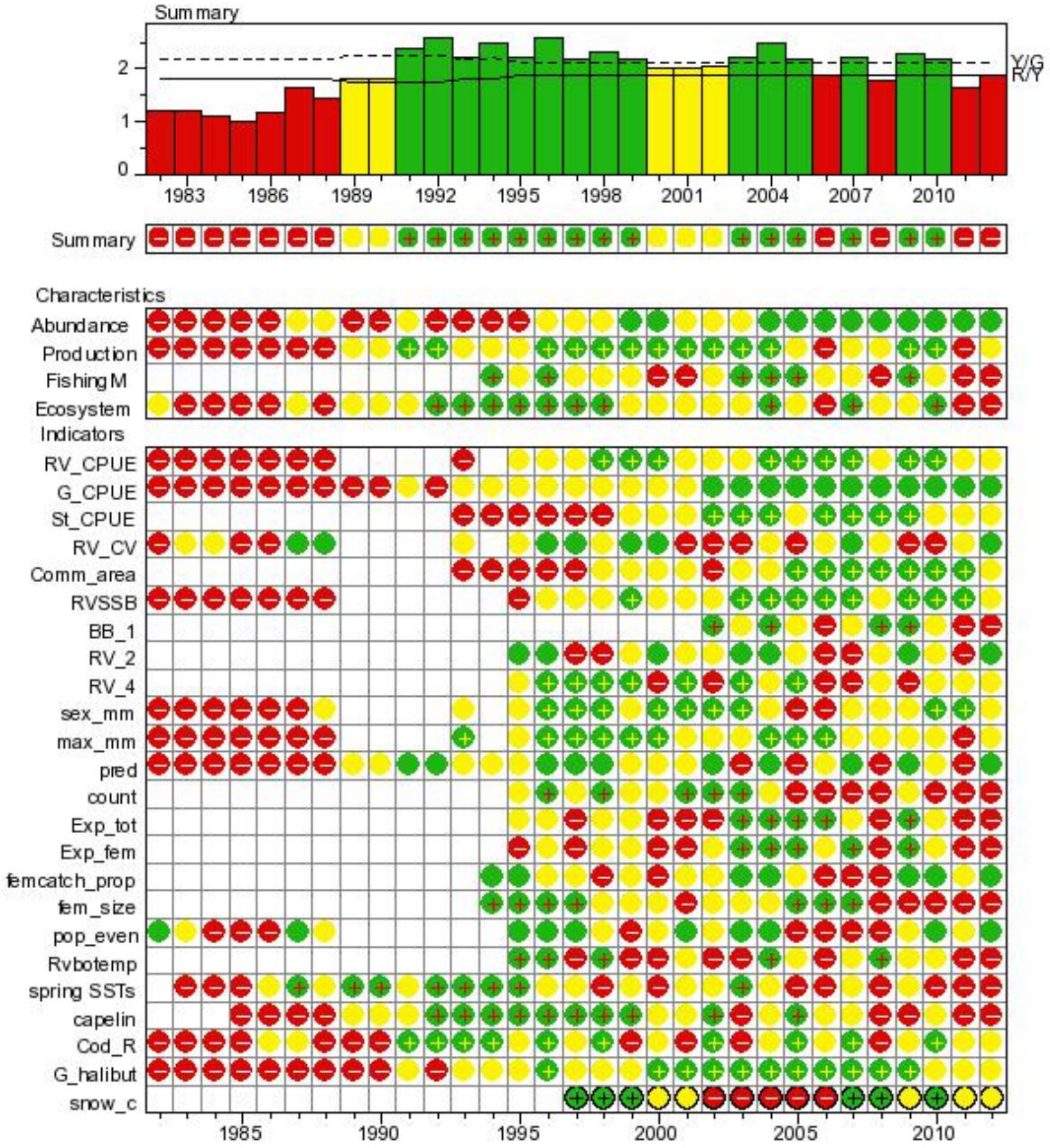


Figure 11. Traffic Light Analysis. Not all indicators in the Traffic Light table are discussed in the text. Please consult the current CSAS Research Document for a detailed description.

Bycatch

The 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 55 commercial sets from 2012 (1 trips from Gulf-based vessels; 2 trips from Nova Scotia vessels) suggests that Gulf and Nova Scotia fleet trawl configurations including the use of the Nordmøre grate continue to ensure low total bycatch (1.56%) by weight. It is noteworthy that this value is very likely over-estimated due to the minimum 1 kg weight recorded by the observers (e.g. a single sand lance would be recorded as 1 kg despite weighing only a few grams). Total bycatch by weight from observed trips in 2012 is approximately 50% lower than was summarized in 2010-2011 (Hardie et al. 2012), much closer to the 2008-2010 summary (1.78%) (Hardie et al. 2011). All observed trips took place during the spring/summer when bycatch has been less than during the fall. There was no observer coverage in SFA 13 (an area where herring and capelin bycatch was much higher than in the other areas) due to lack of fishing in that area during 2012. Atlantic (Striped) Wolffish were caught in one observed commercial set (weighing less than 1 kg in total).

