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An Assessment of the Eastern Scotian Shelf Shrimp Stock and Fishery in 2008 with an Outlook for 2009

Évaluation du stock et de la pêche en 2008 pour la crevette de l'est du plateau néo-écossais et perspectives pour 2009

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ABSTRACT

The expected biomass decrease has begun and is progressing quickly as the 2001 year class passes through the population. Biomass decreased significantly (20%) since last year and 36% since the all-time high of 2004. It is now slightly below average for the 1995-2008, but above the low values of the 1980s survey series. However, the earlier series used a trawl which probably had a lower catchability factor for shrimp; consequently, the difference between the low biomasses of the 1980s and the high biomasses since 1994 may be exaggerated. Decreases were observed in all areas except the inshore, which remained about the same as 2007. The greatest decrease was observed in Shrimp Fishing Area (SFA) 14, which has been fished heavily during the last 3 years, and no longer shows the large biomass which had accumulated over the last 7 years. Effort in SFA 14 remained high in 2008 but due to the biomass decrease exploitation increased to 26%, the highest on record for this area. The spawning stock biomass (SSB) has decreased by 50% since the all time high of 2004 and is now slightly below average for the 1995-2008 series. It remains above the low values of the 1980s; however, the difference may also be exaggerated as described above. Female sizes have also decreased significantly since the mid 1990s; consequently, egg production per unit SSB is now lower. The population continues to be represented in fewer length (and year) classes than previously, which may decrease population stability and increase vulnerability to exploitation. Commercial counts since 2005 have been high due to the prominence of the 2001 year class and their relatively small size due to slower growth - growth overfishing continues to be a concern. Overall exploitation increased to 14.6%, above the average of 12.5%. Female exploitation increased sharply to 20%, near the observed maximum. The proportion of the catch taken during the ovigerous period also increased in 2008. The percentage of females in the catch continued to be low, presumably since many shrimp from the 2001 year have still not changed sex. Commercial catch rates remained high in 2008 and spatial indicators show that the area with the highest commercial catch rates remains large. However, the discrepancy between survey and catch per unit effort (CPUE) may be diagnostic of a large year class as it begins to decline and concentrate in dense shoals over smaller areas, as previously observed for the 1993-1995 year classes.

RÉSUMÉ

La diminution prévue de la biomasse a commencé et progresse rapidement au fur et à mesure que la classe d'âge de 2001 traverse la population. La biomasse a connu une diminution importante de 20 % depuis l'an dernier et de 36 % depuis le sommet inégalé de 2004. Elle se trouve aujourd'hui légèrement sous la moyenne de 1995 à 2008, mais au-dessus des faibles valeurs des relevés réalisés dans les années 1980. Toutefois, les relevés antérieurs ont été réalisés au moyen d'un chalut présentant un facteur de capturabilité plus faible pour la crevette. Par conséquent, l'écart entre les biomasses dans les années 1980 et les biomasses depuis 1994 peut être exagéré. Des diminutions ont été observées dans toutes les zones, à l'exception de la zone côtière, où la biomasse est demeurée à peu près la même qu'en 2007. La diminution la plus marquée a été observée dans la zone de pêche de la crevette (ZPC) 14, qui a fait l'objet d'une intense activité de pêche au cours des trois dernières années. Elle n'abrite plus la biomasse importante qui s'y était accumulée au cours des sept dernières années. En 2008, les efforts de pêche déployés sont demeurés importants dans la ZPC 14, mais, en raison de la diminution de la biomasse, le taux d'exploitation a augmenté à 26 %, un sommet pour cette zone. La biomasse du stock reproducteur (BSR) a chuté de 50 % depuis le sommet inégalé de 2004, et se trouve maintenant légèrement sous la moyenne des relevés réalisés de 1995 à 2008. Elle est demeurée au-dessus des valeurs des années 1980. Toutefois, l'écart peut également être exagéré, tel que décrit plus haut. La taille des femelles a également connu une diminution significative depuis le milieu les années 1990. Par conséquent, la production d'œufs par unité de BSR est maintenant plus faible. La population continue d'être représentée en classes de longueur (et d'âge) moins nombreuses qu'auparavant, ce qui pourrait réduire la stabilité de la population et accroître sa vulnérabilité à l'exploitation. Le nombre de crevettes de taille commerciale par unité de poids depuis 2005 sont élevées en raison de la prépondérance de la classe de 2001 et de sa taille relativement petite en raison de sa croissance plus lente. La surpêche du potentiel de croissance demeure préoccupante. L'exploitation globale a augmenté de 14,6 %, ce qui est supérieur à la moyenne de 12,5 %. L'exploitation des femelles a grimpé jusqu'à 20 %, soit près du maximum observé. La proportion des prises effectuées en période ovifère a également augmenté en 2008. Le pourcentage de femelles dans les prises demeure faible, probablement parce que bon nombre de crevettes de l'année 2001 n'ont pas encore changé de sexe. Les taux de prises commerciales sont demeurés élevés en 2008, et les indicateurs spatiaux démontrent que la zone présentant les taux de prises commerciales les plus élevés demeure vaste. Toutefois, les écarts entre les relevés et les captures par unité d'effort (CPUE) peuvent signaler la présence d'une grande classe d'âge, étant qui commence à s'épuiser et à se concentrer sur les hauts-fonds denses plutôt que dans les petites zones, comme on l'a auparavant observé pour les classes d'âge de 1993 à 1995.

INTRODUCTION

The biology of northern shrimp, *Pandalus borealis*, is reviewed in Shumway et al. (1985) for various stocks world-wide, and by Koeller (1996a, 2000, 2006) and Koeller et al. (2000a, 2003a) for the eastern Scotian Shelf stock. The rationale for the assessment and management approach used is described in Koeller et al. (2000b). The history of the eastern Scotian Shelf shrimp fishery and recent stock assessments are given in Koeller 1996b and Koeller et al. (1996, 1997, 1998, 1999, 2001, 2002, 2003b, 2004, 2005, 2006a, 2006b, 2008). 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 Nordmore grate in 1991. The total allowable catch (TAC) was first reached in 1994, when individual Shrimp Fishing Area (SFAs) quotas were removed. With biomass at historical highs and continued good recruitment, the TAC was raised from 3100mt to 3600mt for 1997 and to 3800mt for 1998. Despite evidence of reduced recruitment to the population, and because of continued high spawning stock biomasses (SSBs) and large year classes (1993-1995) recruiting to the fishery, the TAC was increased to 5000mt for 1999 and to 5500mt for 2000. With the strong year classes completing their life cycle; recruitment only average; a decreasing trend in the survey biomass; increasing exploitation rates; changes in the distribution of the resource, possibly due to increasing temperatures and\or size separation; and increasing harvest levels during the ovigerous period, the TAC was reduced to 5000mt for 2001 and to 3000mt for 2002 and 2003. In 2003, the survey index increased for the first time following 3 successive declines and the TAC was raised to 3500mt for 2004. Signs of improved recruitment in the form of a very strong 2001 year class suggested that the stock would continue to increase. The 2004 survey biomass was the highest on record and the TAC was raised to 5000mt for the 2005 fishery. Despite a declining trend since 2004, biomass has remained relatively high, especially in SFA 14. Consequently, TAC were kept at 5000mt for the 2006-2008 fisheries.

In 2001, shrimp prices dropped sharply, partly due to large quantities of small shrimp in the Newfoundland and Labrador inshore fishery. This resulted in voluntary closures or greatly reduced fishing effort in the Newfoundland, Gulf of St. Lawrence, and eastern Scotian Shelf fisheries during the summer. There were no closures on the Scotian Shelf in 2002. In 2003-2008, effort on the Scotian Shelf virtually stopped during the summer to avoid soft shrimp and crab traps, but picked up again during the fall. Prices for coldwater shrimp have remained low in recent years due to high inventories, small shrimp, and competition from warm water wild and aquacultured shrimp production. This has had serious and widespread economic consequences for the coldwater shrimp industry, ranging from the large offshore concerns (freezer trawlers) operating on both sides of the North Atlantic, to the small inshore trap fishery in Chedebucto Bay, Nova Scotia, which had very low effort during 2005-2008.

Since 1999, many shrimp stock assessments have included a “traffic light” analysis (Koeller et al. 2000b, Mohn et al. 2001, Halliday et al. 2001, Caddy et al. 2005). The organisation of this report is based on this multiple indicator diagnostic approach, with the “Methods” and “Results and Discussion” sections for individual indicators grouped under headings representing "characteristics,” in the order they are presented in the summary. The sections on each indicator in “Methods” provide the methods used to calculate the indicators, and describe their relevance to the characteristic they represent. In “Results and Discussion,” the 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 indicator series used in the analysis is given as an uncaptioned figure directly after the indicator heading. In addition to the indicator time series themselves, their sections in “Results and Discussion” include data which support trends seen in the summarised data. These data are given as numbered and captioned figures and tables at the end of the document. For example, individual SFA data often replicate the indicator trends and thus substantiate them. Supporting data may be entirely different from the main indicator, for example: catch rates in the shrimp trap fishery supported the apparent increasing shrimp aggregation shown by the survey and catch per unit effort (CPUE) data; anecdotal reports of large numbers of 1 year old shrimp found on Cape Breton beaches in 2002 supported survey data indicating a strong 2001 year class, etc. This additional information may be used in the interpretation associated with any change that is given in the “Results and Discussion,” but it is not used in the summary traffic light “scores.” In any case, it should be noted that such scoring is not at this point intended to be translated directly into management action, for example, in the form of rules linked to summary scores. The “traffic light” is currently seen simply as a tool for displaying, summarising, and synthesizing a large number of relevant yet disparate data sources into a consensus opinion on the health of the stock. More formal “reference points” and “control rules” within the framework of the traffic light analysis will be developed during the next 2 years in order to meet conditions associated with the development of the Integrated Fisheries Management Plan.

The shrimp fishing areas on the Scotian Shelf are shown in Figure 1. Table 1 provides basic catch statistics for the fishery since 1980, and Table 2 gives licensing information for the recent period covered under sharing agreements between the Scotia Fundy and Gulf fleets and a multi-year (1998-2002) Integrated Management Plan that included provisions for temporary licences during favourable periods. Although this management plan expired in 2002 and negotiations for a renewed agreement were not successful, the 2003-2006 fisheries essentially operated under its provisions, which included removal of temporary licences when the quota dropped below an agreed threshold. Disagreement between temporary licence holders, who wanted permanency, and the permanent fleet component prevented the successful negotiation of a new multi-year plan. This stumbling block was removed when temporary licences were made permanent, albeit with a lower Individual Transferable Quota (ITQ) than previous permanent licence holders, for the 2005 fishery, and it currently operates under an Integrated Fisheries Management Plan for 2007-2011.

The experimental trap fishery was not under quota management from 1995-1998 except for a 500mt precautionary “cap,” and so the total catch exceeded the TAC due to the trap fishery catch. When the trap fishery in Chedebucto Bay was made permanent in 1999, a trap quota was set at 10% of the total TAC, e.g. 500 tons of the 5000mt TAC was initially allocated to trappers in 1999. Most of any uncaught portion of the initial trap quota was reallocated to the mobile fleet. This reallocation has tended to be late in the year, and some fishers were unable to take advantage of the additional quota; hence, the overall catch has been lower than the TAC since 1999, although other factors have contributed to this as noted above. Note also that the trap quota reallocation has been based on projected catches that were not achieved during some years. In an attempt to avoid reallocations, in 2004, only 300mt were allocated to this fishery, which is closer to its capacity. With an increase in the TAC for 2005, this was increased to 392mt, but trap fishing effort and catch were very low during 2005-2008 due to poor market conditions.

METHODS AND MATERIALS

TRAFFIC LIGHT INDICATORS

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, respectively, of the data in the series, unless an increase was considered bad for stock health, in which case these were reversed. Note that for commercial catch per unit effort series, the "polarity" of the default boundary should be considered with other indicators for certain years. Clearly, the increase in the 2 commercial CPUE series, coupled with increased aggregation and decreased survey abundance, indicated that the increase in the 2 commercial CPUE series in the most recent years should be viewed as a negative development. However, traffic lights were not changed from the default in this document. Similarly, the record high counts experienced by fishers in 2005 are negative in the context of the fishing impact characteristic because they are indicative of growth overfishing, but if considered within the production characteristic, they are positive because they substantiate fishery independent (survey) results of exceptional 4 year old shrimp abundance.

ABUNDANCE

<u>Research Vessel Abundance Index</u>

A 14th industry-funded trawl survey, incorporating a mixed stratified random - fixed station design, was conducted in June 2008. Survey design and station selection methods were similar to previous surveys completed in 1995-2007: fishing depths >100 fathoms, randomly selected stations in strata 13 and 15; fixed stations in strata 14 due to the difficulty in finding trawlable bottom; 30 minute tow length; and 2.5 knot vessel speed. Stations in strata 17 (inshore) were selected randomly at all depths having a bottom type identified as LaHave clay on Atlantic Geosciences Centre surficial geology maps. The 2008 survey was again completed by *MV All Seven* (7th year for this vessel/crew) fishing the standard survey trawl (Gourock #1126 2-bridle shrimp trawl and #9 Bison doors). Catches were standardised to the target distance travelled at 2.5 knots for 30 min (1.25nm). Biomass/population estimates and bootstrapped confidence intervals (Smith 1997) were calculated using the product of the average measured wing spread (17.4m) of the survey trawl and the distance travelled during a standard survey set (1.25nm) as the standard unit area swept by each set (Halliday and Koeller 1981).

The co-operative DFO-industry series begun in 1995 used several different vessel-trawl combinations requiring comparative fishing experiments in 1996 and 1997 (Koeller et al. 1997). In order to obtain a wider range of indicator values for this series, it was extended to include DFO surveys conducted in 1982-1988, a period of low abundance in contrast to the present period of high abundance. There were no comparative fishing experiments that allowed direct intercalibration of the 2 survey series, consequently, catch data were only adjusted by the difference in the wing spreads of the trawls used. Wing spreads were based on the performance specifications of the trawl used for the earlier series, and from actual measurements for the latter series. However, it is probable that the trawl used during the recent series was more efficient in catching shrimp than during the 1982-1988 series, consequently, the large differences in catch rates between the 2 series may be exaggerated and should be interpreted cautiously. Since the cod end mesh size in both series was the same (40mm) size selectivities of the 2 series were assumed to be the same.

NETMINDER during the 2008 Survey

Netminder sensors were in place and operational for all sets of the 2008 survey. Unfortunately data logging was not enabled and the electronic data unavailable for set-by-set adjustments of swept area. However, visual observations of the PC display indicated that the net was operating normally throughout the survey. As in some previous years where this data was unavailable, the long-term average measured wingspread (17.4m) was used.

Gulf Vessels Catch Per Unit Effort

A CPUE index for Gulf based vessels, which have the longest history in the fishery, is calculated as a simple unstandardised mean catch/hour fished for all vessels fishing in any given year. These are the largest vessels in the fleet and although the participating vessels (and fishing gear) have changed considerably, they have always been >65' in length, compared to the <65' Nova Scotia fleet. This is an important time series, because it spans periods of both high and low abundance of the stock. However, since fishing methods and gear have improved over the years, it is likely that the differences in CPUEs between the period of low abundance (pre-1993) and the recent high abundances are exaggerated and should be interpreted cautiously.

Commercial Trawler Standardised Catch Per Unit Effort

The standardised CPUE series for 1993-2008 uses data from April-July inclusive, the months when the bulk of the TAC is caught, for 17 vessels that have fished for at least 7 of the 15-year series. A multiple regression analysis was conducted with year, month, area, and vessel as categorical components. Predicted values and confidence limits for a reference vessel, month, and area were then calculated for each year according to Gavaris (1980). Data on catch rates were obtained from fishers' logs required from all participants and provided by DFO Maritimes Region Statistics Branch.

An increase in this and the preceding indicator does not necessarily indicate increasing stock abundance, especially when coupled with a decrease in the area fished (see commercial fishing area below) or a decrease in the dispersion of the stock (see research vessel coefficient of variation (CV) below).

Research Vessel Coefficient of Variation

A measure of dispersion was calculated from survey data as the simple coefficient of variation of all survey sets for each year, i.e. the standard deviation of all catches divided by the overall average weight caught. An increase in this statistic indicates increased aggregation of shrimp on the grounds.

Commercial Fishing Area

A measure of dispersion was also calculated from commercial data as the number of area units (1 minute squares) having an average catch of >250kg per hour. With catch rates continuing to increase but survey estimates decreasing, a decrease in this index would indicate a concentration of the remaining stock in smaller areas. Interpretations of changes in this index should also take into account changes in the area of other average catch rate categories (see Figure 5), indices of abundance, and the spatial distribution of effort.

PRODUCTION

Research Vessel Age 1 Abundance

The Age 2 abundance indicator discussed below is currently the only estimate of recruitment to the population that spans the current survey time series (1995-2008). However, these shrimp are not caught efficiently by the standard survey trawl. In 2002 this was addressed by attaching a small-meshed "belly-bag" on the footrope under the belly of the standard survey trawl during all regular June survey sets. Seven years of data are now available and the results were included in the traffic light analysis for the first time this year. Belly-bag catches of *P. borealis* were frozen and returned to the laboratory for analysis. In most cases the entire catch was frozen and processed, but some of the largest catches (<5/survey) were subsampled. Abundance of 1- year old shrimp was calculated by the swept area method as per the main trawl, except that wing spread was taken as 1m, the expected width of the belly-bag when fishing.

Research Vessel Age 2 Abundance

A random sample of 8 pounds of shrimp (approximately 300 individuals) was collected from the catch of each survey set and frozen for detailed analysis, i.e. carapace length, individual weight, sex and egg developmental stage. Survey population estimates (numbers) were determined by the swept area method using individual set length frequencies and weights caught, and a length-weight relationship. Survey population estimates by age group were then estimated by separating total population at length estimates from the swept area method into inferred age groups using modal analysis (MIX; MacDonald and Pitcher 1979).

