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# An Assessment of the Eastern Scotian Shelf Shrimp Stock and Fishery in 2006 and Outlook for 2007, including an estimate of bycatch and evaluation of alternative fishery independent abundance indicators

# Évaluation du stock et de la pêche en 2006 pour la crevette de l'est du plateau néo-écossais et perspectives pour 2007, y compris une estimation des prises accessoires et une évaluation des indicateurs de l'abondance de rechange indépendants de la pêche

P. Koeller[1], M. Covey[1] and M. King[2]

[1]Population Ecology Division | Division de l'écologie des populations
Biological Sciences Branch | Direction des sciences biologiques
Department of Fisheries and Oceans | Ministère des Pêches et des Océans
P.O. Box 550 | C.P. 550
Halifax, Nova Scotia | Halifax (Nouvelle Écosse)
B3J 2S7

[2]2261 Fox Island
RR #1 Canso
Guysborough Co, NS B0H 1H0



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**ABSTRACT**

Stock biomass remains high - the 2006 DFO-industry survey index was the third highest of the 12 year series. It decreased slightly from the previous year, mostly due to decreases in SFA13 which has been fished relatively heavily recently. The bulk of the biomass continues to concentrate in the offshore part of SFA 14 (i.e. survey stratum 14, SFA14 or the Misaine Hole). The spawning stock biomass (females) also decreased slightly from 2005, mainly because of slower growth and delayed sex change of the large 2001 year class, but it remains high and is likely to remain high or increase as this year class changes sex during 2006-2007. It should support the higher TAC (5000mt) effected in 2005 for at least one more year. The 2002-2005 year classes are weaker, consequently a biomass decrease is expected following the passage of the 2001 year class through the population. This is similar to what occurred during the last strong recruitment event (1994-1995 year classes), suggesting the establishment of a cyclical population dynamic often seen in established shrimp fisheries. Such a pattern may be indicative of decreased population stability, re-enforcing the need for continued good monitoring information and a precautionary approach in managing this fishery, including decreases in TACs during population downturns. Commercial counts in 2006 were the highest on record because of the prominence of the 2001 year-class, which is increasingly recruiting to the gear as it grows, but shrimp from this year-class are still relatively small for 5-year olds. It constituted the majority of the catch by numbers in 2006. Effort in SFA 14 increased significantly as fishers took advantage of high catch rates and accumulated biomass in this area. Although increased fishing activity occurred again during the ovigerous fall months due to the higher TAC and other factors the proportion of the catch taken during the ovigerous period decreased in 2006. The percentage of females in the catch also decreased due to the large numbers of males from the 2001 year class. Commercial catch rates reached a record high in 2006. Spatial indicators show that the area with the highest commercial catch rates remains large. Analysis of shrimp catches in the eastern Scotian Shelf snow crab surveys indicate that it could produce more accurate and precise abundance estimates than the shrimp survey. However, the selectivity of the nephrops trawl for shrimp is not known, so its usefulness for determining population length composition and recruitment must be determined. .Analysis of bycatch data from shrimp survey and commercial catches indicate that the Normore grate effectively reduces bycatch to an average of 3.6% and 2.3% by weight in the survey and fishery, respectively. However, the numbers of small fish caught by the fishery annually can be relatively large e.g. about 0.5 million small plaice. The impact on the population dynamics of these species is not known.

**RÉSUMÉ**

La biomasse du stock demeure élevée. L’indice du relevé MPO-industrie de 2006 était le troisième plus élevé de la série chronologique de douze ans. Il a légèrement baissé par rapport à l’année précédente, en grande partie en raison des diminutions enregistrées dans la ZPC 13 où la pêche a été relativement intense récemment. La majeure partie de la biomasse continue de se concentrer dans la partie hauturière de la ZPC 14 (c.-à-d., la strate 14 du relevé, la ZPC 14 ou la fosse de Misaine). La biomasse du stock reproducteur (femelles) a, elle aussi, diminué par rapport à 2005, surtout à cause de la lente croissance et du retard dans le changement de sexe de la classe d’âge de 2001, mais elle demeure toutefois élevée et devrait le demeurer ou augmenter en raison du changement de sexe de la classe d’âge de 2001 qui aura lieu en 2006-2007. La biomasse devrait pouvoir soutenir le TAC élevé (5000 tm) en vigueur en 2005 pendant au moins une autre année. Les classes d’âge de 2002 à 2005 sont plus faibles. On s’attend donc à une diminution de la biomasse après le recrutement de la classe d’âge de 2001 au sein de la population. Il s’est produit une situation semblable au moment du dernier recrutement élevé (classes d’âge de 1994 et 1995), laissant ainsi croire à l’établissement d’une dynamique cyclique de la population souvent observée dans les pêches à la crevette bien établies. Une telle tendance pourrait indiquer une diminution de la stabilité de la population, soulignant d’autant plus la nécessité de continuer à bien surveiller l’information et d’adopter une approche prudente pour la gestion de cette pêche, y compris des diminutions des TAC lorsque les populations font face à des déclins. En 2006, les prises commerciales ont été les plus élevées jamais enregistrées en raison de la proéminence de la classe d’âge de 2001, laquelle est de plus en plus prélevée par la pêche à mesure qu’elle grandit. Toutefois, les crevettes de cette classe d’âge sont relativement petites pour cinq ans. Cette classe d’âge a constitué la majorité du nombre de prises en 2006. L’effort de pêche dans la ZPC 14 a sensiblement augmenté puisque les pêcheurs ont profité des taux de prises élevés et de la biomasse accumulée dans cette zone. Bien que la pêche se soit accrue durant les mois ovigères d’automne en raison du TAC plus élevé et d’autres facteurs, la proportion de prises pendant la période ovigère a diminué en 2006. Le pourcentage de femelles pêchées a également diminué à cause du grand nombre de mâles dans la classe d’âge de 2001. Les taux de prises commerciales ont atteint un sommet en 2006. Les indicateurs spatiaux montrent que la zone affichant les taux de prises commerciales les plus élevés demeure grande. L’analyse des prises de crevettes dans les relevés dirigés vers le crabe des neiges de l’est du plateau néo-écossais indiquent que ce relevé pourrait produire des estimations de l’abondance plus précises que le relevé dirigé vers la crevette. Cependant, comme la sélectivité des chaluts à langoustines pour la crevette n’est pas connue, il faut déterminer si ces derniers sont utiles pour établir la distribution des longueurs et le recrutement des populations. Les analyses des données sur les prises accessoires obtenues d’après le relevé dirigé vers la crevette et sur les prises commerciales indiquent que la grille Normore réduit efficacement le nombre de prises accessoires, affichant une moyenne de 3,6 % et de 2,3 % par poids dans le relevé et la pêche respectivement. Cependant, le nombre de petits poissons pêchés annuellement peut être relativement élevé (p. ex. 0,5 million de petits poissons). L’impact sur la dynamique des populations de ces espèces est inconnu.

## INTRODUCTION

The biology of northern shrimp, *Pandalus borealis*, is reviewed in Shumway et al. (1985) for various stocks world-wide, and by Koeller et al. (1996a), Koeller (2000), Koeller et al. (2000a), Koeller et al. (2003) and Koeller (2006) 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 et al. (1996b, 1996d, 1997,1998, 1999, 2001,2002, 2003b, 2004, 2005, and 2006). 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) has been caught every year since individual Shrimp Fishing Area (SFAs) quotas were lifted in 1994. 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 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 5000 mt for 2001 and to 3000 mt for 2002 and 2003. In 2003, the survey index increased for the first time following three 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 continuing good catch rates the TAC was not caught in 2005 for a number of reasons, including poor market conditions, bad weather, soft shrimp, gear conflicts (snow crab fishery) and other logistic problems.

In 2001 shrimp prices dropped sharply 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 2003-2006 effort on the Scotian Shelf virtually stopped during the summer to avoid soft shrimp and crab traps. 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 2005-2006.

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 summarized 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 were given to support the apparent increasing shrimp aggregation shown by the survey and 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.

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 2003-2005 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 for the 2005 fishery – a draft Integrated Fisheries Management Plan (IFMP 2007-2011) is currently under review.

The experimental trap fishery was not under quota management from 1995-1997 except for a 500 mt 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 1998 a trap quota was set at 10% of the total TAC, e.g. 500 tons of the 5000 mt TAC was initially allocated to trappers in 1998. 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 1998. 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 382mt, but trap fishing effort and catch were very low during 2005-2006 due to poor market conditions. TAC underuns for 2005 and 2006 were substantial due to various logistic problems experienced by the mobile fleet. A season extension was requested in 2005, but was not granted on the basis of an expert opinion.

## 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 two commercial CPUE series, coupled with increased aggregation and decreased survey abundance, indicated that the increase in the two 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

### Research Vessel Abundance Index

A twelfth industry-funded trawl survey, incorporating a mixed stratified random - fixed station design, was conducted in June 2006. Survey design and station selection methods were similar to previous surveys completed in 1995-2005: 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 La Have clay on Atlantic Geosciences Centre surficial geology maps. The 2006 survey was again completed by MV *All Seven* (fifth year for this vessel/crew) fishing the new (in 2004) standard survey trawl (Gourock #1126 2-bridle shrimp trawl and #9 Bison doors). Measurements of trawl wing spread and headline height were made throughout most survey sets using NETMINDER sensors. The trawl was fitted with a "belly bag" attached to the footrope and belly between the two middle rollers. Belly bag samples of *P. borealis* were frozen and returned to the laboratory for analysis.

Catches were standardised to the target distance travelled at 2.5 knots for 30 min (1.25 nm). Biomass/population estimates and bootstrapped confidence intervals (Smith 1997) were calculated using the product of the average measured wing spread (17.4 m) 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 1982-88, 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 two 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 1982-88 series, consequently the large differences in catch rates between the two series may be exaggerated and should be interpreted cautiously. Since the cod end mesh size in both series was the same (40 mm) size selectivities of the two series were assumed to be the same.

### 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 ft in length, compared to the <65ft 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 probably 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 Standardized Catch Per Unit Effort

The standardised CPUE series for 1993-2006 uses data from April-July inclusive, the months when the majority of the TAC was caught, for 17 vessels that have fished for at least 7 of the 11 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 below).

### Research Vessel (RV) 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.

# PRODUCTION

## RV Age 2 Abundance

A random sample of 10 pounds of shrimp (approximately 500 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).

The Age 2 abundance indicator is currently the only estimate of recruitment to the population with a longer time series. However, these shrimp are not caught efficiently by the standard survey trawl. This is being addressed by a small meshed “belly-bag” attached on the footrope under the belly of the standard survey trawl during all regular June survey sets. Only 5 years of data are now available, however this gear correctly identified the 2001 year class as large one year before it recruited to the survey trawl, and appears to be useful in assessing year class strength 4-5 years before recruitment to the fishery.

## RV 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 during the survey year and will change sex the following year. They also comprise the bulk of the catch for the next year, and so are a measure of recruitment to the fishery.

## RV Spawning Stock Biomass (Females)

The spawning stock biomass (SSB), 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 transition 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 stock-recruitment relationship has not been identified for the Scotian Shelf, although it has been for some other pandalid 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 4,300mt, about 30% of those found in the late 1990s. It would therefore be prudent not to let the SSB decrease below 4,300, 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.