Sources of Uncertainty

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 the first 10 days of June to try to mitigate this effect. In 2007-2008, problems with NETMIND distance sensors and data logging required 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 somewhat subjective, particularly for larger individuals. Growth rates can change dramatically due to density dependence, as happened with the strong 2001 year class. Consequently, recruitment to the fishery will be delayed and spread over a longer time period.

Because of the timing of the shrimp assessment relative to the collection and analysis of samples, the advice provided at the RAP generally derives from only a portion of these samples (2012**:** 78 of 120 survey samples (41 main trawl, 37 belly-bag) and 26 of 50 commercial samples).

CONCLUSIONS AND ADVICE

At present, the fishable (adult) biomass of shrimp on the Eastern Scotian Shelf appears to be evenly distributed on the fishing grounds and moderately abundant near the average biomass from the past decade. A precautionary TAC reduction in 2012 helped to prevent exceeding the removal reference for this stock, and may have helped to maintain spawning stock biomass in the healthy zone. Analysis of survey and commercial trawl length frequencies suggest that the fishable biomass is currently supported by two relatively strong year classes, the 2007 year class, which recruited to the female component of the population in 2012, and the 2008 year class, which is likely in its last year as males and will recruit to the female component of the population in 2013. The low values of the belly-bag index from 2010-2012 suggest that recruitment to the 2009-2011 year classes was poor. This conclusion is corroborated by the survey and commercial trawl length-frequency distributions, which are dominated by the 2007-2008 year classes with very little indication of strong succeeding year classes. Overall, total and spawning stock biomass are expected to remain relatively stable for 2013, and then to begin to decline in 2014 as the 2007 year class begins to reach the end of its life-expectancy.

The trend towards warmer temperatures on the shrimp grounds, coupled with continued low abundance of most sympatric coldwater species, do not provide an optimistic forecast for strong juvenile recruitment in the next few years. However, it should be noted that a strong recruitment event has previously occurred when temperature indices were elevated (2001).

Given the anticipation of the recruitment of the relatively abundant 2008 year class to spawning stock biomass in 2013, biomass is expected to remain relatively stable and a *status quo* TAC is not expected to exceed the removal reference in 2013. However, similarly to the advice provided in 2011, a TAC reduction would promote higher total and spawning stock biomass in 2013 realized from the full recruitment of the 2007 and 2008 year classes to the female portion of the stock, increasing the likelihood of strong recruitment if conditions are suitable.

OTHER CONSIDERATIONS

At present, no source of funding has been identified to replace the terminated Larocque funding program. As a result, there is a significant deficiency in funds needed to pay for the 2013 research survey and the analysis of survey and commercial port samples. Given that most of the data used for the provision of advice for this fishery, including the biomass and removal reference points, derives from these data, alternative methods will need to be developed if the collaborative research survey is ended. This would likely involve directing available resources to the analysis of commercial port samples and to the development of analytical approaches using fishery dependent data. A reduced-station survey is unlikely to provide sufficient coverage to be useful.

SOURCES OF INFORMATION

This Science Advisory Report is from the December 4, 2012 regional peer review meeting on the Assessment of Eastern Scotian Shelf Shrimp. Additional publications from this process will be posted as they become available on the Fisheries and Oceans Canada Science Advisory Schedule at www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

DFO. 2012. Assessment of Northern Shrimp on the Eastern Scotian Shelf (SFAs 13-15). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2012/001

Hardie, D., M. Covey, M. King, and B. Zisserson. 2011. Scotian Shelf Shrimp 2010-2011. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/102.

Koeller, P. 2000. Relative Importance of Environmental and Ecological Factors to the Management of the Northern Shrimp (*Pandalus borealis*) Fishery on the Scotian Shelf. J. Northw. Atl. Fish. Sci. 27: 21-33.

Koeller, P. 2006. Inferring Shrimp (*Pandalus borealis*) Growth Characteristics from Life History Stage Structure Analysis. J. Shellf. Res. 25: 595-608.

Koeller, P., L. Savard, D. Parsons, and C. Fu. 2000. A Precautionary Approach to Assessment and Management of Shrimp Stocks in the Northwest Atlantic. J. Northw. Atl. Fish. Sci. 27: 235-247.

Koeller, P., C. Fuentes-Yaco, M. Covey, M. King, and B. Zisserson. 2010. The Last Traffic Light on the Scotian Shelf: Shrimp 2009-2010. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/061.

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