Research Vessel Age 4 Abundance

Age 4 abundance is calculated as per Age 2 above, from survey population at length estimates (swept area) and modal analysis.

On the Scotian Shelf, most Age 4 shrimp are in their final year as males. This group represents shrimp that will breed as males during the survey year and will change sex the following year. Since females comprise most of the catch, the last-year males are a measure of recruitment to the fishery.

Research Vessel Spawning Stock Biomass (Females)

The spawning stock biomass, or total weight of females in the population, was calculated with the swept area method from the weight of females in each set, determined by identifying females and their lengths in the detailed sample, the total catch weight, and a length-weight relationship. This estimate includes shrimp that were in the transitional stage during the survey. On the Scotian Shelf, transitional shrimp are seldom found during the fall, i.e. all transitionals complete sex change during the summer and extrude eggs during the late summer.

A clear stock-recruitment relationship has not yet been described for the Scotian Shelf, although it has been for some other panda lid stocks, e.g. the Gulf of Maine, California-Oregon. On the Scotian Shelf, a large population increase began during the late 1980s when SSBs were about 4300mt, about 30% of those found in the late 1990s. It would, therefore, be prudent not to let the SSB decrease below 4300; however, the stock increase at these SSB levels occurred at specific favourable environmental conditions (cold water temperatures and decreasing natural mortality due to predation) and negligible fishing mortalities. Consequently, this SSB should be considered as the very lowest the stock should be allowed to decline. Coincidently, this is nearly identical to the default 0.33 percentile used as the red limit for all indicators, including SSB.

SSB by itself is not a measure of reproductive capacity. Since fecundity is directly related to size, it should be considered in conjunction with the average size at sex transition, maximum size, and amount of fishing during the ovigerous period. In addition, multiparous females tend not to spawn every year. An index of egg production is under development.

Size at Sex Transition (L_t)

Shrimp in transition from the male to the female are identified by the pleopod development method and their average size is calculated as overall weighted average from all sets in the survey.

Koeller et al. (2003b) and Koeller (2006) show that size at transition is related to growth rate. It is hypothesised that an increase in growth rate, due to density dependant effects or temperature increases (Koeller et al. 2000a), results in decreases in the size at transition, maximum size, and fecundity, followed by a population decline.

Maximum Size (L_{max})

Average annual maximum size is calculated as the average of the sample maximum sizes.

The ratio of size at sex transition to maximum size was hypothesised to be constant (invariant) at about 0.8-0.9 for all stocks of *P. borealis* (Charnov and Skúladóttir 2000). This rule was shown to apply to the Scotian Shelf (Koeller et al. 2003b, Koeller 2006). Consequently, maximum size attained in the population is another growth indicator, i.e. change in maximum size is probably indicative of a change in growth rate. The relationship between L_t or L_{max} to changes in growth rate is complex due to the influence of other factors including concurrent changes in longevity and natural mortality (e.g. slower growing shrimp tend to live longer).

Predation

A predation index is calculated as the mean catch/set of all major groundfish species (codes<1000) combined from the summer groundfish survey for strata which encompass the shrimp holes, i.e. strata 443-445 and 459.

This is considered an index of natural mortality. Groundfish abundance is negatively correlated with shrimp abundance on the Scotian Shelf and in most other shrimp fishing areas.

FISHING EFFECTS

Commercial Counts

Fishers determine the number of shrimp per pound (the “count”) in their catches soon after they are brought aboard in order to determine the price which they will obtain from buyers, and adjust fishing practices (especially location) accordingly. This information is of economic importance and is often conveyed to other fishers or buyers before landing, so care is usually taken in obtaining and recording it. The methodology used is basic (number of shrimp in a fixed volume, often a tobacco can, that weighs about 1 pound), but generally agrees with more rigorous methods used by buyers. The index used here is the simple arithmetic average of all counts reported in log books for the year.

This indicator is a measure of the ease or difficulty fishers are having in "making the count," i.e. getting the best price for their shrimp. An increase in the count could indicate that a) recruitment is good and there are so many small shrimp it is difficult to avoid them or b) the population of larger shrimp is declining, or a combination of a) and b). Moreover, an increase in this indicator can be considered good (increased recruitment) or bad (growth overfishing) depending on whether it is placed in the production or fishing effects characteristic. Consequently, this indicator must be considered with others including abundance indices of the different age categories. Note that counts also change considerably during the fishing season, usually starting relatively high, decreasing to a minimum in July, and increasing thereafter, probably due to size specific changes in vertical and\or geographic distribution associated with changes in day length.

Total Exploitation Index

An overall index of exploitation rate is calculated as the total catch weight divided by the RV biomass estimated using the swept area method.

The RV biomass estimate has been shown to be underestimated by as much as 25% because of lack of coverage in shallow areas surrounding the shrimp holes; consequently, the exploitation rate is probably overestimated. This indicator is, therefore, considered an index of exploitation. Since the survey uses a common commercial trawl with a Nordmore grid, its selectivity is similar to commercial gear. The biomass used to estimate exploitation can be considered an estimate of “fishable biomass.”

Female Exploitation Index

This is calculated as the estimated weight of females in the catch divided by the weight of females in the population from the survey, i.e. the spawning stock biomass. An industry-funded port sampling program that began in 1995 allows determination of the catch composition by developmental stage and size from detailed analyses as per survey samples. Samples were collected during the fishery in all areas from all fleet components including vessels <65’ length over all (LOA) landing mainly in Canso and vessels >65’ LOA landing mainly in Arichat. The number of samples per month and area was approximately allocated in proportion to weight caught. Catch at length was determined from a weighted length frequency and a length-weight relationship.

Female exploitation is of interest because the shrimp fishery is selective for the larger females. It can be considered one measure of the impact of fishing on the reproductive potential of the stock.

Proportion of Females in Catch

The proportion of females in the catch by weight to the total catch weight is calculated from commercial samples which identify females, lengths, and individual weights as per survey samples.

A decrease in this indicator could indicate a decrease in the number of larger shrimp in the population due to fishing removals and an increased reliance on smaller animals, i.e. possible growth overfishing and/or recruitment overfishing. It should be interpreted cautiously and in combination with other indicators, since it could also indicate good recruitment conditions and difficulty in avoiding young shrimp.

Average Size of Females in Catch

This indicator is calculated as the overall annual average size of females from port samples collected throughout the fishery.

A decrease in this indicator could indicate a decrease in the number of larger shrimp in the population due to fishing removals and an increased reliance on smaller animals, i.e. possible growth overfishing and/or recruitment overfishing.

Fishing during Ovigerous Period

This is calculated as the percent of the total catch caught during August-March, the usual period when females are carrying eggs.

Since most eggs are laid by a single age class (i.e. Age 5), enough females must escape the fishery to prevent recruitment overfishing. The fishery has generally concentrated in the non-ovigerous period with most of the catch taken during May-July, however, as TACs increased, an increasing amount of the catch has been taken during the ovigerous period. This indicator should be included with spawning stock biomass and size at transition when considering the population's overall reproductive capacity, since their negative effects are probably cumulative. For example, the minimum SSB of 4300 mentioned above would be considerably less in terms of effective reproductive capacity if most is taken before egg hatching.

ECOSYSTEM

Population Age-length Evenness

This indicator is based on the assumption that a population spread evenly across length or age classes is more resilient to environmental or fishing perturbations than one where the population is concentrated in fewer length or age classes. It is calculated from the survey population-at-length estimate as Shannon's equitability index, E_H, which is obtained from Shannon's diversity index, H. The latter is calculated from the proportion (p) of the population in each of the total number of length groups (S).

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

This indicator is placed under the ecosystem characteristic assuming that evenness is related to the population's robustness or resiliency to various perturbations within the ecosystem, but it could also have been placed under fishing effects, since fishing will remove the largest/oldest length/age classes, or production, since an even length/age distribution implies stable recruitment. On the other hand, this index will also respond to the passage of an exceptional year class through the population, which may not be a negative development if the abundance of other year classes remains relatively stable.

Research Vessel Bottom Temperatures

This index is calculated from July groundfish survey data as the mean bottom temperatures at depths >100m in sampling strata (443, 444, 445, and 459) on the eastern Scotian Shelf that encompass the shrimp grounds. Initially, bottom temperatures on these surveys were determined with expendable bathythermographs or reversing thermometers, but more recently (since 1995) they were obtained from Seabird CTD profiles. Shrimp survey bottom temperatures are determined throughout each shrimp survey set with a continuous temperature recorder (Vemco Ltd.) attached to the headline of the trawl. Trends in these data generally agree with groundfish survey data; however, the latter is used in the analysis because of the longer time series.

It is hypothesised that warmer water temperatures have a negative influence on shrimp populations because of the decreased fecundity associated with increased growth rates, decreased size at transition, and decreased maximum size as described above. Recent work also indicates that colder bottom temperatures increase egg incubation times resulting in later hatching times, which are closer to favourable spring growing conditions (warmer surface water and the spring phytoplankton bloom) (Koeller et al. 2009).

Spring Sea Surface Temperatures

Sea surface temperatures (SSTs) are calculated from satellite data as average temperatures within defined rectangles encompassing the shrimp holes. Negative correlations between SSTs and lagged population estimates are common for the southern *P. borealis* stocks, including the Scotian Shelf. This may be related to water-column stability and the match-mismatch of resulting phytoplankton bloom conditions with hatching times as hypothesised by Ouellet et al. (2007). Accordingly, SSTs used were averages for a period encompassing average hatching times on the Scotian Shelf (mid February to mid March).

Research Vessel Capelin Abundance

This is calculated as the average catch/tow in numbers from the July groundfish survey in strata 443-445 and 459.

Capelin are among the most common bycatch species, both in the Scotian Shelf shrimp fishery and the June shrimp survey. Here they have been shown to increase in abundance during cold periods, which are also favourable to shrimp, and so can be considered a sympatric species (e.g. Frank et al. 1994). Their presence can therefore be considered an indicator of conditions favourable to the production of shrimp.

Research Vessel Cod Recruitment

This is calculated as the average number of <30cm fish/tow from the July groundfish survey in strata 443-445 and 459.

Cod abundance is generally negatively correlated with shrimp abundance for most north Atlantic stocks, including the Scotian Shelf. This is probably partly due to large scale environmental influences, such as temperature, which appear to have opposite effects on cod and shrimp population dynamics, as well as a trophic effect of cod predation on shrimp. Restricting this indicator to juvenile cod may therefore decrease the influence of predation and have some predictive value for shrimp abundance.

<u>Research Vessel Greenland Halibut Recruitment</u>

This is calculated as the average number of <30cm fish/tow from the July groundfish survey in strata 443-445 and 459.

Greenland halibut is a cold water species whose abundance is often positively correlated to shrimp abundance. However, it should be noted that Greenland halibut are also known predators of shrimp, and so an increase in this indicator is both positive and negative. Restricting this indicator to juvenile halibut may decrease the influence of predation and have some predictive value for shrimp abundance.

<u>Research Vessel Snow Crab Recruitment</u>

This is the stratified random abundance index for pre-recruits calculated for the snow crab assessment from annual crab surveys in southeastern Nova Scotia. Like Greenland halibut and capelin, snow crab is a cold water species that is often positively correlated with shrimp abundance.

TRAFFIC LIGHT SUMMARY

Individual traffic light indicators were summarised using simple averaging. Each indicator is given a value according to its colour, i.e. green = 3, yellow = 2, and red = 1, and an average is calculated. This average is assigned a "summary colour" according to limits determined by the probability distribution of possible outcomes, i.e. the limits between red, yellow, and green are set so that each of the 3 summary colours has an equal probability of being assigned in a random set of individual indicator colours/values. The DFO Maritimes Regional Science Advisory Process (SAP) review committee has emphasised that the summary is difficult to interpret and should not be the primary consideration in the advice, because issues such as weighting of indicators and harvest rules associated with any particular summary have not been resolved.

BYCATCH

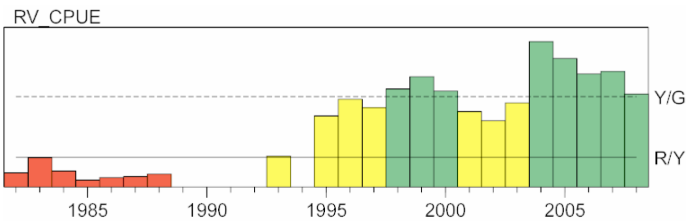
Bycatch information was obtained from the observer database to update the analysis of survey and observer bycatch data given in Koeller et al. (2006b). There were no observer trips in 2007; consequently, only 1 year of data (2008) was available in addition to that presented previously.

RESULTS AND DISCUSSION

Input data for the traffic light analysis are given in Table 3. These data are graphed in the uncaptioned figures immediately following the indicator headings in the section below.

ABUNDANCE

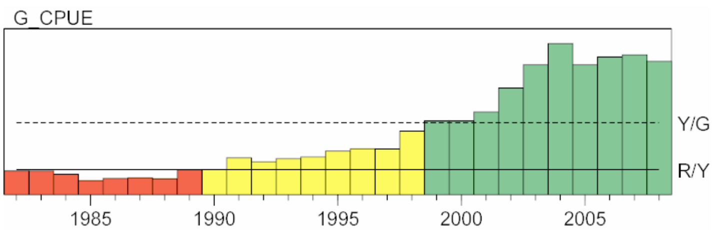
Research Vessel Abundance Index



The stratified survey estimate for 2008 (representing a biomass of 30,904mt using the swept area method) has decreased in 3 of the last 4 years. (Figure 2; tables 4, 6). Stratum 14 showed a large decrease for the second year in a row; however, unlike in 2007, this was not offset by increases in other areas – except for the inshore, which remained stable, other areas also decreased. Stratum 14 continues to contain the highest biomass; however, this margin has decreased significantly from the dominance shown since 2001. The decrease in Stratum 14 may be related to increased fishing pressure as fishers took advantage of the high abundances in this area – exploitation rates here have increased annually since 2004, with an all-time high of 26% in 2008 (Table 6). The distribution of survey catches during the last 2 years is shown in Figure 6. Despite the decreases in total biomass since 2004, it is still at average levels for the recent series, and well above the low levels of the 1980s. Note, however, that the net used in the earlier series was less efficient than the modern shrimp net used currently, and that the differences between these series is probably exaggerated.

Interpretation: The large 2001 year class, which has supported the fishery over the last few years, has reached the end of its life span. Biomass is decreasing rapidly as natural and fishing mortalities increase.

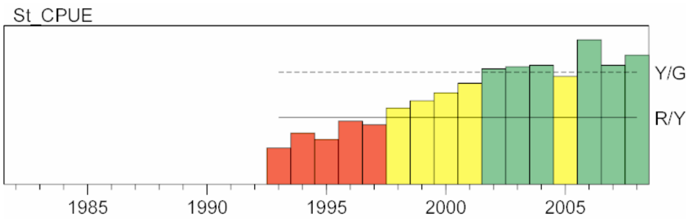
Gulf Vessels Catch Per Unit Effort



The unstandardised Gulf Vessel CPUE showed an increasing trend during the late 1980s to 2003, and has fluctuated at a high level since.

Interpretation: Catch rates by Gulf vessels continue to be excellent and there is no indication of a downturn.

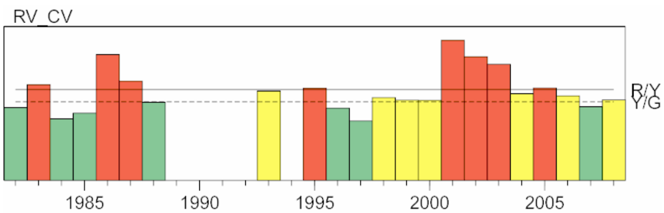
Commercial Trawler Standardised Catch Per Unit Effort



The standardised CPUE series followed a similar pattern to the Gulf series, showing an increasing trend during most of the series, with fluctuations at a high level since 2002. Spatial analyses (Figure 5) have previously shown that CPUEs are not always representative of abundance, but can be influenced by fleet reactions to changes in distribution and densities of shrimp concentrations associated with strong year classes. The spatial distribution of effort during the last 2 years is shown in Figure 7, and the seasonal (monthly) distribution of catch, effort and CPUEs in Figure 8. These did not change greatly in 2007 from previous years. There is evidence of a divergence between the survey index and commercial CPUE - this may be similar to that of 2001-2003, which was then attributed to the decline of the 1993-1995 year classes as they concentrated in smaller areas.

Interpretation: Catch rates continue to be excellent for all fleet sectors, but the divergence in survey and CPUE indices suggests that this may partly be due to changing distributions of the declining 2001 year class.

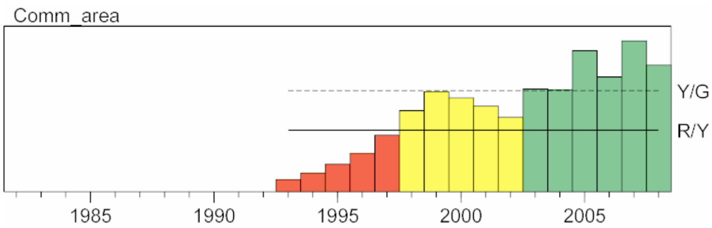
Research Vessel Coefficient of Variation



The survey measure of dispersion (overall CV) decreased has been relatively low since 2004, fluctuating without trend (figures 4, 6).

Interpretation: The relative stability of this indicator at a low value during the last few years appears to be associated with the currently high and evenly distributed abundance, mainly of the 2001 year class.