### 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. (2003a) 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. 2000), 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 hypothesized to be constant (invariant) at about 0.8-0.9 for all stocks of *P. borealis* (Charnov and Skulladotir 2000). This rule was shown to apply to the Scotian Shelf (Koeller et al. 2003a, 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.

### Predation

A predation index is calculated as the mean catch/set of all major groundfish species combined from the summer groundfish survey for strata which encompass the shrimp holes i.e. 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. 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, possibly 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.

### 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 throughout 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 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 4,300 mentioned above would be considerably less in terms of effective reproductive capacity if most is taken before egg hatching.

**ECOSYSTEM**

**RV Bottom Temperatures**

This index is calculated from July groundfish survey data as the mean bottom temperatures at depths >100 m 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 hypothesized 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.

**July Sea Surface Temperatures**

Sea surface temperatures are calculated as average temperatures within defined rectangles encompassing the shrimp holes, using the Oceans Sciences and Biological Oceanography Section SST databases.

Negative correlations between SSTs and lagged population estimates are common for the southern *P. borealis* stocks, including the Scotian Shelf, and are presumably also related to growth and fecundity, possibly because of diurnal migrations to near surface water.

**RV 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). It can therefore be considered an indicator of conditions favourable to the production of shrimp.

**RV 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.

**RV Greenland Halibut Recruitment**

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.

## RV Snow Crab Recruitment

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 three summary colours has an equal probability of being assigned in a random set of individual indicator colours/values. The Regional Advisory Process (RAP) 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.

## Potential Use of Additional Available Abundance Estimates

Two external (to the shrimp program) databases were examined to determine their potential for use in the shrimp assessment as additional abundance indicators. These included the summer groundfish survey, the 4VW cod survey and the fall snow crab survey. Data were obtained from the DFO's Virtual Data Centre (VDC) to determine basic catch information for *P. borealis*.

## Bycatch

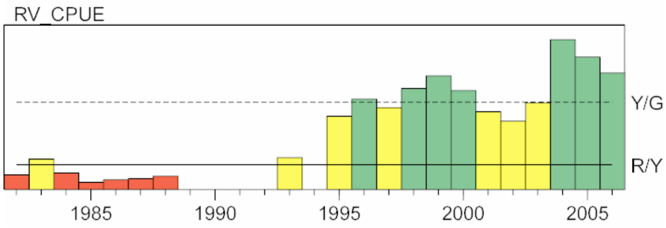
Information on bycatch was requested through the remit and was obtained from two sources, including the annual DFO-industry shrimp survey and the observer program. Bycatch information on the shrimp survey has been collected annually since the start of the series (1995) and archived on spreadsheets. The survey covers most of the shrimp fishing areas using a common commercial shrimp trawl and so should be characteristic of the bycatch taken by the fishery. Observer coverage is quite limited for this fishery and is usually restricted to one or two small areas and trips per year. Temporal coverage has also been limited with samples available only in 1996, 1999, and 2004-2006. These data were obtained from the VDC.

# 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

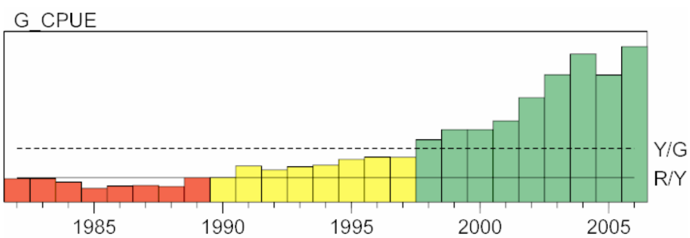
### Research Vessel Abundance Index




The stratified survey estimate for 2006 (representing a biomass of 37,769mt using the swept area method) decreased for the second year in a row from the record high of 2004 (48,438mt), but was still the third highest of the series. (Figure 2, Table 4, 6). Most of the decrease again ocurred in Strata 13 (Louisbourg Hole), which was relatively heavily exploited in recent years. Most of the biomass continues to concentrate in SFA 14, which has been relatively lightly exploited recently. The distribution of survey catches is shown in Figure 6.

*Interpretation:* Overall stock biomass continues to be high. Abundance changes within SFAs may partially reflect changing fishing patterns and exploitation rates.

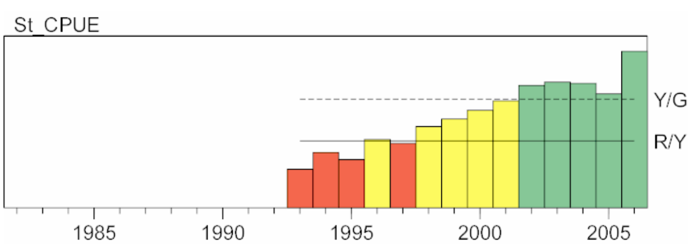
### Gulf Vessels Catch Per Unit Effort




The unstandardised Gulf Vessel CPUE has shown an increasing trend since the 1980s. It decreased in 2005 for the first time in 13 years, but the 2006 index was the highest on record.

*Interpretation:* Catch rates by Gulf vessels continue to be excellent. The increase in 2006 is probably due to the increased availability of the huge 2001 year class as it grew.

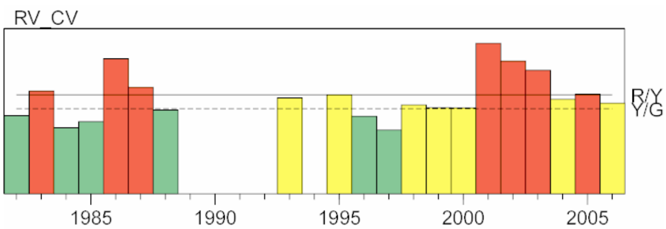
### Commercial Trawler Standardized Catch Per Unit Effort



The standardized CPUE series followed a similar pattern to the Gulf series, showing an increasing trend during most of the series, a recent levelling off and slight decrease, and a sharp increase in 2006 . In contrast, the survey index decreased slightly in 2006 (Figure 3A). Spatial analyses (see below) have previously shown that CPUEs are not always representative of abundance, but can be influenced by changes in distribution and densities of shrimp concentrations. The spatial distribution of effort is shown in Figure 7 and the seasonal (monthly) distribution of catch, effort and CPUEs in Figure 8.

*Interpretation:* Catch rates continue to be excellent for all fleet sectors. The sharp increase in 2006 is probably due to the increased availability of the large 2001 year-class as it grows and is retained by the trawl meshes, and possibly because it is concentrating in denser shoals on the fishing grounds.

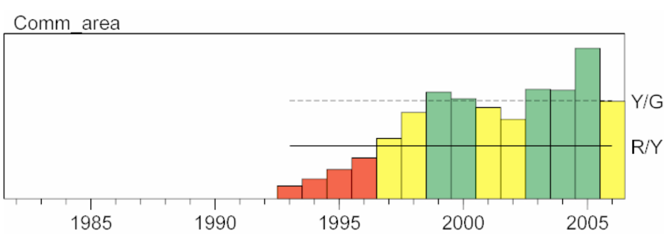
**Research Vessel Coefficient of Variation**




The survey measure of dispersion (overall CV) decreased from 2001-2003, but has been relatively stable since (Figure 4, 6).

*Interpretation:* The decrease in the survey dispersion index from 2001-2003 was associated with a population decrease and the associated concentration of shrimp from several strong year classes. The relative stability of this indicator during the last three years appears to be associated with the concurrent abundance increase.

**Commercial Fishing Area**

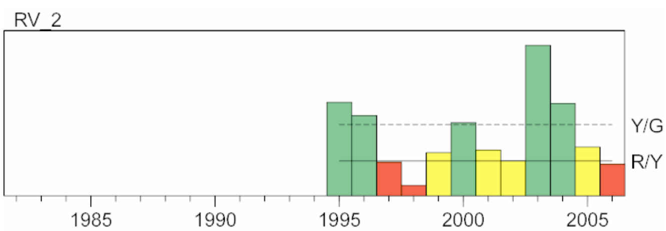



This indicator (area with commercial catch rates >250kg/hour) must be considered with the areas of other catch rates in order to interpret changing distribution and dispersion patterns of the resource. The >250kg/hour area increased since the beginning of the series until 1999, when it began to decrease 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 (albeit with a 2005 increase), while the area of highest concentration has remained large and stable.  Note that the distribution of effort changed significantly over the years (Figure 7), especially in 2004, when much of the effort and catch was taken out of SFA 13 (Louisbourg Hole).  After fairly even distribution of effort in 2005, in 2006 the fleet concentrated effort in the large accumulated biomass in SFA14.

*Interpretation:*  The very large and widespread 2001 year class has become available to the fishery before the trend of increasing areas of high catch rates attributed to the previous set of strong year classes (1994-95) could be reversed.  Consequently, the area of highest catch rates and shrimp concentrations has remained high and the area with lower catch rates and shrimp concentrations has remained relatively low.  The decrease in this indicator is therefore not a concern at this time.

## PRODUCTION

### RV Abundance at Age 2

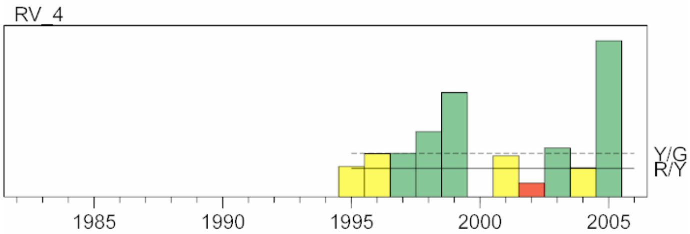



The index of two-year old shrimp has decreased every year since the 2003 peak associated with the large 2001 year class (Table 5).  Good recruitment associated mainly with the 2001 year class is being followed by lower recruitment, similar to what followed the good 1994-1995 year classes.  This cycle of good 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.

Belly bag samples confirm the weakness of the 2004 year class as 2 year olds. They also indicate that the 2005 year class at age 1 is weaker still and the lowest of the 5 year series (Table 5, Figure 10).  The 2001 year class continued to dominate belly bag as well as main trawl samples in 2006.  Belly bag samples generally substantiate results from the main trawl (Figure 11) and indicate several weaker year classes following the strong 2001 year class.

*Interpretation:*  Recruitment is decreasing following the recent recruitment pulse.  This may be a cyclical phenomenon associated with fishing, environmental forcing, or both, and lower population stability.

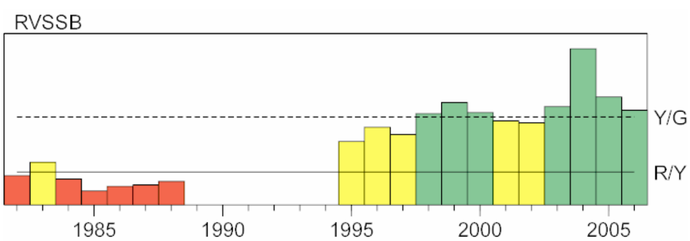
## RV Abundance at Age 4




The abundance of age 4 shrimp increased from below average in 2004 to the highest on record, reflecting the recruitment of the strong 2001 year class to what usually is the oldest male age group in the population. However, in 2006 this age (2002 year class) was undetectable using modal analysis. Although it could be discerned in some length frequency aggregations and is probably present in the large mode attributed mainly to the 2001 year class, it does appear to be small. A similar situation occurred in 1996, following the large 1995 year class (Table 5, Figure 11). This confirms the apparent cyclical recruitment pattern seen with the age 2 indicator above.

*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 very low. However, the large 2001 year class (now 5 years old), which is growing slowly and has delayed sex change will be recruiting to the fishery as females in their place.

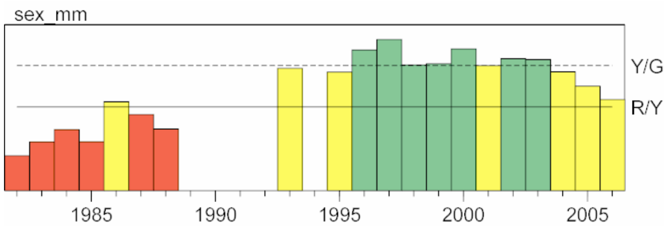
## RV Spawning Stock Biomass (Females)




Research vessel spawning stock biomass decreased in 2005 and again in 2006 from the record high in 2004. However it remains well above the long term average and is considerably higher than during the population increase of the 1990s.

*Interpretation:* The spawning stock biomass (females) has decreased due to the delay in sex change of the 2001 year class, fishery removals and natural mortality of older females. SSB will likely remain high or increase as the 2001 year class changes sex in 2007. There is no concern at present for recruitment overfishing.

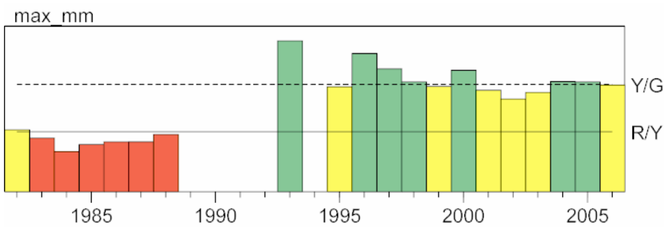
**Average Size at Sex Transition ($L_t$)**




This indicator has been decreasing since 2002 and is now 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:* Size at sex change is related to growth rate (Koeller et al 2003a, Koeller 2006). Growth rates are decreasing in response to increasing densities, which has resulted in the delayed sex change of the 2001 year class. An increasing number of male year classes due to slower growth may result in larger females because of the additional growing season. This would be a positive development as larger females produce more eggs, which in turn could increase population egg production.

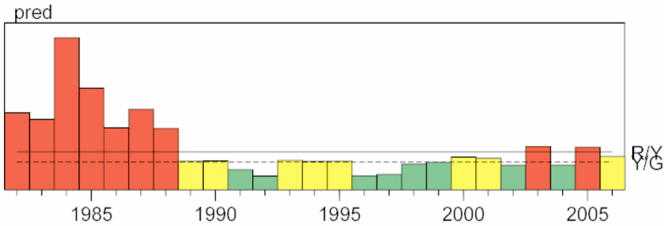
**Average Maximum Size ($L_{max}$)**




Maximum size remains substantially higher than the period of low abundance and faster growth during the 1980s. As with size at transition, annual changes are often reflected in all regions (Figure 13B), however there has been no clear recent trend in this indicator within areas or for the entire stock.

*Interpretation:* There has been no decrease in maximum size similar to that seen for size at sex transition as often occurs when longevities remain unchanged. Maximum size may increase because of the slower growth and delayed sex change of the 2001 year class, which now has an extra year to grow in the male phase.

### Predation

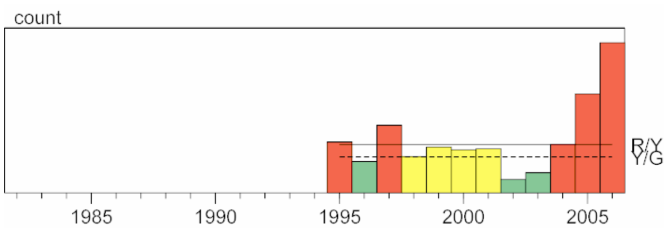



There appears to have been a slight increasing trend since 1995, with two red indicators in recent years. However, groundfish abundance remains well below the high levels during the 1980s when the shrimp population was low.

*Interpretation:* Natural mortality (M) due to predation remains well below the high values of the 1980s that probably contributed to the low shrimp abundances during that period. M may have been increasing slightly since the mid 1990s.

## FISHING IMPACTS

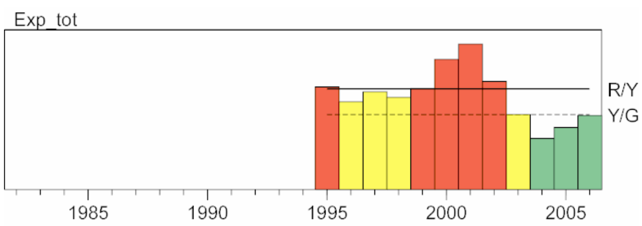
### Commercial Counts




These fishery-derived data reflect the strong recruitment events evident in survey data (compare with age 2 and 4 recruitment). Counts have increased significantly since 2004, as the 2001 year class became more catchable. The catch-at length (Figure 9) shows the relatively large numbers of small shrimp from the 2001 year-class caught in 2004-2006 and survey results show that it continues to be widespread throughout the stock area (Figure 12).

*Interpretation:* Fishers had difficulty remaining below the counts which command the best prices from buyers, which probably exacerbated the problem of low prices generally experienced during the last 2 years. There is some concern for growth overfishing. Higher counts may occur as the 2001 year class grows, but is dependant on its growth rate.

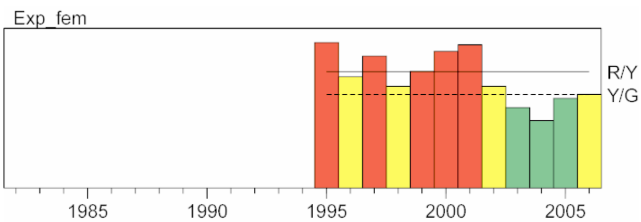
### Exploitation Index



Total exploitation increased again in 2006 due mainly to the increase in the catch and decrease in survey abundance, but it remained below the long-term average. Effort, catch and exploitation rates were again relatively evenly distributed throughout the stock area in 2005, with notably less fishing pressure put on SFA 13, and more in SFA 14 where most of the stock is concentrated (Table 6).

*Interpretation:* Overall exploitation remains relatively low. Currently it is relatively evenly distributed over the fishing grounds with no single area receiving undue heavy exploitation as has happened on occasion in the past.

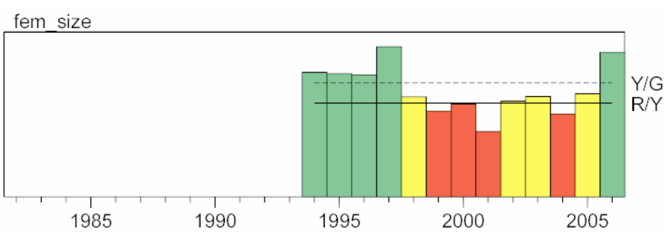
**Female Exploitation Rate**




Female exploitation increased in 2005 and again slightly in 2006 but it remained below the long-term average. Length specific exploitations from 1995-2006 are shown in Figure 16.

*Interpretation:* Female exploitation rates remain below average.

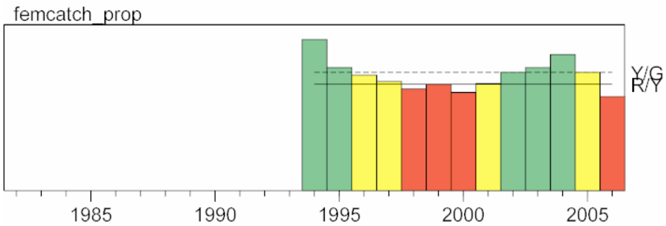
**Mean Size of Females in Catch**




The average size of females in the catch increased in 2006 well above the relatively low values seen since the late 1990s.

*Interpretation*: The average size of females in the catch has decreased as the larger animals were selectively removed from the population by the fishery. Since fecundity is directly related to size this, in combination with other factors (fishing during the ovigerous period, increased female exploitation, size at sex change and maximum size), may have impacted the reproductive capacity of the population. This indicator increased slightly in 2002-2003, as recruitment to the female fraction decreased and the remaining population grew. It is likely to decrease in the next year or two as the large 2001 class begins to change sex.

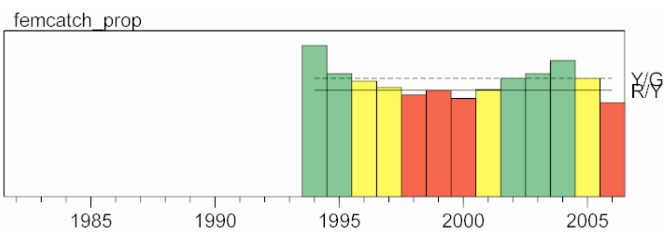
### Proportion of Females in Catch




The proportion of females in the catch showed a decreasing trend from 1994 to 2000 then increased to 2004. It decreased in 2005 and again in 2006.

*Interpretation:* the proportion of females in the catch decreased as a group of strong year classes (1993-1995) recruited to the fishery and more shrimp were caught as males. It has decreased significantly during the last 2 years as more males were caught from the 2001 year class, exacerbated by its delay in sex change. This indicator will likely reverse next year as the year class changes sex.

### Fishing During Ovigerous Period




Fishing during the ovigerous period increased significantly from the early 1990s to a maximum in 2000 due to the longer time required to catch increasing TACs by a relatively small fleet of vessels. In addition, quota transfers have occurred and many vessels fished several individual quotas, further extending the length of the season. This indicator increased in 2001-2002 as the lower TAC was again caught mainly during the non-ovigerous summer period. It decreased in 2005-2006 because of the TAC increase and decreased effort during the summer months due to market conditions. The monthly distribution of catches, effort and catch rates are shown in Figure 8.

*Interpretation:* Fishing during the ovigerous period may have impacting population reproductive potential in 2005-2006 by removing ovigerous females before their eggs had hatched. The degree to which this is a problem has not been established.

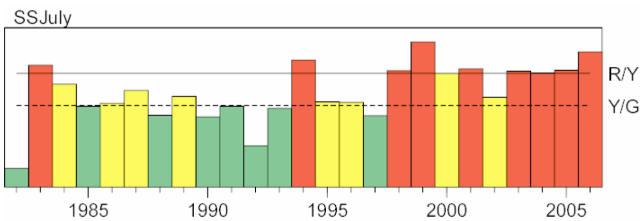
## ECOSYSTEM

### RV (Groundfish Survey) Bottom Temperatures

Bottom temperatures on the shrimp grounds have fluctuated during the groundfish survey time series but in general they decreased during the 1980s and increased during the 1990s, with cooler conditions during the last few years. Temperatures from shrimp surveys by SFA (Figure 14) generally show the same trends as data from groundfish surveys . Cooling during the most recent years appears to be a widespread phenomenon and has been noticed as far away as the Grand Banks, however, bottom temperatures jumped sharply in 2005-2006.

*Interpretation:* decreasing bottom temperatures during the 1980s may have resulted in decreasing growth rates, and corresponding increases in size at transition, maximum size and fecundity. Increasing bottom temperatures during the 1990s did not appear to have resulted in significant increases in growth rates, perhaps due to density-dependant effects. Colder temperatures during more recent years are more favourable for shrimp, however the increase in 2005-2006 may be of concern if a trend of increasing temperatures develops.