COMMERCIAL FISHING AREA

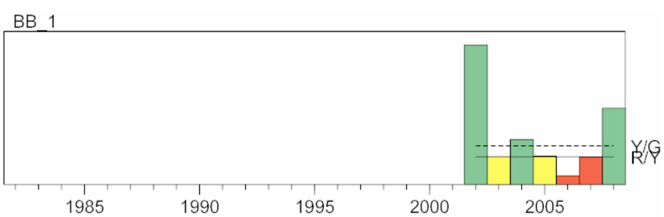


This indicator (area with commercial catch rates >250kg/hour) must be considered with the areas of other catch rates in order to interpret changing distribution and dispersion patterns of the resource. The >250kg/hour area increased since the beginning of the series until 1999, when it began to decrease, presumably because shrimp from several strong year classes formed dense concentrations in a smaller area during the biomass decrease. Consistent with this interpretation, the area with catch rates >150kg began to decrease in 1997, while the interval with the highest catch rates (>450) continued to increase (Figure 5, upper). Also, areas of intermediate catch rates (151-250, 251-350, and 351-450 units) peaked in sequence (Figure 5, lower) as the resource increased in density. The pattern changed from 2001-2002 as the area of highest concentration (>450) continued to increase, while all other areas decreased in size. These have remained relatively small since, while the area of highest concentration has continued to increase.

Interpretation: The changing spatial patterns observed with the decline of the previous group of large year classes (1993-1995) has not been observed to date with the 2001 year class, despite its apparent decline and the divergence of survey and commercial CPUE indicators.

PRODUCTION

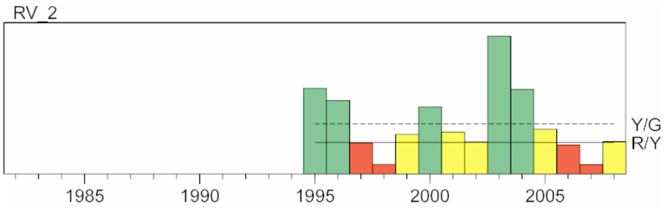
<u>Research Vessel Belly-bag Abundance at Age 1</u>



The belly-bag index shows considerable dynamic range despite only 7 years of data. It correctly predicted the strength of the 2001 year class in 2002, 2 years before it began to show up in commercial catches, and as many as 5 years before it was fully recruited to the fishery (Figure 9). The apparent strength of the 2007 year class as 1 year olds in the 2008 survey supports the hypothesis that a pulsed recruitment pattern has been established, similar to the snow crab stock in the same area but with a cycle of 6-7 years, about equal to the species life cycle. If the 2007 year class holds out as strong, this would make 3 such pulses since the modern fishery began, i.e. associated with the 1995, 2001, and 2007 year classes. The appearance of recruitment cycles of different lengths in 2 different invertebrate fisheries/species, suggests that the fishery may be partially involved in their creation.

Interpretation: The year classes following 2001 are considerably weaker and will not support the fishery at the high TACs of recent years. The 2007 year class appears to be relatively strong, although probably not as strong as the 2001 year class. The 2007 year class will not be fully recruited to the fishery until about 2012.

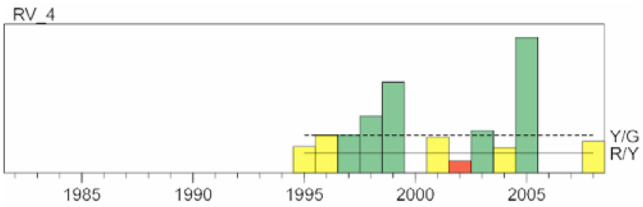
<u>Research Vessel Abundance at Age 2</u>



The index of 2 year old shrimp has decreased every year since the 2003 record value associated with the large 2001 year class (Table 5). The 2005 year class at Age 2 in the 2007 survey is the smallest on record. As confirmed by belly-bag samples, good recruitment associated mainly with the 2001 year class is being followed by lower recruitment, similar to what followed the good 1993-1995 year classes. This cycle of a good recruitment pulse followed by lower recruitment is a familiar pattern in established shrimp fisheries. Population modelling suggests that this may be a fishing effect, particularly when the cycle length approximates the life span. It also suggests lower population stability and the continued need for good monitoring and precaution. In general, this index supports the belly-bag results in characterizing the year classes following 2001 as weaker. (Table 5; figures 10, 11).

Interpretation: Recruitment following the pulse associated with the 2001 year class was relatively low. This may be a cyclical phenomenon associated with fishing, environmental forcing, or both, and lower population stability.

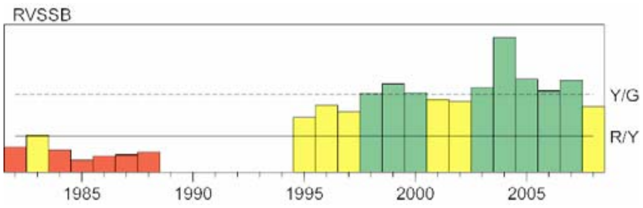
<u>Research Vessel Abundance at Age 4</u>



The abundance of Age 4 shrimp increased from below average in 2004 to the highest on record in 2005, reflecting the recruitment of the strong 2001 year class to what usually is the oldest male age group in the population. However, in 2006 and 2007, this age (2002-2003 year classes) was not differentiated from the large mode attributed mainly to the 2001 year class. A similar situation occurred in 1996, following the large 1995 year class (Table 5; Figure 11). Changes in this indicator reflect the apparent cyclical recruitment pattern seen with the Age 2 indicator above. This index was below average in 2008, indicating that there are relatively few 4 year old males to replace the females from the 2001 year class, and the remaining older males from the 2001 year class which have still not changed sex.

Interpretation: The abundance of 4 year old shrimp that are usually in their last year as males, and will provide the bulk of the catch in next 2+ years, is below average. With females from the 2001 year class experiencing increasing natural and fishing mortality, biomass will probably continue to decrease.

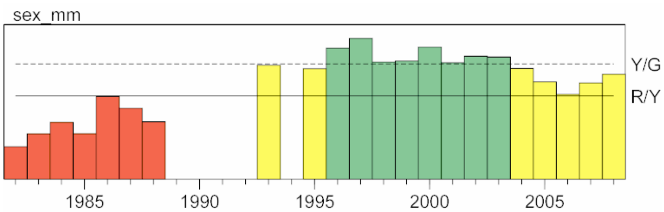
Research Vessel Spawning Stock Biomass (Females)



Spawning stock biomass decreased in 2008 and was below average for the first time in 6 years.

Interpretation: Spawning stock biomass is decreasing as natural and fishing mortality increases for females of the 2001 year class.

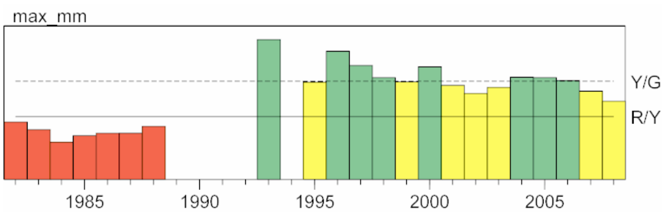
Average Size at Sex Transition (L_t)



This indicator decreased from 2002-2006, but has since increased. It remains significantly lower than the large sizes at sex change recorded in the mid to late 1990s, but not as low as the period of low abundance during the 1980s (Figure 13A).

Interpretation: The increase in size at sex transition during the last 2 years is due to delayed sex change of the large, slow-growing 2001 year class, which now has had an additional 2 years of growth as males.

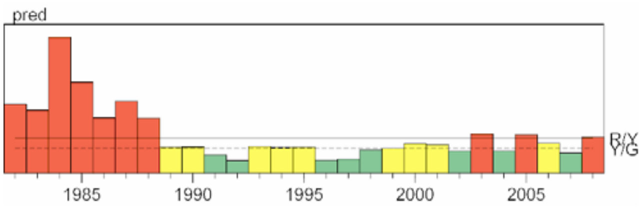
Average Maximum Size (L_{max})



Maximum size continued to decrease in all areas in 2008, but has not yet reached the low values of the 1980s (Figure 13B).

Interpretation: In general and over the long-term, maximum size tends to track size at transition. These 2 indicators are currently diverging, but should reconverge as the larger size at transition of the 2001 year class results in larger shrimp at maximum size. However, the longer term decrease in maximum size in all areas is of concern, since it will exacerbate the decreasing reproductive capacity of a declining spawning stock.

Predation

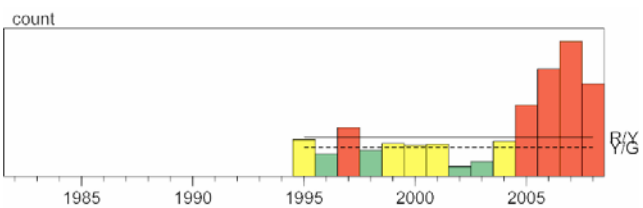


Groundfish abundances remains well below the high levels during the 1980s when the shrimp population was low. There have been only 3 red values for this indicator during the last 20 years; however, all these were within the last 6 years.

Interpretation: Natural mortality (M) due to predation remains well below the high values of the 1980s, but may have increased slightly during recent years.

FISHING IMPACTS

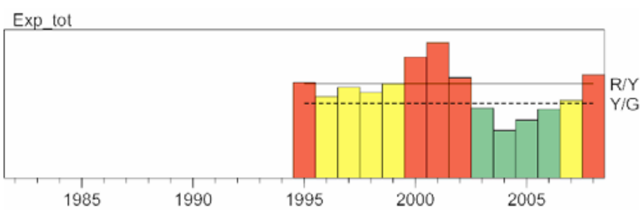
Commercial Counts



This fishery-derived indicator reflects the strong recruitment events evident in survey data (compare with ages 2 and 4 recruitment). Counts increased significantly in 2005, as the 2001 year class became more catchable. They have remained high since, which was not seen during the previous cycle. However, there was a decrease in 2008.

Interpretation: Fishers continue to have difficulty remaining below the counts which command the best prices from buyers. The sustained high counts relative to the previous cycle probably reflect, at least in part, the relative strength and slow growth of the 2001 year class. Growth overfishing of the 2001 year class seems less of a concern now that this year class is near the end of its life cycle. Counts should continue to decline as the remainder of the 2001 year class continues to grow, but the extent of this will be determined by recruitment, growth, and mortality rates.

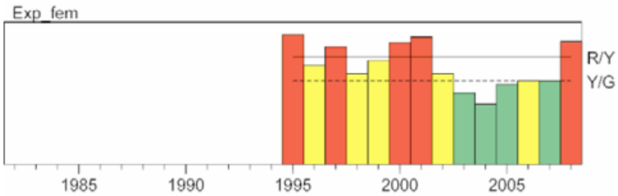
Exploitation Index



Total exploitation has increased annually since 2004. It increased again in 2008 due to the continued high TAC, increased catch, and decreased biomass. Exploitation is now above average, but below the high values reached during the previous cycle. However, it is now at an all time high for the heavily exploited SFA 14.

Interpretation: Increases in exploitation is contributing to biomass decreases, which is particularly evident in SFA 14.

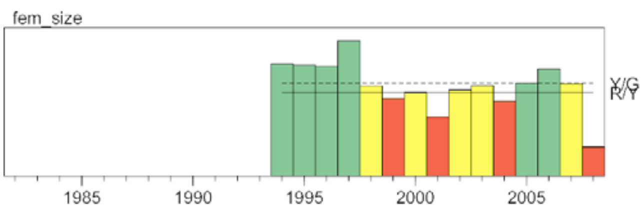
Female Exploitation Rate



From 2001-2007, female exploitation has been relatively stable and below the long-term average; however, it increased significantly in 2008. Length specific exploitation (Figure 15) indicates that the exploitation rate index of the largest females was relatively high.

Interpretation: Female exploitation rates have increased significantly as the SSB biomass has decreased. High exploitation rates of the largest females may be contributing to decreasing maximum sizes and, hence, reproductive capacity.

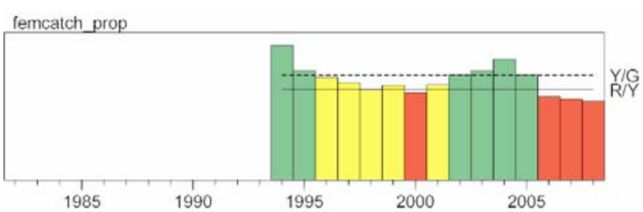
Mean Size of Females in Catch



The average size of females in the catch decreased to an all time low in 2008.

Interpretation: The average size of females in the catch has decreased as the larger animals were selectively removed from the population by the fishery. The large decrease in 2008 is of concern, since it suggests low abundance/unavailability of larger females.

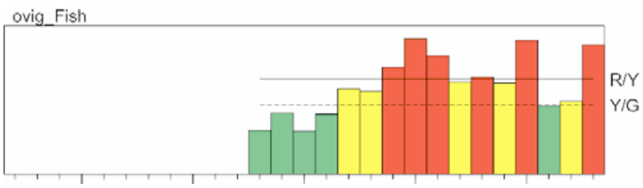
Proportion of Females in Catch



The proportion of females in the catch has been low since 2006.

Interpretation: The low proportion of females in recent years is partially due to the delayed sex change of the 2001 year class and increased catches of the large number of males in the population. Considering other indicators, in 2008 this may also have been partially due to decreasing numbers of females in the population.

Fishing during Ovigerous Period

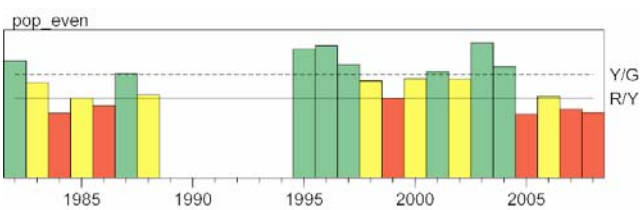


Provided that the projected catch is reached, fishing during the ovigerous period will increase significantly in 2008, partly due to the usual summer fishing hiatus and the longer time required to catch the higher TAC by a relatively small fleet of vessels. The monthly distribution of catches, effort, and catch rates are shown in Figure 8.

Interpretation: Fishing during the ovigerous period may have impacted population reproductive potential in 2008 by removing ovigerous females before their eggs have hatched.

ECOSYSTEM

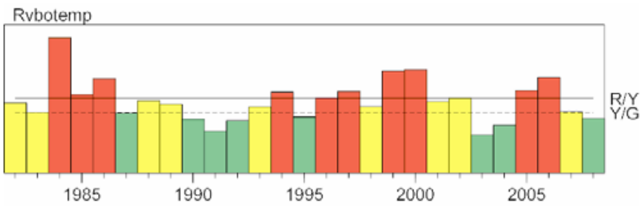
Population Age-length Evenness



Population evenness was high at the beginning of the survey series in 1995 when the fishery was relatively new (it first attained the TAC only in 1994). It declined in the late 1990s as the large 1994-1995 year classes dominated the population, and has been very low during the last 4 years as the 2001 year class dominated, with values comparable to those seen during the low population levels in the mid 1980s.

Interpretation: A large proportion of the population is currently concentrated in only 1 year class, an unstable situation leading to recruitment pulses, population fluctuations, and possible "boom-bust" fishery scenarios. The latest pulse, driven by the maturation of the large 2001 year class and revealed by the 2007 belly-bag results, appears to be underway. Its relative success will partially depend on the environmental conditions met by the larvae produced by the females of the 2001 year class.

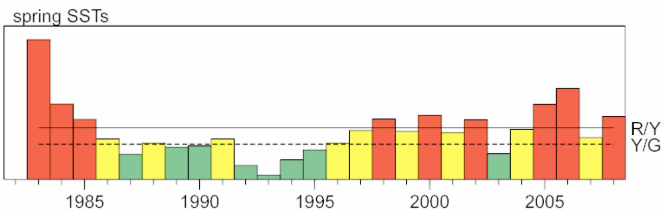
Research Vessel (Groundfish Survey) Bottom Temperatures



Bottom temperatures on the shrimp grounds were relatively high during the 1980s, when the shrimp population was low, and it was low during the population increase of the 1990s. Higher temperatures preceded the population downturn in 2001-2003. Except for 2005-2006, bottom temperatures have been relatively cool since 2002.

Interpretation: Colder temperatures in 2007-2008 may help larval survival by increasing the incubation period, bringing hatching times closer to the spring bloom and vernal warming of surface waters, conditions favourable for larval growth and survival.

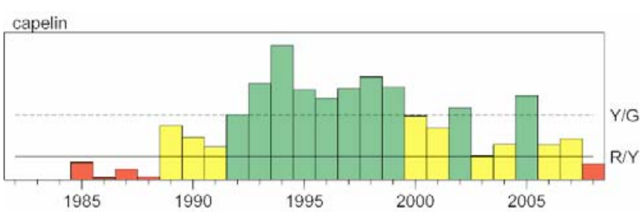
Spring Sea Surface Temperatures



At the southern limits of distribution (Gulf of Maine), surface temperatures are inversely related to shrimp abundance with a lag of 4-5 years. On the Scotian Shelf, the below average temperatures prevalent during the late 1980s and early 1990s may have facilitated the high abundances in the mid to late 1990s associated with the strong 1994-1995 year classes. However, at least one exceptional recruitment event occurred recently (2001) despite relatively high SSTs.

Interpretation: The warm water temperatures since the late 1990s may have contributed to the lower than average recruitments following the 2001 year class.

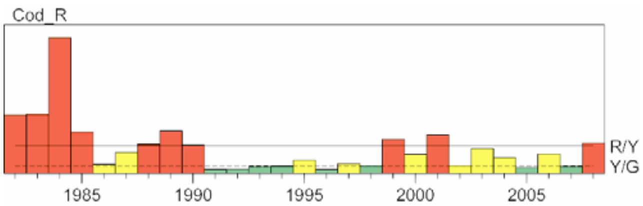
Research Vessel Capelin Abundance



During the last 9 years, capelin abundance has been lower on average than the relatively high values between 1993 to 1999. However, they remain considerably higher than during the period of low shrimp abundance during the 1980s.

Interpretation: Environmental/ecological conditions, which result in high production of capelin and shrimp, have not been as favourable since 2000, but they are better than during periods of poor shrimp and capelin production.