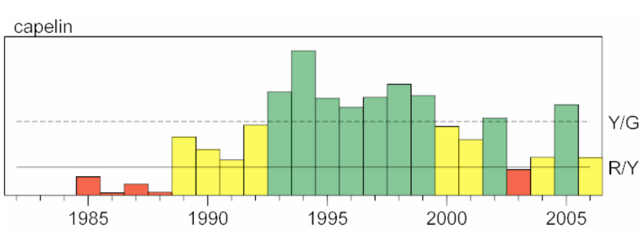
**July Sea Surface Temperatures (SST)**




At the southern limits of distribution (Gulf of Maine), surface temperatures have been shown to be 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 despite relatively high SSTs.

*Interpretation:* The association between SSTs and recruitment is ambivalent, however the current warm water temperatures, if sustained, may contribute to the lower than average recruitment in the future.

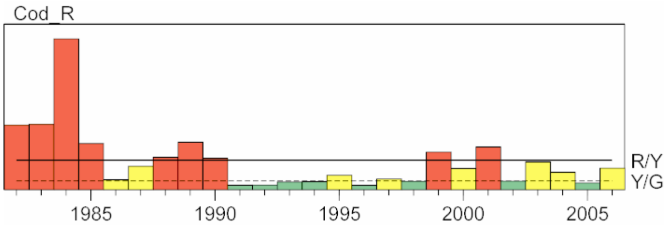
**RV Capelin Abundance**




During the last six 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.

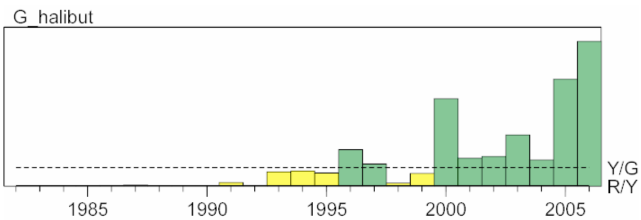
## Cod Recruitment




Cod recruitment 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.

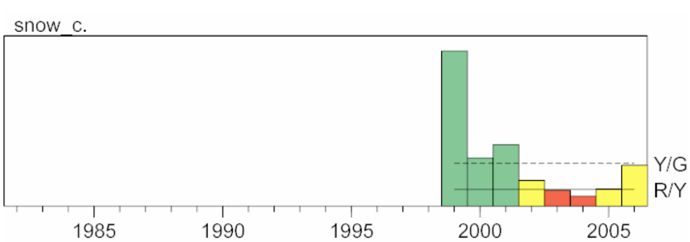
## Greenland Halibut Recruitment




Greenland halibut <30cm continue to be abundant on the eastern Scotian Shelf and appear to have increased significantly during the last 2 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

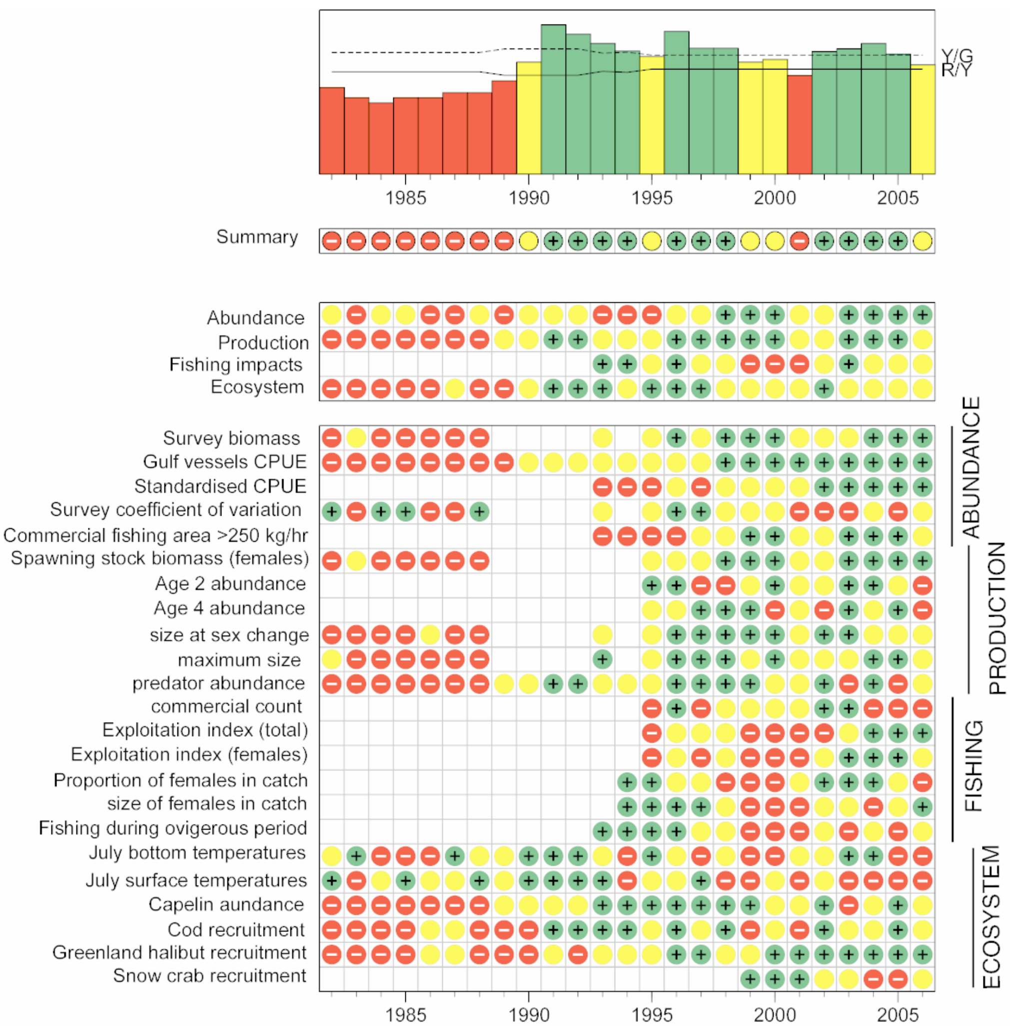



The pre-recruit index from the Cape Breton snow crab survey has been decreasing in recent years and is of concern to this fishery. Snow crab abundance, as with Greenland halibut and capelin, tend to track shrimp abundance, consequently this observation is not in accord with observations and interpretation of trends for the latter two species, i.e. that environmental conditions remain favourable for shrimp. Since snow crab is the only one of the three ecological indicator species that is fished commercially on the Scotian Shelf, it is possible that fishing effects have masked environmental influences. In addition, snow crab abundance cycles appear to be somewhat longer than those for shrimp. There are some signs of improved snow crab recruitment during the last 2 years.

*Interpretation*: Due to fishery effects and difference in natural abundance cycles snow crab recruitment may not currently be an indicator of environmental conditions favourable for shrimp.

**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.*



The overall summary turned yellow in 2006, after green lights for the last four years. The abundance characteristic was the only one the four characteristics that was green. Three of five abundance indicators comprising this characteristics were favourable (green) and the research vessel coefficient of variation improved from red to yellow, probably due to the widespread spread strong 2001 year class. Only the commercial fishing area indicator >250kg/hr decreased, but this does not appear to be a concern in light of the large area of very high (>450kg/hr) catch rates. All other three characteristics were yellow, resulting in the overall yellow rating. The production characteristic turned from green to yellow in 2006, with 4 of the 6 indicators changing to a less favourable colour. Age 2 abundance is now red, reflecting the lower recruitment apparent after the strong 2001 year class, which is a concern. Age 4 abundance was zero due to the non-detectability of the 2002 year-class in the modal analysis, however, this is not a concern at the moment because the slow growing 5 year old shrimp from the 2001 year class, mostly males who delayed sex change, will provide the recruits to the female population usually provided by 4 year olds. Females should therefore be very abundant in 2007 and should sustain the higher TAC for at least another year. A small, probably insignificant increase in the predation indicator changed it from green to red. The fishing impact characteristic remained yellow, with the same number of green (3) yellow (1) and red (2) indicators as the previous year, the latter reflecting the high proportion of females taken during the ovigerous period and high counts. Note that the count indicator is ambiguous in that increases can be interpreted as good or bad depending on whether one is considering recruitment or growth overfishing. The ecosystem characteristic remained yellow despite improvements with indicator species, primarily because of increased surface and bottom temperatures, however there seems to be no clear increasing temperature trend, as yet. At this time there is no indication that the regime may be changing to one less favourable for shrimp and the decreased recruitment following the large 2001 year class may be a cyclical phenomenon often observed in developed shrimp fisheries.

**Potential Use of Additional Available Abundance Estimates**

**Snow Crab**

In fall snow crab surveys (1996-2005), quantitative data recording for unidentified shrimp began in 2002, when numbers caught were estimated (Table 7). Although species were not identified, it is highly probable that the bulk of the catches in water deeper than 200m were *P. borealis.* The estimates are rounded to the nearest thousand, and may be less accurate than if determined from a weighed subsample of the total catch. Beginning in 2004, the numbers of the two main species (*P. borealis* and *P. montagui*) were recorded, also to the nearest thousand. The ratio of *P. borealis/P. montagui* at various depths in this and subsequent surveys could be used to estimate catch by species in 2002-2003. Beginning in 2005, both total numbers and weights caught were recorded for both species. Numbers were calculated from a weighed subsample and total weight was taken directly using the new compensatory scales. The distribution of *P. borealis*, in numbers, for the 4 years (2002-2005) for which numbers caught were estimated and total weights for 2005 are given in Figure 17. The clear advantage of the snow crab surveys is the wider coverage and large number of stations (average ~180/survey) versus only 60 stations for the shrimp survey, which are confined to the main shrimp fishing grounds in water deeper than 100 fathoms (183m), where the bulk of the biomass accumulates during summer. On average about half of the stations on the snow crab survey catch shrimp, while virtually all of the shrimp survey stations catch shrimp. While the distribution pattern between the crab (Figure 17) and shrimp survey (Figure 6) are similar, the snow crab surveys show many catches in water shallower than 100 fathoms, because during fall-spring shrimp move into shallower water. In addition, the snow crab survey covers an area of shrimp abundance not covered by the shrimp survey, i.e. north of Sable Island and east of the Gully. The Nephrops trawl used on crab surveys appears to be less efficient at catching shrimp than the shrimp trawl used during shrimp surveys (Table 7), on average catching only 0.74 grams of shrimp per $m^2$ (sets with shrimp only), wheras the shrimp trawl caught 10 times that amount (all sets). However, this difference is probably at least partly due to lower densities in the fall due to movement of some shrimp to shallower water, and to differences in the depth distribution of stations between these surveys.

**Groundfish**

Numbers and weights have been recorded for the two main shrimp species every year since 2000, for the summer survey, which covers the entire Scotian Shelf, and the 4VW spring survey, designed for cod, both using RV *Alfred Needler*. Cumulative catches from 2000-2006 (excluding the 2004 survey conducted by another vessel) are shown in Figure 18. The two survey series show similar distributions to the shrimp and snow crab survey. The clear advantage of the summer groundfish survey is the wide coverage, including the Bay of Fundy and near Roseway Basin which both show small numbers of shrimp, and have been the location of fisheries in the past (late 1960s, early 1970s). The summer survey, while showing the concentration east of the Gully found in the crab survey, also seems to indicate that this concentration extends eastward into the northern part of the Gully itself. This is seen more clearly in the spring survey. The discontinuity between the area north of Sable Island and the Gully in the spring survey is probably due to the lack of stations between these areas. The summer survey also shows shrimp distributed along the edge of the Laurentian Channel in relatively small numbers, as also shown by several recent exploratory shrimp surveys (not shown). These shrimp may originate from the northern Gulf stock. While the groundfish surveys provide good distributional information on a wide scale, which is useful for stock delineation, relatively few shrimp are caught per survey. For the summer survey, of the approximately 200 stations completed annually only 28 catch shrimp on average. This is better for the spring survey partly because it concentrates on the eastern Scotian Shelf (23 of about 100 stations catch shrimp). For stations that catch shrimp, on average the groundfish trawl catches about 1/10 of the shrimp trawl, for the same length of tow, but covers more ground due to faster tow speed (Table 7). Its efficiency for shrimp appears to be about the same as the nephrops trawl. Note, however, that this is based on the wing spread (at 17.5 almost the same as the shrimp trawl) swept area. Since the groundtrawl wing meshes are too large to retain most shrimp, the effective mouth opening is probably much smaller, i.e. nearer to the codend opening where the liner would retain most shrimp. Its actual efficiency may therefore be better than the Nephrops trawl.

**Conclusions**

Although the Nephrops trawl used seems to be less efficient at catching shrimp, some of the difference in calculated efficiency is due to differences in station distribution (by depth and relative shrimp concentrations) and survey season. The fall snow crab survey provides more synoptic and denser coverage of shrimp distribution for the eastern Scotian Shelf shrimp stock than the June shrimp survey, which concentrates only on the commercial shrimp grounds. Consequently, the snow crab survey could provide a more precise and accurate estimate of shrimp abundance changes as an index, while the shrimp survey provides biomass estimates which are closer to actual values, allowing for a fairly realistic estimate of exploitation rate. Since exploitation could also be estimated as an index, it is possible that the snow crab survey could provide all the information currently provided by the shrimp survey, more accurately and precisely. However, the selectivity of the Nephrops trawl is not known, including its usefulness for estimating pre-recruits as is currently done with the belly bag. Selectivity for the two trawls should be compared during 2007 surveys by collecting shrimp samples for length frequency analysis during the snow crab survey. Depending on results, consideration should then be given to combining the shrimp and snow crab surveys in 2008. This should result in considerable savings (shrimp survey contract) with very little additional effort, and may improve assessment accuracy. At a minimum, shrimp catches from the crab survey will provide a useful additional abundance index once the length of the series has increased.

The groundfish survey trawl is about as efficient at catching shrimp as the nephrops trawl, and probably more so if the effective opening (lined codend) is considered. Relatively few stations are located in the commercial shrimp grounds and the usual distribution pattern is clear only after a number of years of accumulated catches are plotted. An estimate of shrimp abundance from groundfish survey shrimp catches is therefore likely to be less accurate and precise than the shrimp or snow crab survey estimates. The groundfish survey provides the most synoptic coverage, including all of the Scotian Shelf, and the Bay of Fundy where shrimp fisheries have occurred in the past. Since northern shrimp are a good indicator of ecosystem change in both the Pacific (Anderson 2000) and Atlantic (Koeller 2000, Koeller et al, in press) it would be beneficial to continue estimating numbers and weight caught for that reason alone. The results should also be usefull as an additional abundance indicator and should be incorporated into the assessment now that the series is six years in length.

## Bycatch

### Shrimp Survey

The estimated total number and weight of each species caught during each shrimp survey is given in Table 8. Capelin was the most important species both as numbers and weight caught, accounting for 66% of the bycatch of individuals and 30% of the weight (Table 9). About a dozen species accounted for most (99%) of the catch in numbers and weight. Note that silver hake, while second in importance in terms of weight and numbers, was not caught consistently throughout the survey series, with the bulk of the catch taken during one or two sets in 2000 (Table 8). Other important species, including flatfish (turbot, plaice, witch), redfish, herring, and Vahl's eelpout were caught relatively consistently throughout the survey series, and within each survey (Table 10). Some species (e.g. snake blennies), although not as prevalent throughout were quite common locally (ie within survey strata), however this analysis has not looked at bycatch by sub-areas. The percentage of the total catch consisting of bycatch ranged from 1.1 to 10.1% (Table 11), with an average of 3.6% by weight. Note that the two years in which bycatches were relatively high (2000, 2002) were unusual. The bulk of the bycatch in those years consisted of one or two large catches of silver hake (2000) and capelin (2002).

In order to determine the approximate numbers and weight of each species removed by the fishery each year the percent bycatch by weight (Table 11) and species composition (Table 8) from the surveys were scaled to the annual commercial catch (Table 12). Note that this is intended as an approximation only in that it assumes that commercial effort is distributed as is survey effort, that species are distributed evenly throught the area, and that the catchabilities of bycatch species are the same as the survey trawl for all commercial vessels and gears. It also ignores the actual weights of species catches recorded as 0 (i.e. <0.5 kg). Total weight of bycatch for the shrimp fishery ranged from 52 to 397mt annually, however as described above, the two largest annual catches (2000 and 2002) are driven by a few very large survey catches of silver hake and capelin. The average total annual bycatch of 135mt, consisting mainly of capelin (39mt), American plaice (23mt), turbot (11mt), witch flounder (12mt), herring (8.5mt), redfish (7mt) Vahl's eelpout (4.2mt) and gaspereau (2.1mt) is relatively insignificant in terms of weight, but may be more important in terms of numbers, since all the fish passing through the grate are small prerecruits. For example, the annual American plaice bycatch of 23mt represents about 0.5 million fish (Table 12). Unfortunately, the impact on recruitment cannot be determined in the absence of absolute population estimates as determined, for example, by Virtual Population Analysis.

**Observer Data**

Comparisons between survey and commercial bycatches must be made cautiously since observer coverage is limited to only 5 years and a total of 26 sets, about 5 sets/year. (Table 13). Observer spatial coverage is also limited, with no coverage in the most commercially important SFA14, although the other 3 fishing areas had some sets sometime during the observed period. A relatively large number of sets were observed in the Sable Island area, which is not covered by the survey. The most notable difference between survey and observer bycatch is the relatively low importance of capelin in the latter. This must be at least partly due to the absence of observer coverage in SFA14, where most of the capelin bycatch is caught on the survey. Silver hake is the most prominent bycatch in observer sets, and the second most important (after capelin) in survey sets, despite high variances. Flatfish are prominent in both the observer and survey sets. Note that the presence of winter flounder and the absence of American plaice in 2004 observer sets is probably due to misidentification or data processing error. On a set by set basis, percent bycatch by weight ranged from <1% to 11%, with an overall average of 2.2%, somewhat less than the 3.5% averaged on surveys.

**Conclusions**

Survey and observer bycatch data confirm the effectiveness of the mandatory Nordmore grate in reducing fish bycatch to negligible levels in terms of weight. Despite low weight, relatively large numbers of small pre-recruit commercial species, especially flatfish, are caught as bycatch in the shrimp fishery. The impact on the population dynamics of these species is not known.

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Table 1. TACs (trawls) and catches (trawls and traps) from the eastern Scotian Shelf shrimp fishery 1980-2006.

| | TAC | | Catch | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Trawl | Trap | Trawl | | | | Trap | |
| | | | SFA | | | | | |
| | | | 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 |
| **[4]2006** | 4608 | 392 | 743 | 2306 | 823 | 3872 | 7 | 3879 |

[1] Nordmore separator grate introduced.

[2] Overal TAC not caught because TAC for SFA 14 and 15 was exceeded.

[3] Individual SFA TACs combined

[4] Preliminary to Nov. 1, a projected catch of 4,000mt 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 | 1(14) | 20(28)[8] | 7(24)[9] |
| 2006 | 5(14) | 18(28) | 7(24) |