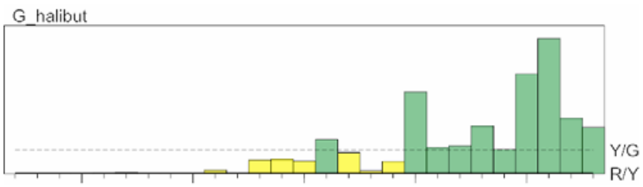
Cod Recruitment



Cod recruitment (<30cm) remains well below values seen in the 1980s.

Interpretation: Environmental conditions continue to be less favourable for cod and more favourable for shrimp. Natural mortality for shrimp due to cod predation is likely to remain low for some time.

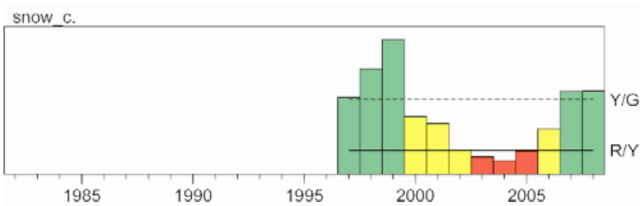
Greenland Halibut Recruitment



Greenland halibut <30cm continue to be abundant on the eastern Scotian Shelf, and appear to have increased significantly during the last 4 years. This species was rarely found during the warmer period of the 1980s when shrimp and capelin were also low in abundance. Note that the relationship of the shrimp resource to this indicator is ambivalent, since Greenland halibut are also known predators of shrimp.

Interpretation: Conditions still appear to be favourable for Greenland halibut and shrimp, but the increased abundance of halibut may be impacting on the shrimp population by increasing predation and natural mortality.

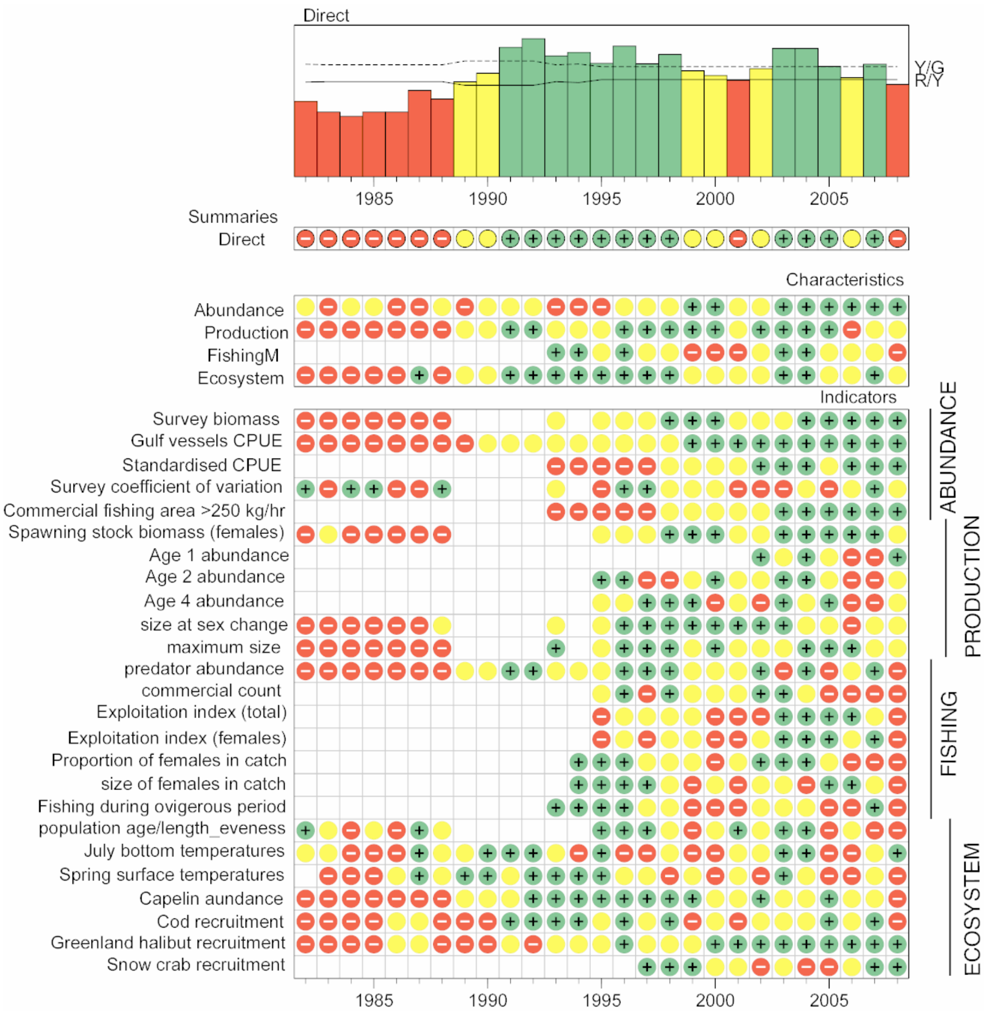
Snow Crab Recruitment



The male pre-recruit index from the snow crab survey off southern Cape Breton decreased from 1999 to 2004, but has been increasing since. Snow crab abundance, as with Greenland halibut and capelin, tend to track shrimp abundance in the long-term, however, snow crab have considerably longer longevities and population cycles.

Interpretation: The decrease in snow crab recruitment from 1999-2004 is beginning to reverse, suggesting that longer term environmental conditions for crab and shrimp are still favourable. The pulsed recruitment pattern seen in this and the shrimp populations may have similar causes. Since the cycles differ in length between these species, their cause is probably not entirely environmental, but may be driven, at least in part, by the fisheries.

TRAFFIC LIGHT SUMMARY



Note: The overall summary value is derived by a simple averaging process which does not account for complex interactions between indicators which may be occurring. Consequently, even the interpretation of individual indicators must be approached cautiously with regard to their relationship to stock health. Their placement within characteristics is also open to interpretation.

In 2008, the overall traffic light summary turned red for only the second time in 20 years. The previous red light (2002) was associated with decreasing biomasses as the strong 1993-1995 year classes passed through the population, analogous to the current situation but with the 2001 year class. However, the situation is more pressing now in that more of the population is concentrated in this one year class; consequently, subsequent biomass decreases will likely to be more rapid. Note that in the previous cycle, the red summary was derived from 1 red characteristic (fishing impacts) and 3 yellow ones. Currently, the fishing impact characteristic is also red and the production and ecosystem characteristics yellow, as previously; however, the abundance characteristic remains green. This is partially due to the continued good (green) commercial catch rates, which are not necessarily representative of abundance, and because the survey biomass estimate is still about average. With survey abundance expected to continue decreasing this characteristic will probably also turn yellow next year. Although the fishing impact characteristic was red at both instances when the overall summary was red, it is noteworthy that currently all indicators in this characteristic are red, a situation which has not occurred before for any characteristic.

BYCATCH

Bycatch information for the 2 observer trips, comprising 35 commercial fishing sets on 2 different vessels, is given in Table 7. Bycatch by weight represented 0.17% and 0.85% of the shrimp catch for the 2 trips, significantly less than the previous 11–year average of 2.17% for 1996-2006 (Koeller et al. 2006b). This difference may partly be due to differences in fishing gear/methods/areas associated with the larger offshore vessels observed in 2008, versus the mainly smaller inshore vessels in the previous analysis. It is noteworthy that a large vessel captain present during the Science Advisory Process in which the previous bycatch analysis was presented indicated that the reported bycatches were much larger than in his experience. Bycatch in 2008 was comprised mostly of redfish, capelin, witch flounder, American plaice, snake blennies, and alligatorfish (possibly misidentified sea pouchers (Lepdogonus decagonus) commonly caught during the survey. Apparently bycatches continue to be negligible for this fishery.

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Table 1. Total allowable catches (TACs; trawls) and catches (trawls and traps) from the eastern Scotian Shelf shrimp fishery 1980-2008.

	TAC		Catch					
	Trawl	Trap	Trawl SFA				Trap	
Year			13	14	15	Total		Total
1980	5021		491	133	360	984		984
1981	-		418	26	10	454		454
1982	4200		316	52	201	569		569
1983	5800		483	15	512	1010		1010
1984	5700		600	10	318	928		928
1985	5560		118	-	15	133		133
1986	3800		126	-	-	126		126
1987	2140		148	4	-	152		152
1988	2580		75	6	1	82		82
1989	2580		91	2	-	93		93
1990	2580		90	14	-	104		104
[1]**1991**	2580		81	586	140	804		804
1992	2580		63	1181	606	1850		1850
[2]**1993**	2650		431	1279	317	2044		2044
[3]**1994**	3100		8	2656	410	3074		3074
1995	3170		168	2265	715	3148	27	3175
1996	3170		55	2299	817	3171	187	3358
1997	3600		570	2422	583	3574	222	3797
1998	3800		562	2014	1223	3800	131	3931
1999	4800	200	717	1521	2464	4702	149	4851
2000	5300	200	473	1822	2940	5235	201	5436
2001	4700	300	692	1298	2515	4505	263	4768
2002	2700	300	261	1553	885	2699	244	2943
2003	2700	300	612	1623	373	2608	157	2765
2004	3300	200	2041	755	376	3172	96	3268
2005	4608	392	1190	1392	1054	3636	9	3645
2006	4608	392	846	1997	1111	3954	32	3986
2007	4820	200	267	2633	1678	4578	4	4582
[4]**2008**	4900	100	231	3141	1128	4496	4	4500

[1] Nordmore separator grate introduced.
[2] Overall TAC not caught because TAC for Shrimp Fishing Area (SFA) 14 and 15 was exceeded.
[3] Individual SFA TACs combined.
[4] Preliminary to October 23, a projected catch of 4500mt was used to calculate exploitation rates, etc.

Table 2. Number of active vessels and total licences (in brackets) for the eastern Scotian Shelf shrimp fishery.

	Trap	Trawl	
Year	**S-F**[1]	**S-F**[2]	**Gulf**[3]
1995	4	24(23)	6(23)
1996	9(17)	21(24)	6(23)
1997	10(17)	18(23)	6(23)
1998	15(26)	17(28)[4]	10(23)[5]
1999	15(22)	19(28)[4]	10(23)[5]
2000	12(21)	18(32)[6]	10(23)[5]
2001	10(28)	18(28)[4]	10(23)[5]
2002	10(14)[7]	15(23)	6(23)
2003	9(14)	14(23)	5(23)
2004	6(14)	14(23)	6(23)
2005	2(14)	20(28)[8]	7(24)[9]
2006	5(14)	18(28)	7(24)
2007	2(14)	20(28)	7(24)
2008	1(14)	17(28)	7(24)

[1] All but one active trap licences are vessels <45'. They receive about 8% of the total allowable catch (TAC).
[2] These vessels receive about 70% of the TAC according to the management plan. Inactive NAFO 4X licences (15) not included in total.
[3] All licences 65-100' length over all (LOA). Eligibility to fish in Scotia-Fundy for about 23% of the TAC.
[4] Temporary allocation divided among 5 vessels.
[5] Temporary allocation divided among 4 vessels.
[6] Temporary allocation divided among 9 licences.
[7] Nine (9) licences were made permanent for 2002. The reduction in the total number of trap licences is due to cancellation of some non-active exploratory licences.
[8] Five (5) temporary licences made permanent.
[9] One (1) temporary licence made permanent.

Table 3. Input data for traffic light analysis.

Indicators	RV_CPUE	G_CPUE	St_CPUE	RV_CV	Comm_area	RVSSB	BB_1	RV_2	RV_4	sex_mm	max_mm	pred	count	Exp_tot	Exp_fem	femcatch_p	fem_size	ovig_Fish	pop_even	Rvbotemp	spring S	capelin	Cod_R	G_halibut	snow_c.
Action	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile	Pctile
Indirect																									
Rule	abundance (productior		==	red)	+																				
Direct																									
Overwts	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Maxwts	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Level_YG	0.66	0.66	0.66	0.33	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.33	0.33	0.33	0.33	0.66	0.66	0.33	0.66	0.33	0.33	0.66	0.33	0.66	0.66
Level_RY	0.33	0.33	0.33	0.66	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.66	0.66	0.66	0.66	0.33	0.33	0.66	0.33	0.66	0.66	0.33	0.66	0.33	0.33
Characteristics	Polarity																								
Abundance	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Production	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
FishingM	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0
Ecosystem	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1
Year																									
1982	34.5	128	NAN	65.54235	NAN	5040.7	NAN	NAN	NAN	21.71567	28.23559	179.29	NAN	NAN	NAN	NAN	NAN	NAN	0.808033	2.569091	NAN	0	2.3846	0	NAN
1983	71.5	127.7	NAN	86.01369	NAN	7323.1	NAN	NAN	NAN	22.10738	28.03171	164.05	NAN	NAN	NAN	NAN	NAN	NAN	0.773812	2.220909	2.7767	0	2.4151	0	NAN
1984	39	109.5	NAN	55.35139	NAN	4461	NAN	NAN	NAN	22.4624	27.6918	353.25	NAN	NAN	NAN	NAN	NAN	NAN	0.726571	4.954444	0.4767	0	5.569	0.060764	NAN
1985	17	75.4	NAN	60.47674	NAN	2417.7	NAN	NAN	NAN	22.11304	27.87091	236.37	NAN	NAN	NAN	NAN	NAN	NAN	0.750052	2.864444	-0.073	1.5542	1.7091	0.051471	NAN
1986	23	87.3	NAN	113.1413	NAN	3187.9	NAN	NAN	NAN	23.26099	27.93519	144.33	NAN	NAN	NAN	NAN	NAN	NAN	0.737725	3.451176	-0.773	0.1344	0.3683	0.085784	NAN
1987	25.5	90.7	NAN	89.20279	NAN	3424.5	NAN	NAN	NAN	22.89225	27.93636	187.04	NAN	NAN	NAN	NAN	NAN	NAN	0.788656	2.192857	-1.323	0.7652	0.8659	0.162037	NAN
1988	31.5	85.1	NAN	70.19206	NAN	4047	NAN	NAN	NAN	23.48061	28.11905	142.81	NAN	NAN	NAN	NAN	NAN	NAN	0.755248	2.645455	-0.923	0.1727	1.1947	0.057566	NAN
1989	NAN	133.4	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	66.581	NAN	NAN	NAN	NAN	NAN	NAN	NAN	2.517273	-1.073	18.377	1.7535	0	NAN
1990	NAN	134.5	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	67.326	NAN	NAN	NAN	NAN	NAN	NAN	NAN	1.973043	-1.023	9.2281	1.1632	0	NAN
1991	NAN	197.9	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	46.906	NAN	NAN	NAN	NAN	NAN	NAN	NAN	1.5375	-0.773	5.0715	0.1659	0.463853	NAN
1992	NAN	176.3	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	NAN	32.1	NAN	NAN	NAN	NAN	NAN	NAN	NAN	1.92069	-1.723	34.878	0.1691	0.084541	NAN
1993	75	193	190.6795	80.32	31	NAN	NAN	NAN	NAN	24.21605	30.4525	68.529	NAN	NAN	NAN	NAN	NAN	12.04614	NAN	2.4245	-2.073	193.36	0.2868	1.860152	NAN
1994	NAN	202.4	268.5581	NAN	48	NAN	NAN	NAN	NAN	NAN	NAN	66.166	NAN	NAN	NAN	0.8897967	26.04963	18.20267	NAN	2.976	-1.523	1563.9	0.2999	1.978313	NAN
1995	173	233.8	235.3282	82.84489	71	10912	NAN	358.5	875.92	24.1096	29.30833	66.52	55.92	13.4414	21.0351	0.7246029	26.02959	11.71402	0.826895	2.048214	-1.173	138.62	0.5358	1.735172	NAN
1996	213.5	245.9	331.9642	64.87851	99	13368	NAN	307.34	1247.6	24.7413	30.13929	32.558	54.47	11.498	16.1062	0.6800966	26.00976	16.37874	0.83186	2.738148	-0.923	87.534	0.1611	4.784847	NAN
1997	193	245.5	312.6476	53.4554	146	12101	NAN	128.85	1257.5	25.04026	29.75763	35.85	57.16	12.8003	19.0801	0.6428408	26.44078	23.23776	0.802049	2.996296	-0.473	146.64	0.396	2.906094	7038
1998	238.5	341	399.4216	74.41755	209	15707	NAN	39.89	1883.7	24.31246	29.43232	59.866	54.83	12.0783	14.728	0.5993151	25.67582	22.58465	0.776629	2.437083	-0.063	284.31	0.3068	0.41271	10182.4
1999	268.5	396	438.3603	72.1962	258	17607	NAN	165.63	3010.2	24.34782	29.31818	64.133	55.54	13.2447	16.8957	0.6255354	25.4562	28.92315	0.749408	3.743571	-0.504	159.96	1.3907	1.672614	12865.2
2000	233.5	396	479.4059	71.99518	242	15893	NAN	280.34	0	24.77178	29.72143	76.288	55.34	17.0605	19.7862	0.5782558	25.56624	36.70458	0.780617	3.79	0.0713	32.375	0.7869	11.43957	5282.8
2001	183.5	444	530.3369	126.0315	221	14476	NAN	174.9	1184.1	24.29452	29.22344	73.28	55.42	19.0507	20.7233	0.6310519	25.14556	32.11821	0.791542	2.618125	-0.552	15.994	1.5792	3.659454	5155
2002	161.4	572	606.0686	111.1492	192	14133	980	134.00	399.17	24.49541	29.00357	57.301	53.15	14.1673	14.7178	0.6973723	25.60901	25.13581	0.780038	2.737778	-0.091	49.85	0.316	3.875452	2265.1
2003	204.4155	697.085	617.3008	104.4793	265	16916	196	576.74	1411.1	24.46898	29.16607	100.65	53.65	9.82933	11.6276	0.7251795	25.68051	26.44734	0.836181	1.39	-1.302	2.698	1.0255	6.690889	2950.9
2004	353.7	810.906	624.3992	78.00419	263	26856	316	354.09	839.46	24.11824	29.44167	57.455	55.75	6.68748	9.7501	0.8013584	25.41152	25.47267	0.799207	1.751176	-0.432	5.9286	0.6415	3.436608	1221.2
2005	312.9	697	566.6572	83.01133	364	18587	198	187.02	4502.5	23.70755	29.43103	99.049	59.49	8.13811	12.9732	0.6635234	25.72156	29.51574	0.72517	3.027	0.4658	99.407	0.2488	13.99674	1613
2006	275.2	739	758.3782	75.86295	296	16289	61	121.3	0	23.3233	29.35167	77.4674	63.23	10.551	13.5553	0.5538905	25.9628	29.21892	0.752791	3.497	1.0301	5.7774	0.7953	18.92322	3491.5
2007	281	750	624.5059	66.3	389	18346	194	39	0	23.67049	29.0678	51.641	66.04	11.9226	12.296	0.4544831	25.71394	19.92334	0.732843	2.251356	-0.727	8.4538	0.2914	7.769687	6522.8
2008	226	716.3	677.9062	72.33881	327	13116	537	134.72	1046.2	23.93881	28.7963	92.81941	61.67	14.5614	19.93	0.5217479	24.63812	35.1988	0.727469	2.0	NAN	1.3621	1.2415	6.509835	7675.3

Table 4. Set statistics from DFO-industry survey AS0801 conducted by MV All Seven from 2-14 June 2008.

SET	SFA	DATE	LAT.	LONG.	SPEED (kts)	DIST. (n. m.)	DUR. (min)	WING. (m)	DEPTH (fth)	TEMP (^oC)	RAW CATCH	stand. catch (kg)	DENSITY (gm/m^2 or m.t./km2)
1	13	02-Jun-2008	4539°87.60	5906°70.20	2.4	1.16	30	17.4	125	3.1	17	18.6	0.5
2	13	02-Jun-2008	4535°20.20	5854°81.60	2.5	1.17	29	17.4	124	3.0	31	33.4	0.8
3	13	02-Jun-2008	4541°34.60	5854°33.60	2.3	1.11	29	17.4	132	3.1	40	44.9	1.1
4	13	02-Jun-2008	4543°12.20	5858°18.80	2.4	1.16	29	17.4	151	3.2	146	157.3	3.9
5	13	02-Jun-2008	4545°12.00	5847°41.20	2.4	1.13	29	17.4	147	3.5	168	186.0	4.6
6	13	02-Jun-2008	4547°62.80	5848°28.80	2.4	1.23	30	17.4	144	3.4	194	197.9	4.9
7	13	02-Jun-2008	4548°38.40	5843°97.40	2.4	1.20	30	17.4	145	3.4	207	215.9	5.4
8	13	02-Jun-2008	4551°30.60	5844°05.80	2.4	1.20	30	17.4	149	3.3	101	105.0	2.6
9	13	02-Jun-2008	4550°87.40	5833°76.80	2.4	1.17	30	17.4	145	3.4	73	78.8	2.0
10	13	03-Jun-2008	4549°77.00	5829°83.80	2.4	1.15	30	17.4	169	3.4	59	64.1	1.6
11	13	03-Jun-2008	4547°19.00	5834°03.20	2.4	1.16	29	17.4	154	3.5	174	187.6	4.7
12	13	03-Jun-2008	4543°93.20	5836°39.60	2.4	1.17	30	17.4	133	3.1	90	95.7	2.4
13	13	03-Jun-2008	4545°48.60	5822°93.20	2.3	1.11	29	17.4	203	2.7	21	23.6	0.6
14	13	03-Jun-2008	4534°46.40	5819°53.00	2.3	1.17	30	17.4	197	2.7	32	34.0	0.8
15	**13**	**03-Jun-2008**	**4524°52.80**	**5806°66.60**	**2.3**	**1.13**	**30**	**17.4**	**110**	**3.0**	**133**	**147.0**	**3.6**
16	14	04-Jun-2008	4455°70.40	5820°31.00	2.3	1.12	29	17.4	133	1.6	379	421.7	10.5
17	14	04-Jun-2008	4450°64.60	5831°45.80	2.4	1.13	29	17.4	135	1.5	181	200.3	5.0
18	14	04-Jun-2008	4447°71.20	5838°50.20	2.3	1.11	30	17.4	139	1.6	371	416.5	10.3
19	14	04-Jun-2008	4455°62.00	5843°32.00	2.4	1.13	29	17.4	145	1.4	181	200.4	5.0
20	14	04-Jun-2008	4447°85.60	5852°87.20	2.3	1.13	30	17.4	140	1.5	446	494.8	12.3
21	14	04-Jun-2008	4439°68.40	5901°80.00	2.4	1.16	30	17.4	119	1.3	476	512.7	12.7
22	14	04-Jun-2008	4450°89.80	5903°44.40	2.3	1.13	30	17.4	122	1.2	453	498.9	12.4
23	14	04-Jun-2008	4447°91.00	5911°17.80	2.5	1.22	30	17.4	129	1.3	367	377.6	9.4
24	14	05-Jun-2008	4450°32.20	5928°26.60	2.4	1.17	30	17.4	139	1.8	401	428.3	10.6
25	14	05-Jun-2008	4442°24.00	5934°15.20	2.3	1.17	31	17.4	117	2.1	386	413.0	10.3
26	14	05-Jun-2008	4442°79.80	5947°01.00	2.3	1.09	29	17.4	138	2.3	142	162.7	4.0
27	14	05-Jun-2008	4451°13.20	5942°55.80	2.3	1.15	30	17.4	119	1.9	224	244.1	6.1
28	14	05-Jun-2008	4442°03.00	5959°56.80	2.4	1.15	29	17.4	116	1.9	263	286.0	7.1
29	14	05-Jun-2008	4446°86.60	5958°59.60	2.3	1.11	29	17.4	130	1.9	156	176.1	4.4
30	14	05-Jun-2008	4453°53.80	5958°47.60	2.3	1.14	30	17.4	104	2.2	209	230.1	5.7
31	17	07-Jun-2008	4522°44.60	6100°99.60	2.4	1.18	30	17.4	58	1.1	51	54.5	1.4
32	17	07-Jun-2008	4528°02.00	6048°21.00	2.3	1.14	30	17.4	73	1.0	194	213.6	5.3
33	17	07-Jun-2008	4525°41.60	6039°94.80	2.3	1.12	29	17.4	80	1.2	353	394.0	9.8
34	17	07-Jun-2008	4529°42.40	6040°21.20	2.3	1.15	30	17.4	82	1.5	559	608.2	15.1
35	17	07-Jun-2008	4531°65.00	6028°50.60	2.2	1.11	30	17.4	91	1.5	721	814.5	20.2
36	17	07-Jun-2008	4535°19.00	6012°24.00	2.3	1.10	29	17.4	83	1.6	315	359.3	8.9
37	17	07-Jun-2008	4537°00.80	5959°29.80	2.3	1.12	29	17.4	94	1.9	110	122.1	3.0
38	17	10-Jun-2008	4532°56.80	6005°82.00	2.2	1.07	29	17.4	93	2.1	118	138.2	3.4
39	17	10-Jun-2008	4528°12.20	6005°96.40	2.4	1.10	28	17.4	90	2.1	281	318.6	7.9
40	17	10-Jun-2008	4525°30.80	5952°44.60	2.4	1.19	30	17.4	88	2.2	164	171.6	4.3
41	17	10-Jun-2008	4522°62.60	5958°60.20	2.4	1.12	28	17.4	93	2.1	215	239.6	5.9
42	17	10-Jun-2008	4519°56.00	6002°60.40	2.3	1.13	29	17.4	92	1.8	136	149.9	3.7
43	17	10-Jun-2008	4517°97.00	5956°61.60	2.5	1.16	29	17.4	85	2.0	88	95.1	2.4
44	17	10-Jun-2008	4513°50.00	5956°65.20	2.4	1.13	29	17.4	94	1.8	342	377.8	9.4
45	17	10-Jun-2008	4517°94.00	6016°60.80	2.3	1.09	29	17.4	121	1.6	120	137.7	3.4
46	15	12-Jun-2008	4443°17.60	6012°24.00	2.3	1.11	29	17.4	114	2.7	116	130.2	3.2
47	15	12-Jun-2008	4445°19.80	6021°01.80	2.3	1.12	29	17.4	114	1.7	123	137.0	3.4
48	15	12-Jun-2008	4448°66.00	6016°38.60	2.4	1.14	29	17.4	168	1.9	160	175.7	4.4
49	15	12-Jun-2008	4456°15.40	6022°15.20	2.3	1.13	29	17.4	124	1.6	223	246.6	6.1
50	15	12-Jun-2008	4449°73.40	6036°32.40	2.4	1.13	29	17.4	135	1.3	347	381.9	9.5
51	15	12-Jun-2008	4451°27.00	6040°29.60	2.3	1.13	29	17.4	140	1.2	242	268.2	6.7
52	15	12-Jun-2008	4445°34.20	6042°66.60	2.3	1.11	29	17.4	116	1.1	260	294.5	7.3
53	15	12-Jun-2008	4451°02.40	6046°00.80	2.2	1.03	29	17.4	144	1.1	89	108.0	2.7
54	15	12-Jun-2008	4455°06.80	6046°93.20	2.3	1.09	29	17.4	121	1.1	365	419.3	10.4
55	15	14-Jun-2008	4447°22.00	6053°88.60	2.6	1.08	29	17.4	138	1.1	46	52.8	1.3
56	15	14-Jun-2008	4450°35.20	6056°26.20	2.2	1.05	29	17.4	132	1.2	59	69.5	1.7
57	15	14-Jun-2008	4455°54.20	6057°54.60	2.4	1.17	29	17.4	110	1.2	97	103.4	2.6
58	15	14-Jun-2008	4453°30.40	6102°71.80	2.5	1.13	29	17.4	116	1.0	139	153.6	3.8
59	15	14-Jun-2008	4456°08.80	6105°46.60	2.3	1.08	29	17.4	105	1.0	67	78.0	1.9
60	15	14-Jun-2008	4458°41.60	6059°95.20	2.3	1.08	28	17.4	104	1.0	65	75.3	1.9

Table 5. 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	Average
1[4]								980	196	316	198	61	194	537	354.60
2	359	307	129	40	166	280	175	134	616	354	187	121	39	135	217.22
3	1046	276	1159	785	27	757	362	383	312	3118	652	880	506	185	746.34
4	876	1248	1257	1884	3010	0[3]	1184	399	1506	839	4502	0[3]	0[3]	1046	1613.89
5+	1702	2162	1539	2047	1952	3374	2110	1847	1727	3324	2224	5106	5506	3346	2711.88
TOTAL	3983	3993	4084	4755	5155	4412	3831	2763	4161	7636	7763	6169	6244	5249	4892.11
4+ males[1]	1369	1971	1578	2243	3235	1784	1771	938	1526	1549	4956	3916	2804	3528	2279.95
primiparous[2]	649	777	709	889	736	728	817	678	551	870	786	771	1739	906	823.10
multiparous	560	661	509	647	991	863	706	630	1188	1698	1183	480	1157	496	867.06
total females	1209	1438	1218	1535	1727	1591	1523	1308	1739	2568	1969	1251	2896	1402	1690.16

[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] Four (4) year olds of the 1996 and 2002, 2003 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.
[4] Belly-bag.

Table 6. Survey biomasses, commercial shrimp catches, and exploitation rates (catch/biomass) by survey strata (13-15, offshore part), and the inshore area (17), 1995-2008.

		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	mean
	13	4838	6838	5921	7188	9517	5866	4089	3114	7047	12184	9687	6129	7507	4144	6719
biomass	14	9068	12094	9472	11279	11040	9364	12325	12020	12035	20228	20035	18929	15957	12710	13325
	15	5300	6610	4737	4549	7807	7268	2073	2766	3751	4399	4378	5130	5345	4227	4881
	17	4415	3663	6221	9530	8262	9365	6541	2872	5296	11627	10333	7581	9622	9823	7511
	total	23621	29205	26351	32546	36626	31863	25028	20773	28130	48438	44433	37769	38431	30904	32437
	13	168	55	570	514	612	301	588	254	581	2003	1186	629	235	212	565
catch	14	2265	2299	2422	2012	1503	2009	1616	1553	1622	754	1441	1996	2518	3305	1951
	15	715	817	583	618	589	1609	1132	265	225	339	600	445	668	352	640
	17	0	0	0	787	2121	1498	1629	873	330	143	389	915	1161	631	748
	total	3148	3171	3575	3931	4825	5417	4965	2945	2758	3239	3616	3985	4582	4500	3904
	13	3.5	0.9	9.1	7.2	6.5	5.1	13.8	8.2	8.3	16.4	12.2	10.3	3.1	5.1	7.8
exploitation	14	25.2	20.1	24.1	17.8	13.7	21.5	12.6	12.9	13.5	3.7	7.2	10.5	15.8	26.0	16.1
	15	13.6	13.1	11.6	13.6	7.6	22.2	52.4	9.6	6.0	7.7	13.7	8.7	12.5	8.3	14.3
	17	0.0	0.0	0.0	8.3	25.8	16.1	23.9	30.4	6.2	1.2	3.8	12.1	12.1	6.4	10.4
	total	13.4	11.5	12.8	12.1	13.2	17.1	19.1	14.2	9.8	6.7	8.1	10.6	11.9	14.6	12.5

Table 7. Bycatch from all observer trips conducted in 2008.

Observed TRIP # 1																						
	SFA 14						SFA 15															
SPECIES	1	3	5	11	13	21	2	4	6	7	8	9	10	12	14	15	16	17	18	19	20	TOTAL
PANDALUS BOREALIS	3732	4141	3641	2253	2276	1060	4107	3573	3528	1903	3585	2437	1117	2503	3766	2948	969	2174	2471	1970	2756	56910
WITCH FLOUNDER	2	2	3	3	3	4	3	2	4	3	3	5	5	3	3	3	2	2	5	4	4	68
AMERICAN PLAICE	2	2	3	5	3	4	3	2	4	3	5	5	6	5	3	3	4	4	5	4	5	80
HERRING(ATLANTIC)												5										5
REDFISH UNSEPARATED	6	4	5	5	5	4	5	4	5	6	5	5	5	5	5	6	4	4	5	6	5	104
CAPELIN	4	6	5	5	5	4	5	4	5	6	6	5	6	5	8	6	4	4	5	8	6	112
PALE EELPOUT													3		2							5
SNAKE BLENNY	3	4	5	3	3	3	2	2	8	6	8	5	5	3	3	3	4	2	5	6	4	87
THORNY SKATE	2						2															4
ALLIGATORFISH			2		2			2	2	2		2		2		2			2	2		20
% BYCATCH	0.51%	0.43%	0.63%	0.92%	0.91%	1.76%	0.48%	0.45%	0.79%	1.35%	0.75%	1.30%	2.62%	0.91%	0.63%	0.77%	1.82%	0.73%	1.08%	1.50%	0.86%	0.85%

Observed TRIP # 2																	Grand Total	
	SFA 14						SFA 15										Kgs	%
SPECIES	1	3	5	7	9	11	13	2	4	6	8	10	12	14	15	TOTAL		
PANDALUS BOREALIS	993	3841	3569	3959	2907	2198	3462	3427	3545	2210	5140	4775	1571	3309	1500	46406	103316	99.4580%
WITCH FLOUNDER	1		1	1	1	1	1	1	1	1				1	1	11	79	0.0761%
AMERICAN PLAICE	1		1		1		1	1		1	1				1	8	88	0.0847%
HERRING(ATLANTIC)			2						2							4	9	0.0087%
REDFISH UNSEPARATED	1	1	1				1	1	1	1	1	1	1		1	11	115	0.1107%
CAPELIN	2	2	1	1	1	1	1	2	1	1	2	2	1	1	1	20	132	0.1271%
PALE EELPOUT																	5	0.0048%
SNAKE BLENNY																	87	0.0838%
THORNY SKATE		1	1	1	1			1		1				1		7	11	0.0106%
EELPOUTS (NS)	1	1		1			1			1	1			1		7	7	0.0067%
ALLIGATORFISH																	20	0.0193%
FOURBEARD ROCKLING	1	1						1			1	1		1		6	6	0.0058%
BLENNIIDAE SP.		1	1		1									1		4	4	0.0039%
% BYCATCH	0.70%	0.18%	0.22%	0.10%	0.17%	0.09%	0.14%	0.20%	0.14%	0.27%	0.12%	0.08%	0.13%	0.18%	0.27%	0.17%	103879	100.0000%