[1] All but one active trap licences are vessels < 45'. They receive about 8% of the 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' 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_are | RVSSB | RV_2 | RV_4 | sex_mm | max_mm | pred | count | Exp_tot | Exp_fem | femcatch_ | fem_size | ovig_Fish | Rvbotemp | SSJuly | 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 |
| Indirect | | | | | | | | | | | | | | | | | | | | | | | |
| Rule | abundance | (production | == | 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 |
| Maxwts | 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 | 0.33 | 0.33 | 0.33 | 0.33 | 0.66 | 0.66 | 0.33 | 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 | 0.66 | 0.66 | 0.66 | 0.66 | 0.33 | 0.33 | 0.66 | 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 |
| Production | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FishingM | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ecosystem | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| Year | | | | | | | | | | | | | | | | | | | | | | | |
| 1982 | 34.5 | 128 | NAN | 65.54235 | NAN | 5040.651 | NAN | NAN | 21.71567 | 28.23559 | 179.292686 | NAN | NAN | NAN | NAN | NAN | NAN | 2.569091 | 9.666667 | 0 | 2.384565 | 0 | NAN |
| 1983 | 71.5 | 127.7 | NAN | 86.01369 | NAN | 7323.053 | NAN | NAN | 22.10738 | 28.03171 | 164.048548 | NAN | NAN | NAN | NAN | NAN | NAN | 2.220909 | 15.15 | 0 | 2.415085 | 0 | NAN |
| 1984 | 39 | 109.5 | NAN | 55.35139 | NAN | 4460.964 | NAN | NAN | 22.4624 | 27.6918 | 353.252042 | NAN | NAN | NAN | NAN | NAN | NAN | 4.954444 | 14.14 | 0 | 5.569005 | 0.060764 | NAN |
| 1985 | 17 | 75.4 | NAN | 60.47674 | NAN | 2417.714 | NAN | NAN | 22.11304 | 27.87091 | 236.366641 | NAN | NAN | NAN | NAN | NAN | NAN | 2.864444 | 12.96 | 1.554196 | 1.709072 | 0.051471 | NAN |
| 1986 | 23 | 87.3 | NAN | 113.1413 | NAN | 3187.874 | NAN | NAN | 23.26099 | 27.93519 | 144.334129 | NAN | NAN | NAN | NAN | NAN | NAN | 3.451176 | 13.1175 | 0.134395 | 0.368328 | 0.085784 | NAN |
| 1987 | 25.5 | 90.7 | NAN | 89.20279 | NAN | 3424.457 | NAN | NAN | 22.89225 | 27.93636 | 187.043602 | NAN | NAN | NAN | NAN | NAN | NAN | 2.192857 | 13.8075 | 0.765207 | 0.865885 | 0.162037 | NAN |
| 1988 | 31.5 | 85.1 | NAN | 70.19206 | NAN | 4047.021 | NAN | NAN | 23.48061 | 28.11905 | 142.805285 | NAN | NAN | NAN | NAN | NAN | NAN | 2.645455 | 12.4825 | 0.172697 | 1.194676 | 0.057566 | NAN |
| 1989 | NAN | 133.4 | NAN | NAN | NAN | NAN | NAN | NAN | NAN | NAN | 66.5807068 | NAN | NAN | NAN | NAN | NAN | NAN | 2.517273 | 13.4875 | 18.37692 | 1.753472 | 0 | NAN |
| 1990 | NAN | 134.5 | NAN | NAN | NAN | NAN | NAN | NAN | NAN | NAN | 67.325839 | NAN | NAN | NAN | NAN | NAN | NAN | 1.973043 | 12.4 | 9.228149 | 1.163194 | 0 | NAN |
| 1991 | NAN | 197.9 | NAN | NAN | NAN | NAN | NAN | NAN | NAN | NAN | 46.90625 | NAN | NAN | NAN | NAN | NAN | NAN | 1.5375 | 12.965 | 5.071521 | 0.165925 | 0.463853 | NAN |
| 1992 | NAN | 176.3 | NAN | NAN | NAN | NAN | NAN | NAN | NAN | NAN | 32.0996304 | NAN | NAN | NAN | NAN | NAN | NAN | 1.92069 | 10.8625 | 34.8781 | 0.169082 | 0.084541 | NAN |
| 1993 | 75 | 193 | 189.7542 | 80.32 | 31 | NAN | NAN | NAN | 24.21605 | 30.4525 | 68.5293002 | NAN | NAN | NAN | NAN | NAN | 12.04614 | 2.4245 | 12.8575 | 193.3647 | 0.286815 | 1.860152 | NAN |
| 1994 | NAN | 202.4 | 271.2615 | NAN | 48 | NAN | NAN | NAN | NAN | NAN | 66.1655119 | NAN | NAN | NAN | 0.889797 | 26.04963 | 18.20267 | 2.976 | 15.42 | 1563.886 | 0.299893 | 1.978313 | NAN |
| 1995 | 173 | 233.8 | 237.1014 | 82.84489 | 71 | 10912.15 | 358.5 | 875.92 | 24.1096 | 29.30833 | 66.5204986 | 55.91921 | 13.44143 | 21.03511695 | 0.724603 | 26.02959 | 11.71402 | 2.048214 | 13.195 | 138.6199 | 0.535806 | 1.735172 | NAN |
| 1996 | 213.5 | 245.9 | 335.8408 | 64.87851 | 99 | 13368.38 | 307.34 | 1247.63 | 24.7413 | 30.13929 | 32.5581745 | 54.47081 | 11.49803 | 16.10622323 | 0.680097 | 26.00976 | 16.37874 | 2.738148 | 13.17 | 87.53381 | 0.161116 | 4.784847 | NAN |
| 1997 | 193 | 245.5 | 316.7922 | 53.4554 | 146 | 12100.8 | 128.85 | 1257.47 | 25.04026 | 29.75763 | 35.8503392 | 57.16123 | 12.80027 | 19.08013572 | 0.642841 | 26.44078 | 23.23776 | 2.996296 | 12.4675 | 146.637 | 0.396019 | 2.906094 | NAN |
| 1998 | 238.5 | 341 | 399.5295 | 74.41755 | 209 | 15707.48 | 39.89 | 1883.71 | 24.31246 | 29.43232 | 59.8659213 | 54.83246 | 12.07829 | 14.72795595 | 0.599315 | 25.67582 | 22.58465 | 2.437083 | 14.85788 | 284.3053 | 0.306786 | 0.41271 | NAN |
| 1999 | 268.5 | 396 | 436.6215 | 72.1962 | 258 | 17607.48 | 165.63 | 3010.18 | 24.34782 | 29.31818 | 64.1333002 | 55.53736 | 13.24469 | 16.89572718 | 0.625535 | 25.4562 | 28.92315 | 3.743571 | 16.37973 | 159.9563 | 1.390683 | 1.672614 | 212445 |
| 2000 | 233.5 | 396 | 479.3183 | 71.99518 | 242 | 15893.36 | 280.34 | 0 | 24.77178 | 29.72143 | 76.2879786 | 55.34039 | 17.06054 | 19.78617993 | 0.578256 | 25.56624 | 36.70458 | 3.79 | 14.70485 | 32.37517 | 0.786922 | 11.43957 | 65895 |
| 2001 | 183.5 | 444 | 525.6538 | 126.0315 | 221 | 14475.58 | 174.9 | 1184.11 | 24.29452 | 29.22344 | 73.2801083 | 55.42376 | 19.05066 | 20.72328607 | 0.631052 | 25.14556 | 32.11821 | 2.618125 | 14.95657 | 15.9944 | 1.579162 | 3.659454 | 84211 |
| 2002 | 161.4 | 572 | 601.0916 | 111.1492 | 192 | 14133.2 | 134.00 | 399.1674 | 24.49541 | 29.00357 | 57.3008945 | 53.14969 | 14.16731 | 14.71784957 | 0.697372 | 25.60901 | 25.13581 | 2.737778 | 13.44069 | 49.85036 | 0.315962 | 3.875452 | 35104 |
| 2003 | 204.4155 | 697.085 | 618.0791 | 104.4793 | 265 | 16916.16 | 576.74 | 1411.072 | 24.46898 | 29.16607 | 100.654518 | 53.64665 | 9.829331 | 11.62760971 | 0.725179 | 25.68051 | 26.44734 | 1.39 | 14.82949 | 2.697975 | 1.025495 | 6.690889 | 21674 |
| 2004 | 353.7 | 810.906 | 611.4988 | 78.00419 | 263 | 26856.47 | 354.0949 | 839.4576 | 24.11824 | 29.44167 | 57.4551237 | 55.74617 | 6.687475 | 9.750099688 | 0.801358 | 25.41152 | 25.47267 | 1.751176 | 14.72647 | 5.928558 | 0.641498 | 3.436608 | 13632 |
| 2005 | 312.9 | 699 | 560.5802 | 83.01133 | 364 | 18587.5 | 187.0171 | 4502.482 | 23.70755 | 29.43103 | 99.0491569 | 59.48509 | 8.138107 | 12.97315708 | 0.663523 | 25.72156 | 29.51574 | 3.027 | 14.87547 | 99.40693 | 0.248843 | 13.99674 | 23505 |
| 2006 | 275.2 | 851 | 768.9347 | 75.86295 | 236 | 16288.53 | 121.2993 | 0 | 23.3233 | 29.35167 | 77.46739628 | 63.27783 | 9.697996 | 13.55526719 | 0.55389 | 26.35375 | 18.58516 | 3.497 | 15.85459 | 5.777386 | 0.795312 | 18.92322 | 55929 |

Table 4. Set statistics from DFO-industry survey AS0601 conducted by MV All Seven June 2 - 13 2006.