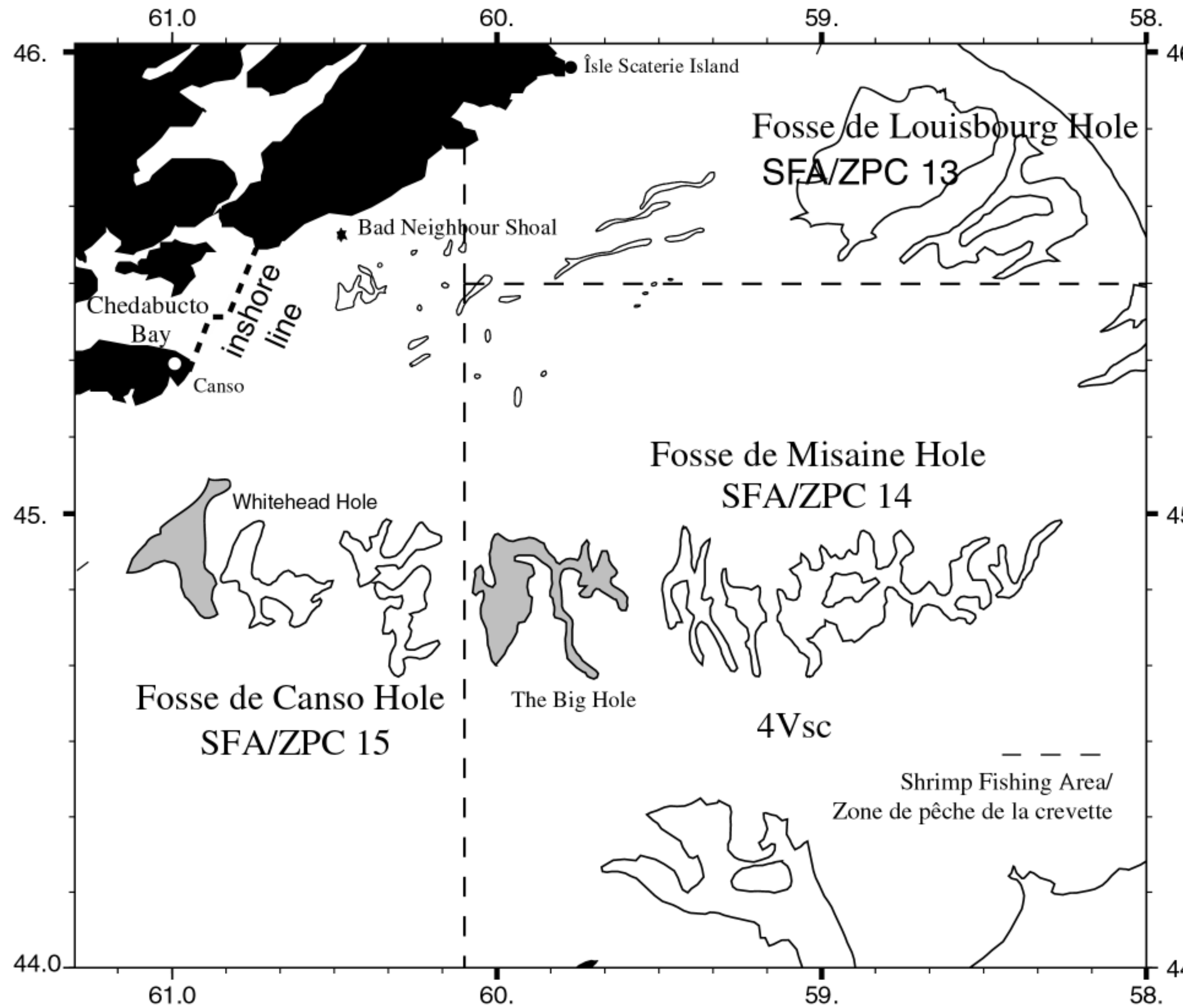

Figure 1. Shrimp Fishing Areas (SFAs) on the eastern Scotian Shelf. The inshore line prohibits trawlers from fishing inside Chedebucto Bay during the trapping season (fall to spring). Note the distinction between SFAs used to report catches and survey strata defined offshore (strata 13, 14, 15) by the 100 fathom contour (solid lines) and inshore (stratum 17) by the extent of LaHavre clay north of 45°10' and west of 59°20' on surficial geology maps).

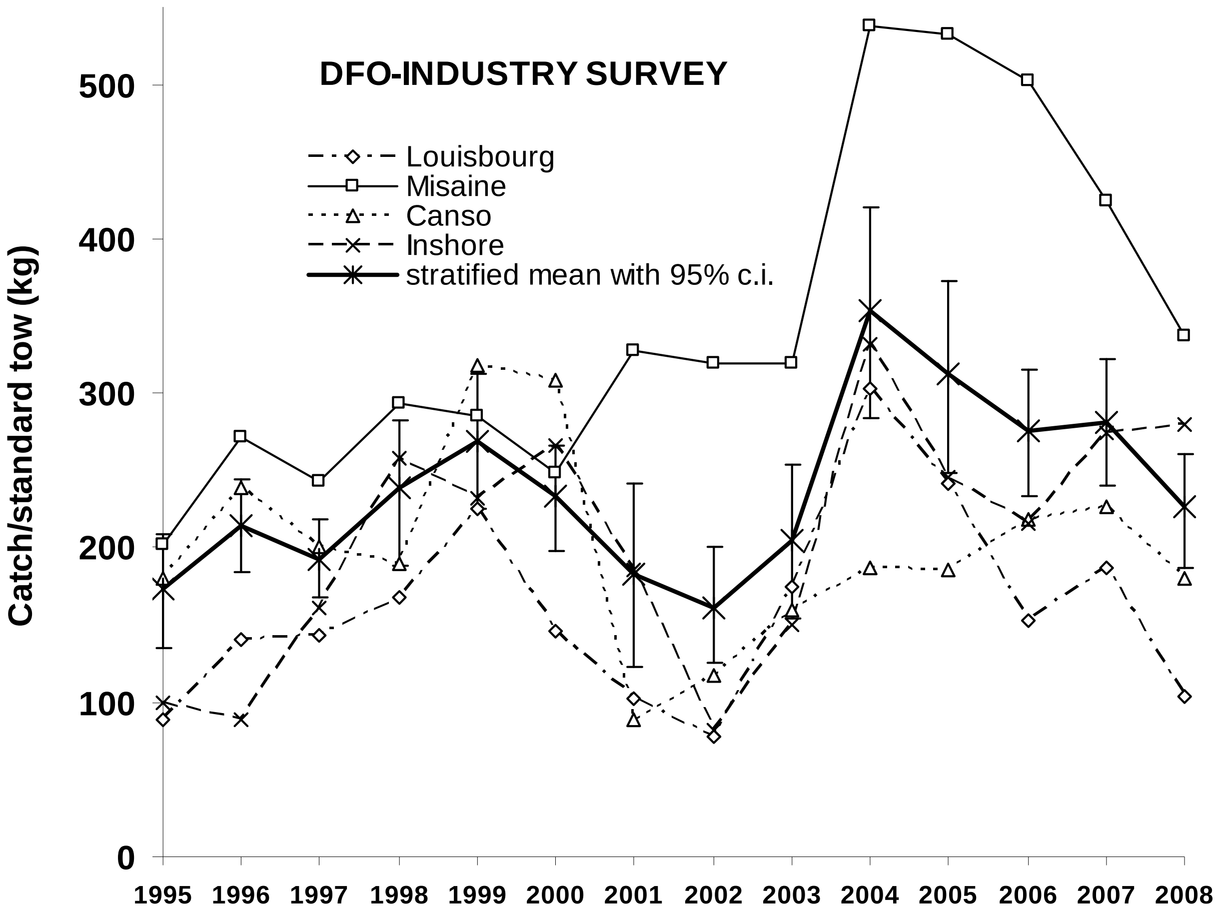

Figure 2. Stratified catch/standard tow for DFO-industry co-operative surveys, 1995-2008, and estimates for the individual strata, which approximately correspond to the main shrimp holes and Shrimp Fishing Areas (SFA). Sratum 13 - Louisbourg Hole and SFA 13; Stratum 14 - Misaine Holes and SFA 14; Stratum 15 - Canso Holes and the offshore part of SFA 15. The 'Inshore', or Stratum 17, is comprised of inshore parts of SFA 13-15.

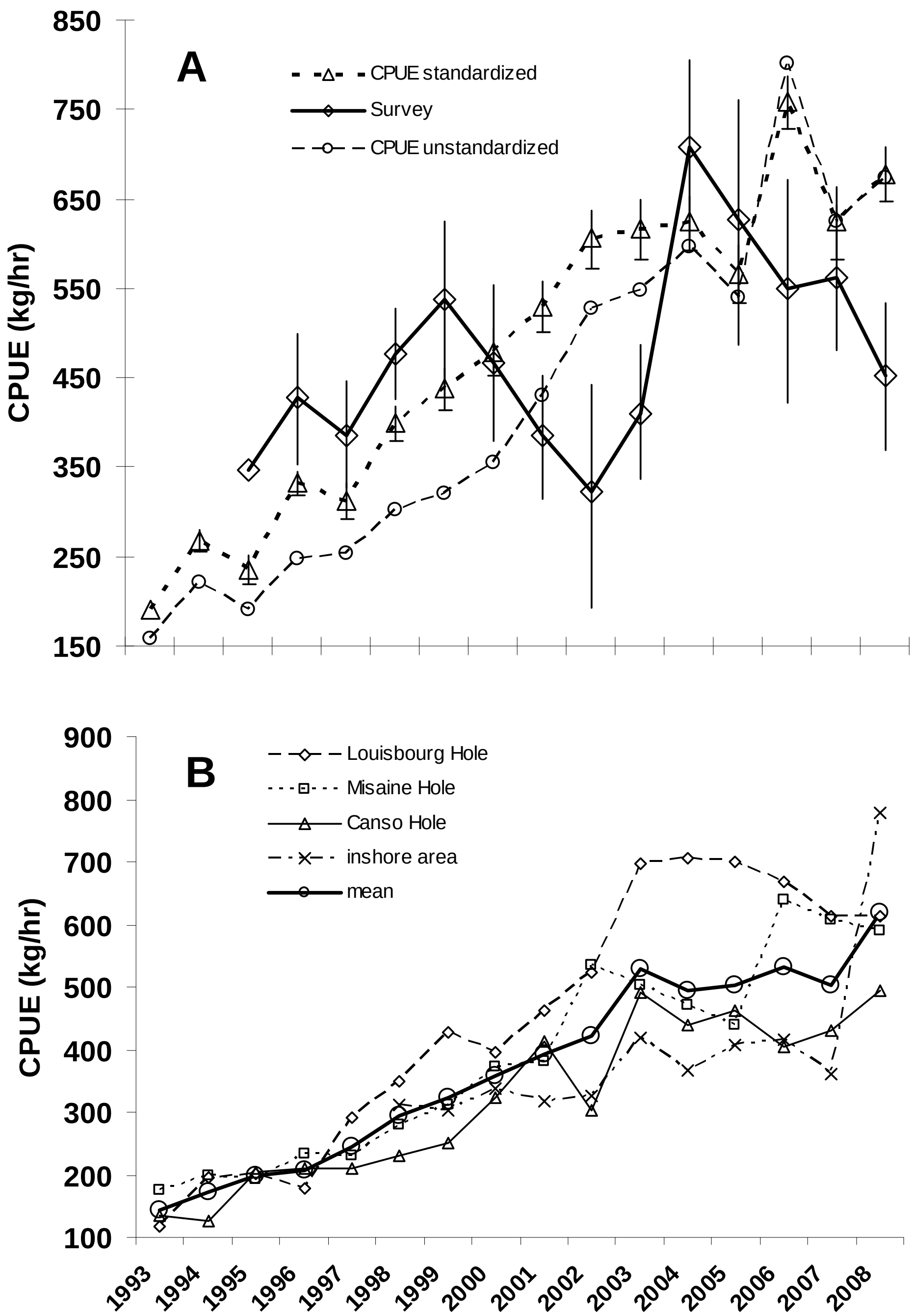

Figure 3. A - survey stratified estimate (solid line) and standardised catch per unit effort (CPUE) with 95% confidence intervals (dashed line), and B - unstandardised commercial CPUE for each fishing area. Note that Shrimp Fishing Area (SFA) 15 includes the inshore, but the latter is also shown separately since fishing began there in 1998.

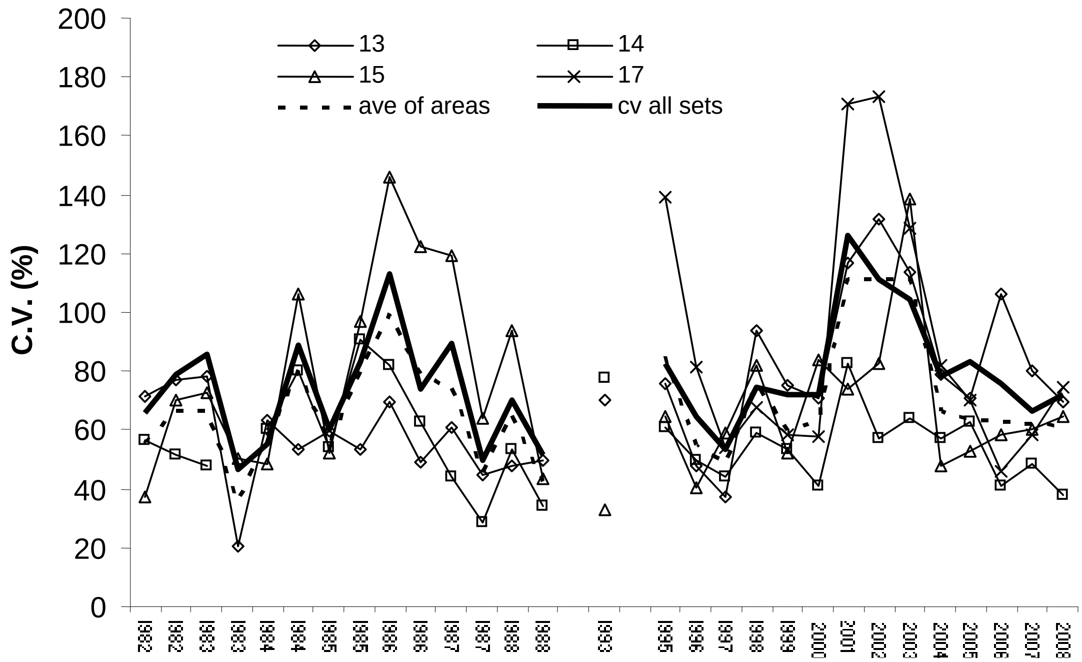

Figure 4. Coefficients of variation (CV) for shrimp survey strata 13, 14, 15, and 17. Note that the earlier survey series has 2 values per year, 1 for the spring and 1 for the fall survey.

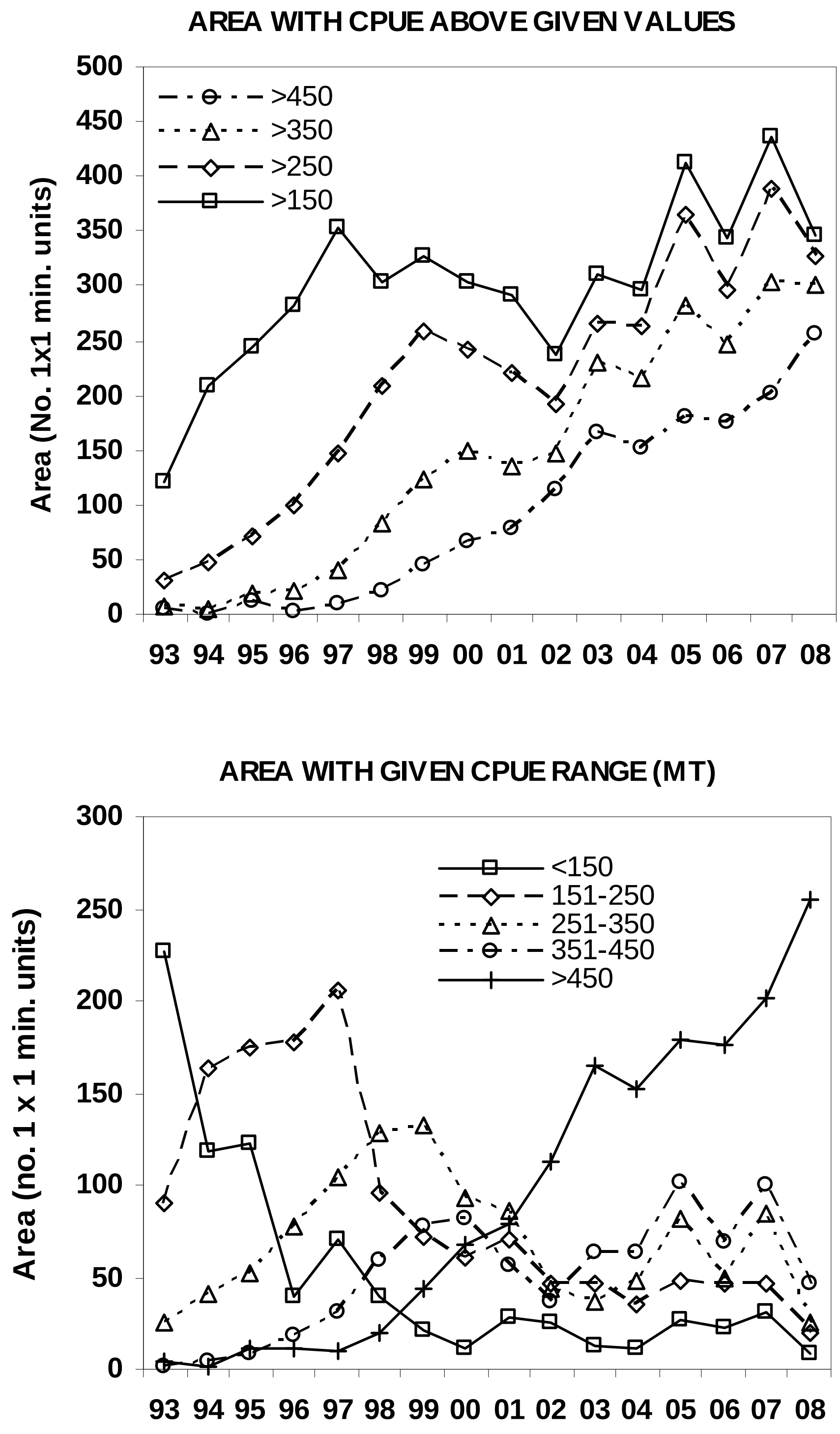

Figure 5. Number of 1 minute square unit areas fished by the shrimp fleet with mean catch rates above (top) and within (bottom) the values or ranges specified in the legend.

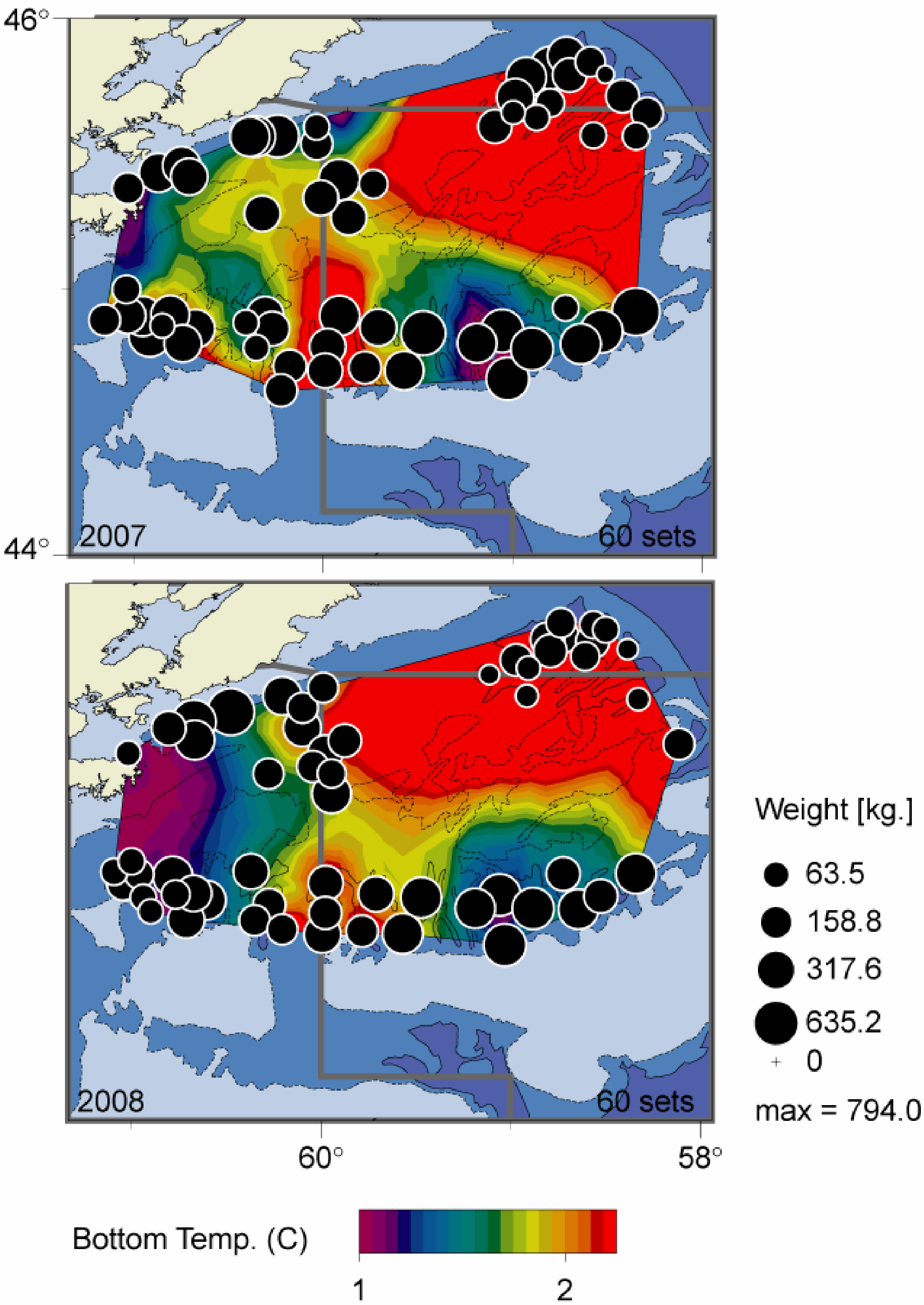

Figure 6. Distribution of catches (kg/standard 30 min tow) and bottom temperatures from DFO-industry surveys 2007-2008. See previous research documents for distributions prior to 2007.

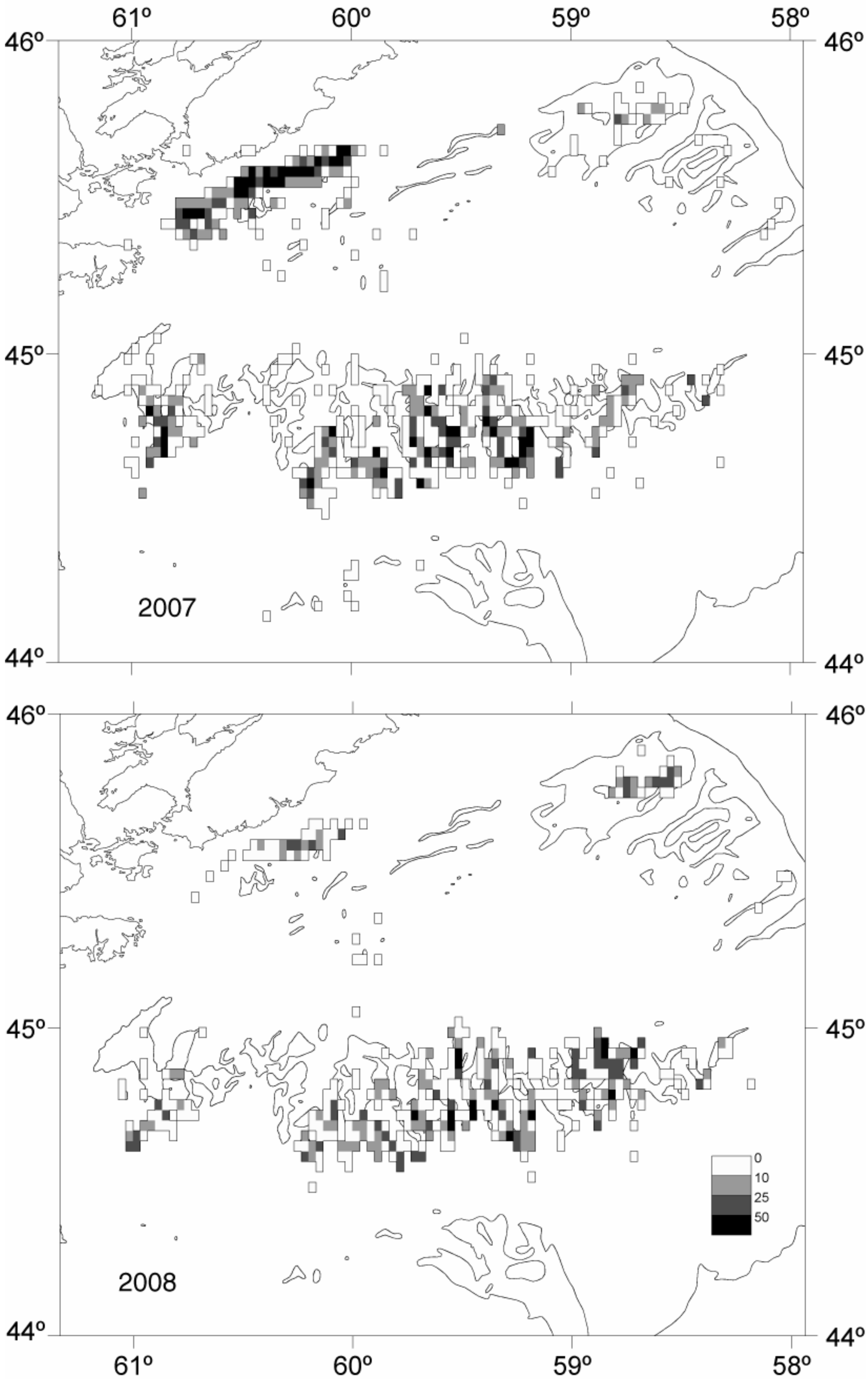

Figure 7. Annual effort by trawlers 2007-2008, cumulative by 1 minute squares. See previous research documents for effort distribution prior to 2007.

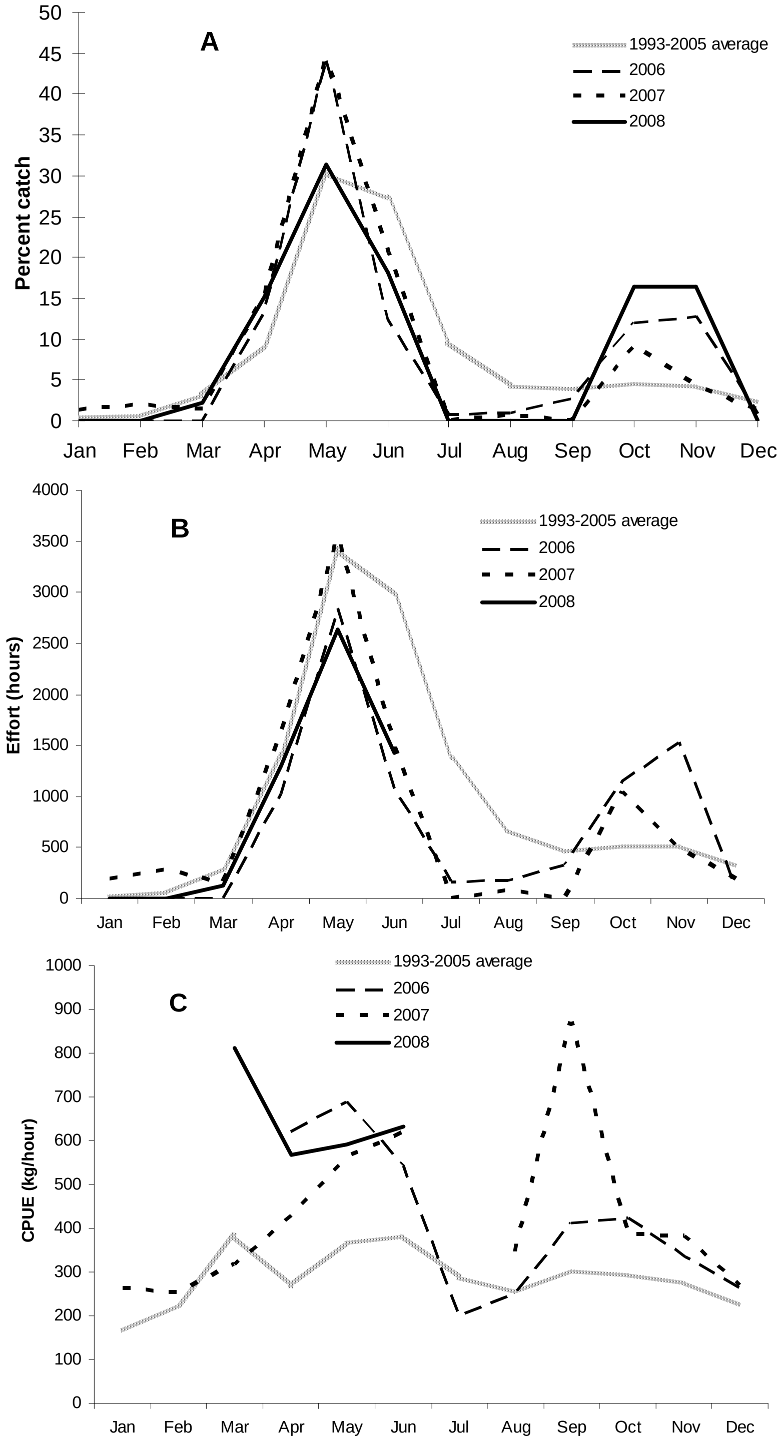

Figure 8. A - catches from the shrimp fishery as a percentage of the total catch, B - average catches per unit effort (CPUEs), and C - total effort, by month.

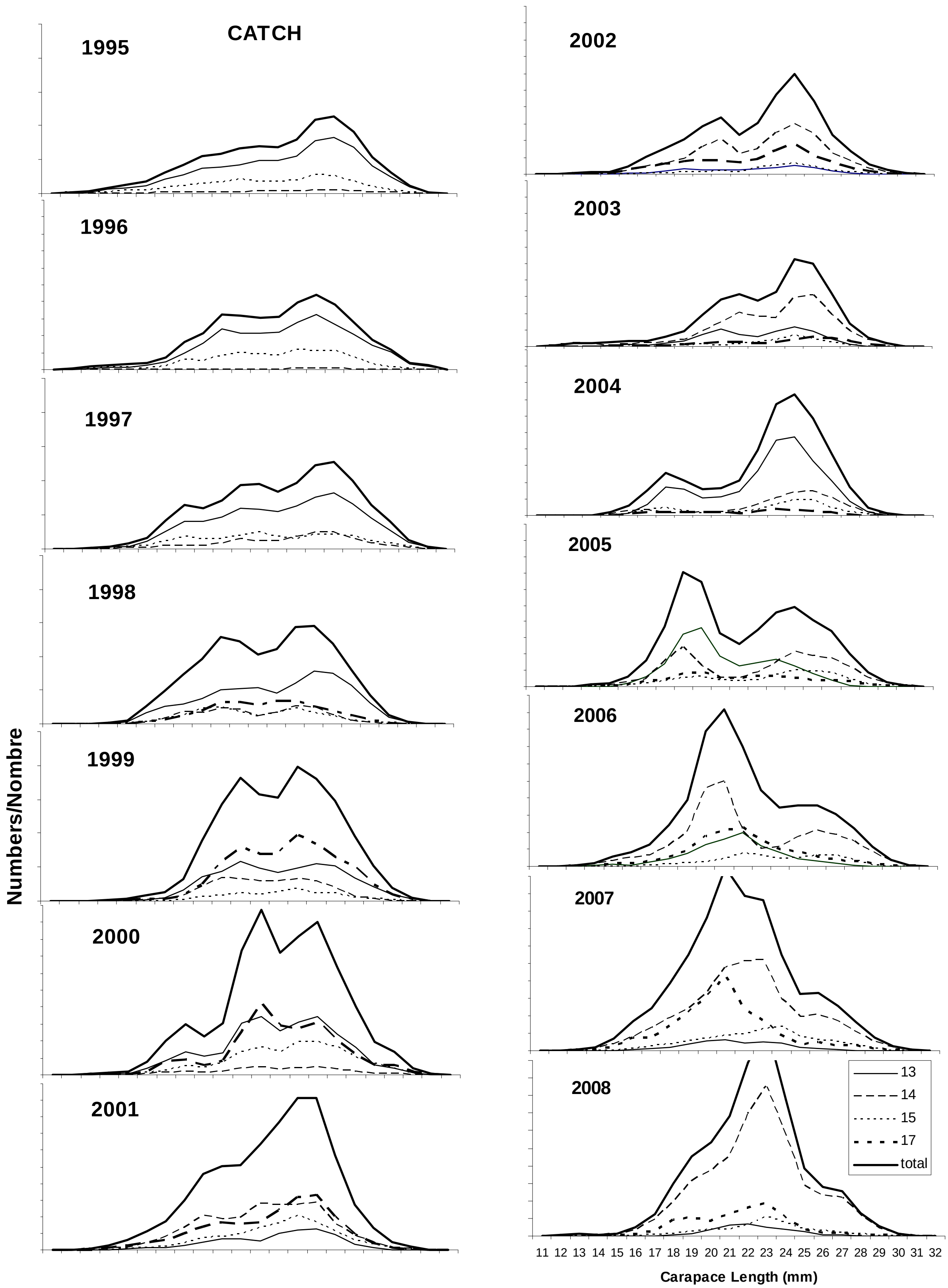

Figure 9. Catch at length from commercial sampling, 1995-2008.

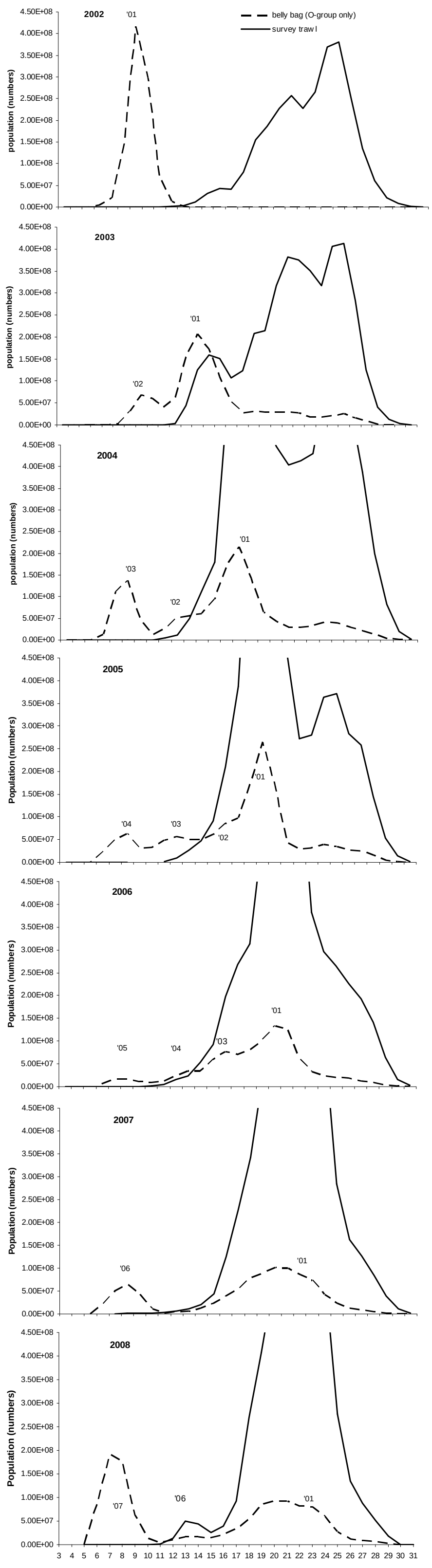

Figure 10. Population estimates from belly-bag and main trawl catches for the 2002-2008 survey. Note that the 2002 belly-bag estimate was made only for 1 year olds.