| SET | SFA | DATE | LAT. | LONG. | SPEED (kts) | DIST. (n. m.) | DUR. (min) | WING. (m) | DEPTH (fth) | TEMP (°C) | RAW CATCH | stand. catch (kg) | DENSITY (gm/$m^2$ or m.t./km2) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 13 | 02-Jun-06 | 45°34.64 | 59°07.82 | 2.3 | 1.13 | 29 | 18.6 | 111 | 4.5 | 42 | 43.1 | 1.1 |
| 2 | 13 | 02-Jun-06 | 45°36.85 | 58°53.72 | 2.3 | 1.13 | 29 | 17.7 | 119 | 5.0 | 76 | 82.5 | 2.0 |
| 3 | 13 | 02-Jun-06 | 45°38.92 | 58°56.32 | 2.2 | 1.09 | 29 | 17.2 | 129 | 4.9 | 103 | 119.7 | 3.0 |
| 4 | 13 | 02-Jun-06 | 45°42.08 | 58°59.42 | 2.3 | 1.13 | 29 | 16.5 | 144 | 5.4 | 150 | 174.5 | 4.3 |
| 5 | 13 | 02-Jun-06 | 45°48.08 | 59°00.08 | 2.3 | 1.11 | 29 | 19.1 | 117 | 4.8 | 71 | 73.1 | 1.8 |
| 6 | 13 | 02-Jun-06 | 45°50.32 | 58°49.04 | 2.4 | 1.17 | 30 | 16.7 | 137 | 4.9 | 359 | 401.2 | 10.0 |
| 7 | 13 | 02-Jun-06 | 45°51.41 | 58°41.93 | 2.4 | 1.18 | 30 | 16.9 | 146 | 5.1 | 564 | 614.6 | 15.3 |
| 8 | 13 | 02-Jun-06 | 45°48.08 | 58°39.48 | 2.4 | 1.17 | 30 | 15.3 | 150 | 5.3 | 162 | 196.0 | 4.9 |
| 9 | 13 | 02-Jun-06 | 45°46.03 | 58°36.49 | 2.3 | 1.14 | 29 | 16.8 | 130 | 5.2 | 35 | 39.5 | 1.0 |
| 10 | 13 | 02-Jun-06 | 45°45.02 | 58°43.61 | 2.4 | 1.19 | 30 | 15.4 | 145 | 5.3 | 123 | 146.6 | 3.6 |
| 11 | 13 | 03-Jun-06 | 45°49.64 | 58°32.90 | 2.4 | 1.20 | 30 | 16.4 | 156 | 5.2 | 168 | 184.7 | 4.6 |
| 12 | 13 | 03-Jun-06 | 45°45.53 | 58°23.17 | 2.3 | 1.15 | 30 | 17.8 | 197 | 4.1 | 45 | 47.9 | 1.2 |
| 13 | 13 | 03-Jun-06 | 45°37.39 | 58°14.87 | 2.3 | 1.13 | 30 | 17.2 | 198 | 3.8 | 25 | 28.0 | 0.7 |
| 14 | 13 | 03-Jun-06 | 45°33.58 | 58°21.54 | 2.2 | 1.12 | 30 | 17.1 | 172 | 3.8 | 50 | 57.3 | 1.4 |
| 15 | 13 | 03-Jun-06 | 45°34.16 | 58°44.17 | 2.3 | 1.13 | 30 | 17.9 | 120 | 3.9 | 72 | 77.8 | 1.9 |
| 16 | 17 | 04-Jun-06 | 45°17.65 | 59°51.75 | 2.2 | 1.09 | 29 | 18.4 | 103 | 2.8 | 147 | 159.3 | 4.0 |
| 17 | 17 | 04-Jun-06 | 45°12.99 | 59°55.94 | 2.4 | 1.19 | 30 | 18.0 | 126 | 2.8 | 218 | 222.3 | 5.5 |
| 18 | 17 | 04-Jun-06 | 45°20.53 | 60°01.56 | 2.4 | 1.20 | 30 | 17.8 | 118 | 2.9 | 144 | 147.2 | 3.7 |
| 19 | 17 | 04-Jun-06 | 45°19.19 | 60°14.00 | 2.4 | 1.17 | 29 | 18.0 | 114 | 2.6 | 119 | 122.5 | 3.0 |
| 20 | 17 | 04-Jun-06 | 45°20.26 | 60°17.18 | 2.4 | 1.12 | 30 | 18.1 | 107 | 2.6 | 149 | 159.8 | 4.0 |
| 21 | 17 | 04-Jun-06 | 45°24.66 | 60°08.06 | 2.3 | 1.14 | 30 | 17.6 | 105 | 2.7 | 184 | 199.8 | 5.0 |
| 22 | 17 | 04-Jun-06 | 45°29.05 | 60°02.96 | 2.3 | 1.13 | 30 | 17.8 | 99 | 2.8 | 267 | 289.1 | 7.2 |
| 23 | 17 | 04-Jun-06 | 45°32.60 | 60°10.36 | 2.4 | 1.16 | 30 | 17.8 | 104 | 2.6 | 211 | 222.9 | 5.5 |
| 24 | 17 | 04-Jun-06 | 45°34.96 | 60°13.92 | 2.3 | 1.15 | 30 | 17.5 | 80 | 2.4 | 347 | 374.5 | 9.3 |
| 25 | 17 | 05-Jun-06 | 45°33.85 | 60°20.04 | 2.3 | 1.15 | 30 | 18.4 | 99 | 2.6 | 456 | 470.1 | 11.7 |
| 26 | 17 | 05-Jun-06 | 45°26.89 | 60°25.36 | 2.3 | 1.12 | 30 | 18.2 | 104 | 2.5 | 179 | 190.3 | 4.7 |
| 27 | 17 | 05-Jun-06 | 45°32.95 | 60°34.16 | 2.4 | 1.14 | 29 | 17.8 | 71 | 2.4 | 136 | 146.6 | 3.6 |
| 28 | 17 | 05-Jun-06 | 45°29.82 | 60°38.81 | 2.3 | 1.10 | 29 | 17.3 | 79 | 2.4 | 147 | 169.0 | 4.2 |
| 29 | 17 | 05-Jun-06 | 45°24.98 | 60°39.99 | 2.3 | 1.10 | 30 | 17.9 | 81 | 2.5 | 119 | 131.4 | 3.3 |
| 30 | 17 | 05-Jun-06 | 45°22.42 | 61°01.24 | 2.5 | 1.22 | 30 | 16.3 | 60 | 1.9 | 211 | 231.6 | 5.7 |
| 31 | 14 | 07-Jun-06 | 44°51.54 | 59°03.48 | 2.4 | 1.16 | 30 | 18.2 | 126 | 2.1 | 469 | 483.3 | 12.0 |
| 32 | 14 | 07-Jun-06 | 44°47.46 | 59°11.39 | 2.4 | 1.19 | 29 | 17.3 | 122 | 2.2 | 366 | 388.2 | 9.6 |
| 33 | 14 | 07-Jun-06 | 44°50.17 | 59°28.36 | 2.3 | 1.16 | 30 | 17.5 | 132 | 2.9 | 505 | 538.2 | 13.4 |
| 34 | 14 | 07-Jun-06 | 44°51.21 | 59°42.50 | 2.5 | 1.22 | 29 | 17.2 | 118 | 3.2 | 467 | 486.0 | 12.1 |
| 35 | 14 | 07-Jun-06 | 44°47.17 | 59°58.54 | 2.4 | 1.18 | 30 | 16.9 | 134 | 3.0 | 798 | 871.9 | 21.6 |
| 36 | 14 | 07-Jun-06 | 44°53.57 | 59°59.77 | 2.4 | 1.19 | 30 | 17.3 | 113 | 2.7 | 245 | 259.0 | 6.4 |
| 37 | 15 | 11-Jun-06 | 44°59.46 | 60°57.42 | 2.3 | 0.96 | 25 | 17.9 | 104 | 4.3 | 161 | 202.8 | 5.0 |
| 38 | 15 | 11-Jun-06 | 44°58.36 | 61°01.67 | 2.4 | 1.13 | 29 | 18.0 | 105 | 4.8 | 101 | 108.2 | 2.7 |
| 39 | 15 | 11-Jun-06 | 44°56.18 | 61°06.63 | 2.2 | 1.06 | 30 | 17.4 | 104 | 5.0 | 163 | 191.9 | 4.8 |
| 40 | 15 | 11-Jun-06 | 44°52.52 | 60°58.17 | 2.3 | 1.13 | 30 | 18.0 | 132 | 5.4 | 369 | 395.3 | 9.8 |
| 41 | 15 | 11-Jun-06 | 44°55.13 | 60°56.90 | 2.3 | 1.08 | 29 | 18.0 | 107 | 4.8 | 130 | 145.7 | 3.6 |
| 42 | 15 | 11-Jun-06 | 44°56.09 | 60°47.89 | 2.3 | 1.07 | 29 | 17.9 | 117 | 5.1 | 210 | 238.0 | 5.9 |
| 43 | 15 | 11-Jun-06 | 44°52.68 | 60°48.07 | 2.3 | 1.12 | 30 | 17.9 | 133 | 5.1 | 95 | 102.8 | 2.6 |
| 44 | 15 | 11-Jun-06 | 44°49.78 | 60°40.62 | 2.4 | 1.13 | 30 | 16.8 | 159 | 4.9 | 151 | 172.3 | 4.3 |
| 45 | 15 | 11-Jun-06 | 44°46.52 | 60°36.34 | 2.3 | 1.14 | 29 | 17.9 | 132 | 4.9 | 129 | 137.9 | 3.4 |
| 46 | 15 | 12-Jun-06 | 44°56.53 | 60°26.95 | 2.2 | 1.07 | 29 | 17.6 | 120 | 2.9 | 443 | 510.9 | 12.7 |
| 47 | 15 | 12-Jun-06 | 44°53.95 | 60°21.25 | 2.3 | 1.10 | 29 | 17.6 | 111 | 2.9 | 95 | 106.8 | 2.7 |
| 48 | 15 | 12-Jun-06 | 44°56.62 | 60°13.90 | 2.3 | 1.12 | 30 | 17.8 | 114 | 2.8 | 329 | 358.7 | 8.9 |
| 49 | 15 | 12-Jun-06 | 44°51.11 | 60°13.97 | 2.2 | 1.08 | 30 | 18.2 | 159 | 3.0 | 322 | 356.4 | 8.8 |
| 50 | 15 | 12-Jun-06 | 44°43.36 | 60°12.07 | 2.3 | 1.10 | 30 | 18.4 | 118 | 4.2 | 105 | 113.3 | 2.8 |
| 51 | 15 | 12-Jun-06 | 44°39.26 | 60°17.84 | 2.3 | 1.14 | 30 | 18.3 | 123 | 3.2 | 123 | 128.5 | 3.2 |
| 52 | 14 | 12-Jun-06 | 44°41.60 | 60°00.67 | 2.3 | 1.12 | 30 | 18.0 | 117 | 4.1 | 330 | 356.4 | 8.8 |
| 53 | 14 | 12-Jun-06 | 44°42.75 | 59°46.95 | 2.3 | 1.09 | *29* | 18.4 | 138 | 3.8 | 73 | 79.1 | 2.0 |
| 54 | 14 | 13-Jun-06 | 44°41.45 | 59°34.28 | 2.4 | 1.14 | *29* | *17.6* | 119 | 3.3 | 575 | 622.1 | 15.4 |
| 55 | 14 | 13-Jun-06 | 44°40.78 | 59°18.50 | 2.4 | 1.18 | *30* | 17.5 | 119 | 2.6 | 442 | 466.3 | 11.6 |
| 56 | 14 | 13-Jun-06 | 44°39.34 | 59°02.32 | 2.3 | 1.11 | *29* | 18.1 | 117 | 2.2 | 457 | 494.7 | 12.3 |
| 57 | 14 | 13-Jun-06 | 44°47.97 | 58°51.03 | 2.3 | 1.14 | 30 | 17.1 | 140 | 2.4 | 334 | 373.3 | 9.3 |
| 58 | 14 | 13-Jun-06 | 44°50.38 | 58°33.04 | 2.4 | 1.15 | 30 | 18.5 | 137 | 2.6 | 723 | 736.5 | 18.3 |
| 59 | 14 | 13-Jun-06 | 44°54.79 | 58°21.10 | 2.4 | 1.15 | 30 | 17.1 | 133 | 2.7 | 689 | 761.6 | 18.9 |
| 60 | 14 | 13-Jun-06 | 44°55.27 | 58°31.57 | 2.4 | 1.13 | 30 | 20.5 | 129 | 2.6 | 665 | 624.2 | 15.5 |

Table 5. Minimum survey population numbers at age from modal analysis. Numbers x 10-6. Age 1 estimates are from catches in the belly-bag attached to the main trawl. [3]4 year olds not distinguished in the modal analysis

| | | 95 | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | Ave |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | | | | | | 980 | 196 | 316 | 155 | 58 | 342 |
| | 2 | 359 | 307 | 129 | 40 | 166 | 280 | 175 | 134 | 616 | 354 | 187 | 121 | 238.97 |
| | 3 | 1046 | 276 | 1159 | 785 | 27 | 757 | 362 | 383 | 312 | 3118 | 652 | 880 | 813.16 |
| | 4 | 876 | 1248 | 1257 | 1884 | 3010 | 0[3] | 1184 | 399 | 1506 | 839 | 4502 | 0[3] | 1679.66 |
| | 5+ | 1702 | 2162 | 1539 | 2047 | 1952 | 3374 | 2110 | 1847 | 1727 | 3324 | 2224 | 5106 | 2426.18 |
| | | | | | | | | | | | | | | |
| | TOTAL | 3983 | 3993 | 4084 | 4755 | 5155 | 4412 | 3831 | 2763 | 4161 | 7636 | 7720 | 6167 | 4888.36 |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| 4+ males | | 1369 | 1971 | 1578 | 2243 | 3235 | 1784 | 1771 | 938 | 1526 | 1549 | 4913 | 3914 | 2232.50 |
| primiparous | | 649 | 777 | 709 | 889 | 736 | 728 | 817 | 678 | 533 | 847 | 786 | 771 | 746.78 |
| multiparous | | 560 | 661 | 509 | 647 | 991 | 863 | 706 | 630 | 1175 | 1768 | 1183 | 480 | 842.93 |
| total females | | 1209 | 1438 | 1218 | 1535 | 1727 | 1591 | 1523 | 1308 | 1708 | 2615 | 1969 | 1251 | 1589.71 |

Table 6. Survey biomasses, commercial shrimp catches and exploitation rates (catch/biomass) by survey strata (13-15, offshore part), and the inshore area (17), 1995-2006.

| | | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 4837 | 6838 | 5920 | 7187 | 9517 | 5919 | 4089 | 3114 | 7047 | 12184 | 9686 | 6129 |
| | 14 | 9067 | 12094 | 9471 | 11278 | 11039 | 9544 | 12325 | 12020 | 12035 | 20228 | 20035 | 18929 |
| BIOMASS(mt) | 15 | 5299 | 6610 | 4736 | 4548 | 7806 | 7213 | 2073 | 2766 | 3751 | 4399 | 4378 | 5130 |
| | 17 | 4415 | 3663 | 6220 | 9530 | 8262 | 9183 | 6541 | 2872 | 5296 | 11627 | 10333 | 7580.671 |
| | **total** | **23620** | **29206** | **26349** | **32545** | **36625** | **31860** | **25038** | **20773** | **28130** | **48438** | **44433** | **37769** |
| | | | | | | | | | | | | | |
| | 13 | 169 | 58 | 538 | 514 | 615 | 302 | 565 | 254 | 582 | 2003 | 1186 | 684 |
| | 14 | 2284 | 2435 | 2285 | 2012 | 1511 | 2016 | 1552 | 1552 | 1626 | 754 | 1441 | 2385 |
| CATCH(mt) | 15 | 721 | 865 | 550 | 618 | 592 | 1615 | 1087 | 265 | 226 | 339 | 600 | 489 |
| | 17 | 0 | 0 | 0 | 787 | 2132 | 1503 | 1564 | 872 | 331 | 143 | 389 | 443 |
| | **total** | **3175** | **3358** | **3373** | **3931** | **4851** | **5436** | **4768** | **2943** | **2765** | **3239** | **3616** | **4000** |
| | | | | | | | | | | | | | |
| | 13 | 3.5 | 0.9 | 9.1 | 7.2 | 6.5 | 5.1 | 13.8 | 8.2 | 8.3 | 17.6 | 12.2 | 11.2 |
| | 14 | 25.2 | 20.1 | 24.1 | 17.8 | 13.7 | 21.5 | 12.6 | 12.9 | 13.5 | 3.6 | 7.2 | 12.6 |
| EXPLOITATION(%) | 15 | 13.6 | 13.1 | 11.6 | 13.6 | 7.6 | 22.2 | 52.4 | 9.6 | 6.0 | 9.6 | 13.7 | 9.5 |
| | 17 | 0.0 | 0.0 | 0.0 | 8.3 | 25.8 | 16.1 | 23.9 | 30.4 | 6.2 | 1.7 | 3.8 | 5.8 |
| | **total** | **13.4** | **10.9** | **13.6** | **12.1** | **13.2** | **17.1** | **19.1** | **14.2** | **9.8** | **7.2** | **8.1** | **10.6** |