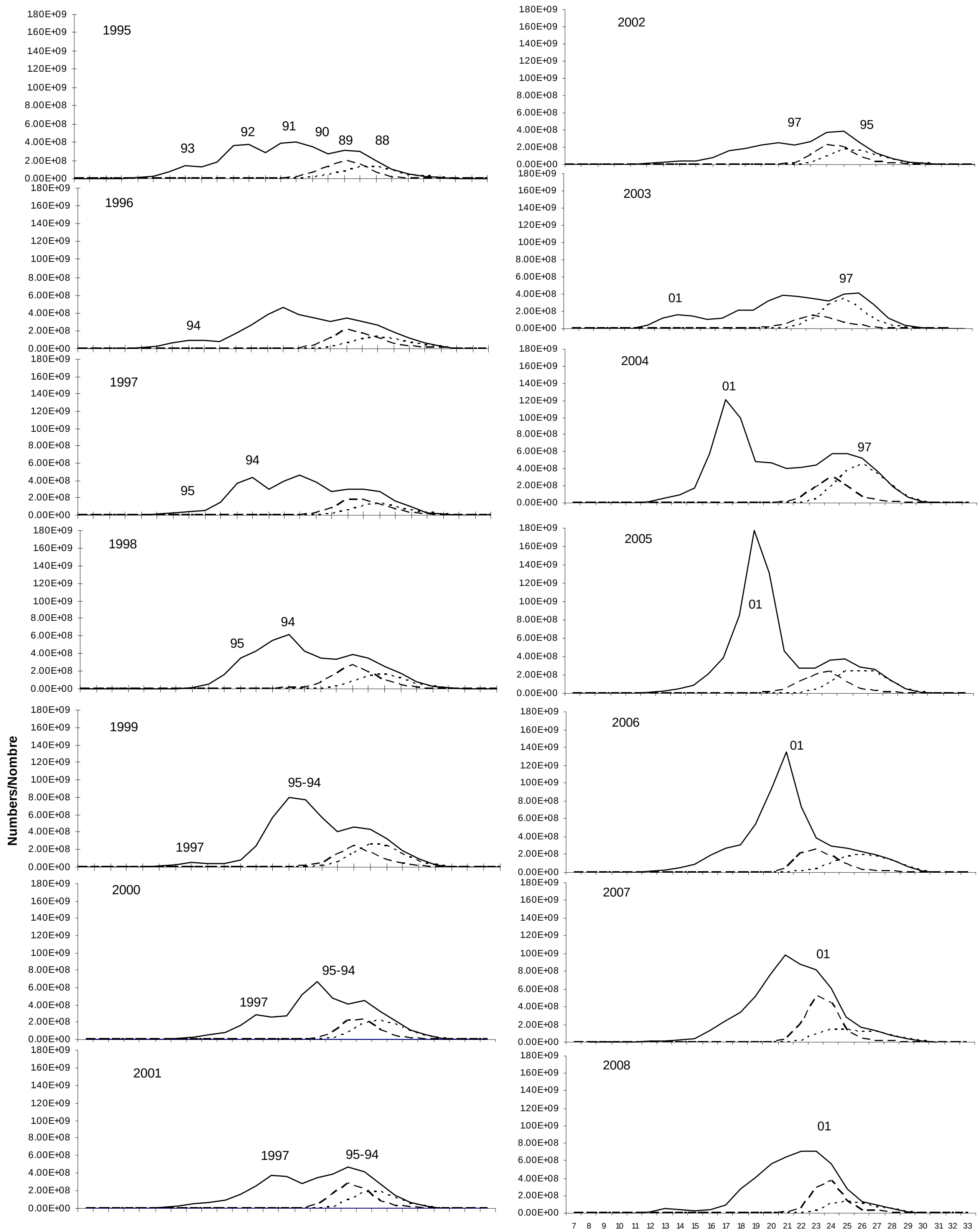

Figure 11. Population estimates at length from DFO-industry surveys 1995-2008. The heavy dotted line in each figure represents transitional and primiparous shrimp, and the stippled line represents multiparous shrimp.

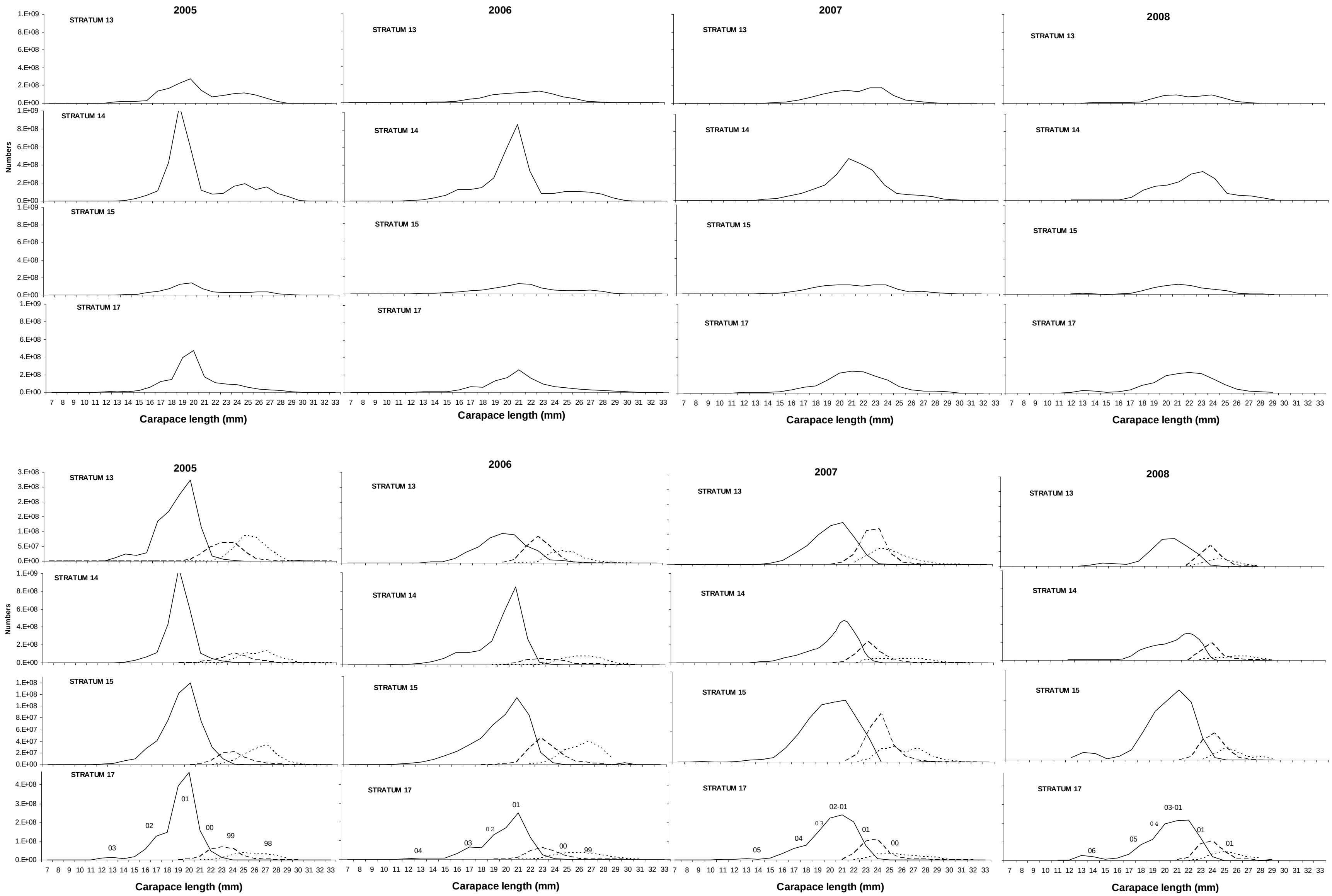

Figure 12. Population at length estimates by Shrimp Fishing Area (SFA) from the DFO-industry survey conducted in June, 2005 -2008. Top: all Y-axis scales same, total numbers only; bottom: scales same within SFAs, males (solid line), primiparous (dashed), and multiparous (dotted) females separated.

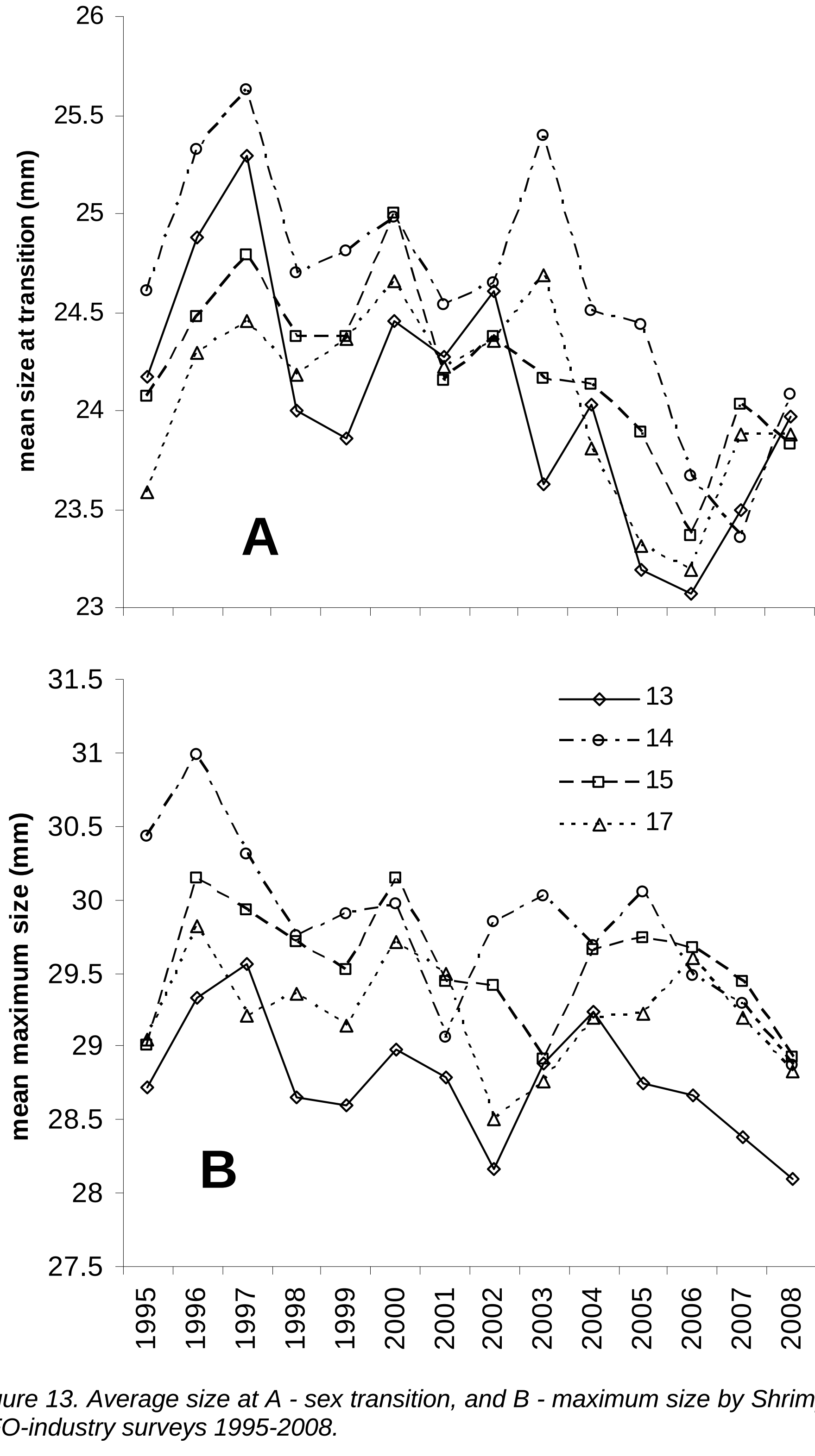

Figure 13. Average size at A - sex transition, and B - maximum size by Shrimp Fishing Area (SFA) for the DFO-industry surveys 1995-2008.

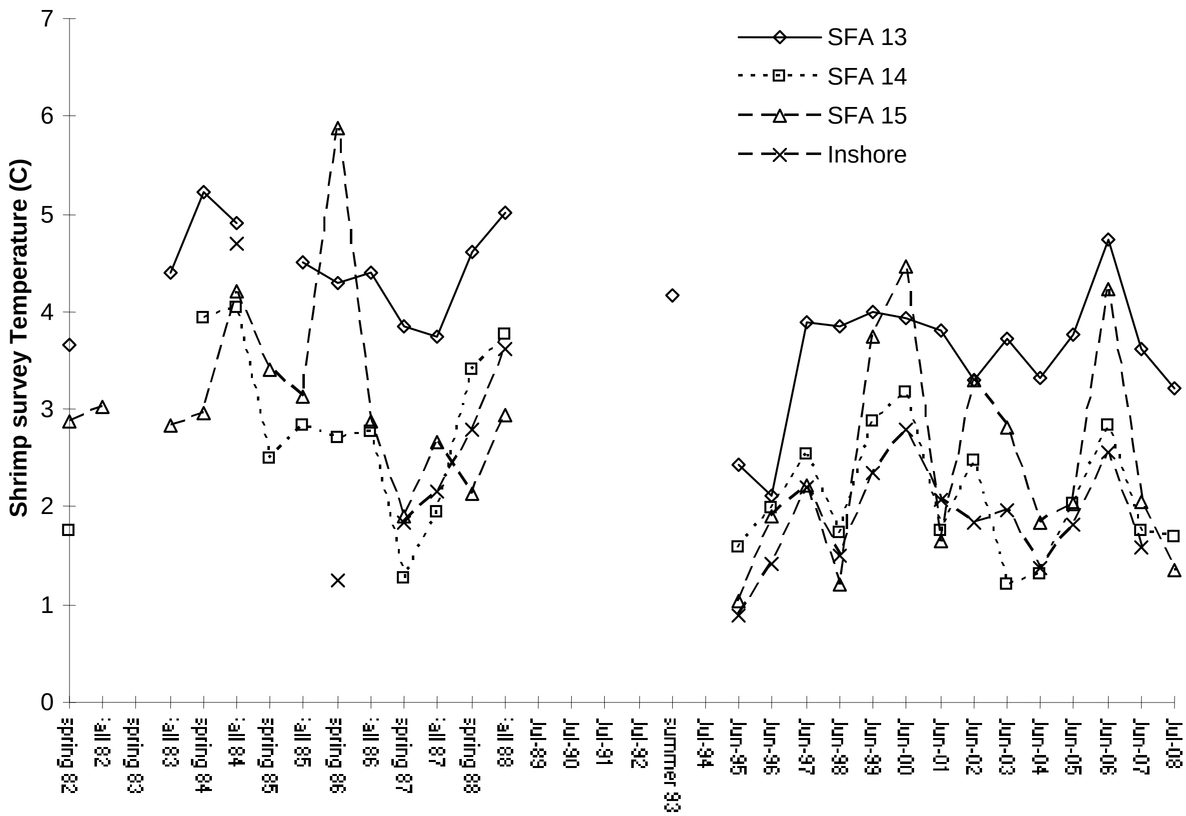

Figure 14. Mean bottom temperatures from shrimp surveys by Shrmip Fishing Area (SFA). Note that both spring and fall values were available from the earlier series (1982-1988), but only 1 survey (June) was conducted annually in the recent series.

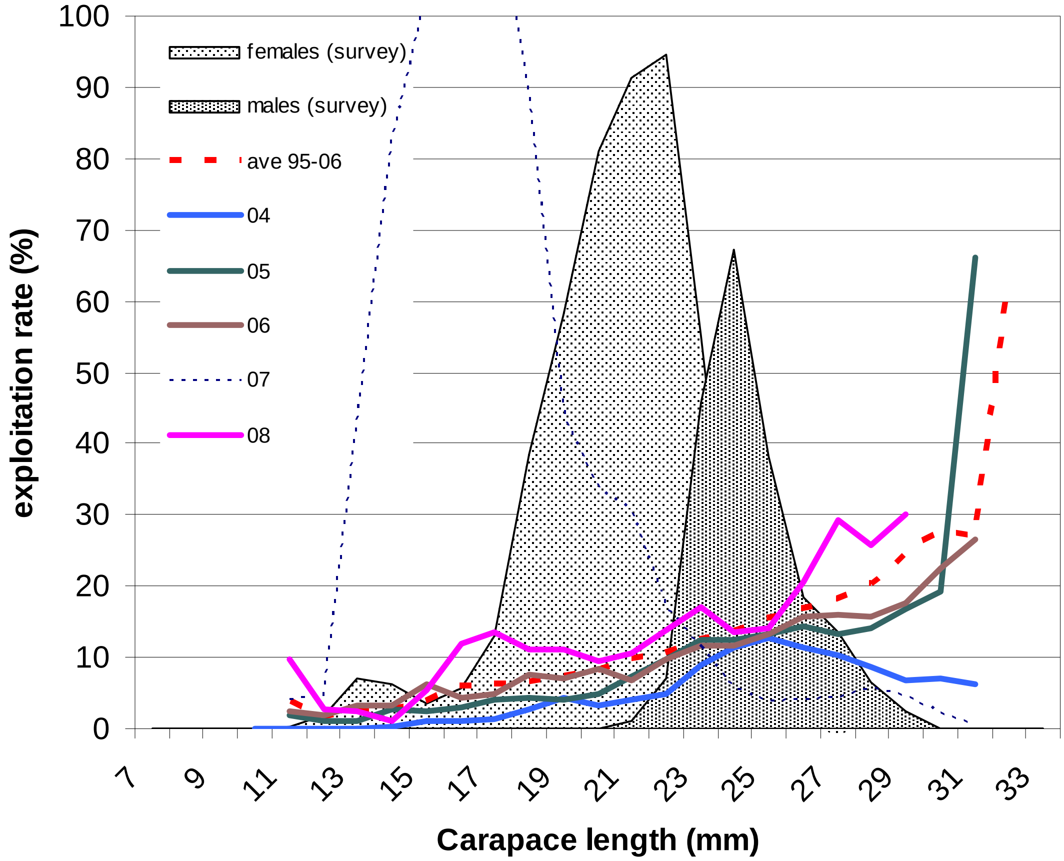

Figure 15. Exploitation at length from commercial sampling and DFO-industry surveys (1995-2008). Year 2007 values appear to be anomalous due to 5 samples of unusually small shrimp from the inshore area.