Table 7. Information on shrimp collected during eastern Scotian Shelf snow crab surveys and calculated relative trawl efficiencies (gm/$m^2$) for trawls used on shrimp, crab and groundfish surveys. [1]rounded estimate

Snow crab survey

| | shrimp spp. | | | P. borealis | | | P. montagui | | |
|---|---|---|---|---|---|---|---|---|---|
| | **id'ed** | **counted** | **weighed** | **id'ed** | **counted** | **weighed** | **id'ed** | **counted** | **weighed** |
| **1996** | yes | no | no | no | no | no | no | no | no |
| **1997** | yes | no | no | no | no | no | no | no | no |
| **1998** | yes | no | no | no | no | no | no | no | no |
| **1999** | yes | no | no | no | no | no | no | no | no |
| **2000** | yes | no | no | no | no | no | no | no | no |
| **2001** | yes | no | no | no | no | no | no | no | no |
| **2002** | yes | yes[1] | no | no | no | no | no | no | no |
| **2003** | yes | yes[1] | no | no | no | no | no | no | no |
| **2004** | yes | yes[1] | no | yes | yes | no | yes | yes | no |
| **2005** | yes | yes | yes | yes | yes | yes | yes | yes | yes |

trawl efficiencies

| | **Mean kg/tow** | **Mean tow length (min)** | **Mean speed (kts)** | **Mean Catch per $m^2$ (gms)** |
|---|---|---|---|---|
| **2005 crab survey** | 2.5658 | 5 | 2 | 0.74 |
| **2005 shrimp survey** | 303.22 | 30 | 2.5 | 7.53 |
| **2000-2006 groundfish** | | | | |
| spring | 34.13 | 30 | 3.5 | 0.60 |
| summer | 37.82 | 30 | 3.5 | 0.66 |

Table 8. Total numbers and weight (kg) caught of all bycatch species for shrimp surveys conducted from 1995-2004. Weights were not recorded for individual catches weighing less than ~ 0.5 kg. Blanks for both weight and numbers indicate zero catches

| | 1995 | | 1996 | | 1997 | | 1998 | | 1999 | | 2000 | | 2001 | | 2002 | | 2003 | | 2004 | | ave | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **#** | **Wt** | **#** | **Wt** | **#** | **Wt** | **#** | **Wt** | **#** | **Wt** | **#** | **Wt** | **#** | **Wt** | **#** | **Wt** | **#** | **Wt** | **#** | **Wt** | **#** | **Wt** |
| Capelin | 10565 | 121 | 5318 | 46 | 3577 | 21 | 3868 | 75 | 2114 | 42 | 227 | 3 | 4710 | 102 | 57978 | 867 | 1776 | 37 | 1073 | 92 | 9121 | 141 |
| Silver Hake | 1530 | 29 | 1106 | 41 | 1311 | 40 | 1896 | 197 | 1221 | 102 | 908 | 105 | 918 | 86 | 692 | 32 | 1395 | 60 | 1500 | 177 | 1248 | 87 |
| Plaice | 1418 | 20 | 938 | 12 | 737 | 15 | 1247 | 28 | 1289 | 54 | 1727 | 89 | 1013 | 58 | 500 | 25 | 631 | 40 | 480 | 72 | 998 | 41 |
| Witch | | | | | | | 25 | | 162 | 12 | 5460 | 589 | 63 | 5 | 16 | 1 | 382 | 22 | | 64 | 611 | 69 |
| Turbot | 64 | 4 | 1254 | 23 | 471 | 26 | 117 | 17 | 415 | 39 | 1430 | 85 | 392 | 53 | 49 | 5 | 454 | 33 | 1118 | 116 | 576 | 40 |
| Herring | 144 | 5 | 68 | 2 | 105 | 1 | 200 | 8 | 561 | 21 | 1195 | 67 | 755 | 46 | 296 | 15 | 468 | 47 | 140 | 19 | 393 | 23 |
| Redfish | 1216 | 24 | 476 | 14 | 88 | 4 | 216 | 13 | 204 | 15 | 364 | 37 | 200 | 13 | 22 | | 30 | 2 | 104 | 12 | 292 | 13 |
| Vahl's Eelpout | 56 | 3 | 85 | 3 | 41 | 1 | 699 | 104 | 57 | 7 | 309 | 49 | 322 | 24 | 202 | 22 | 163 | 19 | 214 | 129 | 215 | 36 |
| Gaspereau | 3 | | | | | | 75 | 2 | 30 | 3 | 287 | 34 | 17 | | 230 | 13 | 114 | 7 | 55 | 11 | 81 | 7 |
| White Hake | | | 62 | | 210 | 4 | 114 | 1 | 71 | 6 | 28 | | 22 | | 16 | | 29 | | 93 | 5 | 65 | 2 |
| Pollock | 73 | 2 | 27 | 1 | 95 | 4 | 1 | | 3 | | 1 | | | | 3 | | 2 | | 358 | | 56 | 1 |
| Snake Blenny | | | 65 | | 73 | | 43 | | 79 | 1 | 34 | | 19 | | 11 | | 16 | | 142 | 6 | 48 | 1 |
| Cod | 38 | 2 | 27 | | 8 | | 11 | 1 | 57 | 3 | 28 | 4 | 64 | 8 | 44 | 4 | 41 | 2 | 34 | 7 | 35 | 3 |
| Sea Poacher | | | 30 | | 41 | 1 | 52 | 5 | 30 | 3 | 20 | 2 | 15 | 1 | 4 | | 6 | | 16 | 3 | 21 | 2 |
| Illex | 1 | | | | | | 110 | 4 | 43 | 2 | | | 1 | | 10 | | | | 3 | | 17 | 1 |
| 4 Brd. Rockling | | | | | | | 4 | | 31 | 4 | 55 | 10 | 2 | 1 | 1 | | 6 | | | | 10 | 2 |
| Hake | 17 | | | | | | | | | | 1 | | 59 | 4 | 5 | | | | | | 8 | 0 |
| Alligatorfish | 10 | | 16 | 1 | | | 15 | | 13 | 2 | 5 | 1 | 7 | 1 | 5 | | 3 | | 7 | | 8 | 0 |
| Skate | 11 | | 61 | 1 | | | | | 1 | | 6 | | | | | | | | 2 | | 8 | 0 |
| Sea Snail | 70 | 1 | | | | | | | | | 2 | | 3 | | | | 2 | | | | 8 | 0 |
| Longfin Hake | | | | | | | | | 1 | | | | 18 | | 16 | 1 | | | 1 | | 4 | 0 |
| Shad | | | | | | | 8 | | 2 | | | | 2 | | 1 | | | | 18 | 1 | 3 | 0 |
| Snow Crab | 14 | | | | | | 3 | | | | 4 | | 3 | | 1 | | 1 | | 5 | | 3 | 0 |
| Sculpins | | | | | | | 4 | | | | 1 | | | | | | 1 | | | | 1 | 0 |
| Wolffish | | | | | | | | | 3 | | 2 | | | | | | | | | | 1 | 0 |
| Winter fl. | | | | | | | 1 | | 2 | | 2 | | | | | | | | | | 1 | 0 |
| Saury | | | | | | | 1 | | 1 | | 1 | | 1 | | | | | | | | 0 | 0 |
| Haddock | | | | | | | | | 1 | | | | 2 | | | | | | | | 0 | 0 |
| Octopus | 2 | | | | | | | | | | | | | | | | | | | | 0 | 0 |
| Y.T Flounder | | | | | | | | | | | | | 2 | | | | | | | | 0 | 0 |
| Lumpfish | | | | | | | | | | | 1 | 1 | | | | | | | | | 0 | 0 |
| Hagfish | 1 | | | | | | | | | | | | | | | | | | | | 0 | 0 |
| Smelt | | | | | | | | | | | 1 | | | | | | | | | | 0 | 0 |
| **Total** | **15233** | **212** | **9533** | **143** | **6757** | **118** | **8710** | **455** | **6391** | **313** | **12099** | **1076** | **8610** | **402** | **60102** | **986** | **5520** | **270** | **5363** | **713** | **13832** | **469** |

Table 9. Percent composition of bycatch species in descending order of importance according to average catch/survey, conducted from 1995-2004.

| | Number | | | Weight | |
|---|---|---|---|---|---|
| | % of catch | cum. | | % of catch | cum. |
| Capelin | 65.940 | 65.940 | Capelin | 29.982 | 29.982 |
| Silver Hake | 9.021 | 74.960 | Silver Hake | 18.567 | 48.549 |
| Plaice | 7.215 | 82.175 | Witch | 14.776 | 63.325 |
| Witch | 4.416 | 86.591 | Plaice | 8.813 | 72.138 |
| Turbot | 4.167 | 90.759 | Turbot | 8.523 | 80.661 |
| Herring | 2.842 | 93.601 | Vahl's Eelpout | 7.721 | 88.382 |
| Redfish | 2.111 | 95.712 | Herring | 4.936 | 93.318 |
| Vahl's Eelpout | 1.553 | 97.265 | Redfish | 2.839 | 96.157 |
| Gaspereau | 0.586 | 97.851 | Gaspereau | 1.499 | 97.656 |
| White Hake | 0.466 | 98.318 | Cod | 0.648 | 98.304 |
| Pollock | 0.407 | 98.725 | 4 Brd. Rockling | 0.329 | 98.633 |
| Snake Blenny | 0.348 | 99.073 | White Hake | 0.327 | 98.960 |
| Cod | 0.254 | 99.328 | Sea Poacher | 0.321 | 99.281 |
| Sea Poacher | 0.155 | 99.482 | Pollock | 0.158 | 99.439 |
| Illex | 0.121 | 99.604 | Snake Blenny | 0.147 | 99.586 |
| 4 Brd. Rockling | 0.072 | 99.675 | Illex | 0.126 | 99.712 |
| Hake | 0.059 | 99.735 | Alligatorfish | 0.099 | 99.811 |
| Alligatorfish | 0.059 | 99.793 | Hake | 0.087 | 99.898 |
| Skate | 0.059 | 99.852 | Sea Snail | 0.029 | 99.927 |
| Sea Snail | 0.056 | 99.907 | Shad | 0.021 | 99.948 |
| Longfin Hake | 0.026 | 99.933 | Longfin Hake | 0.019 | 99.968 |
| Shad | 0.022 | 99.956 | Lumpfish | 0.019 | 99.987 |
| Snow Crab | 0.022 | 99.978 | Skate | 0.013 | 100.000 |
| Sculpins | 0.004 | 99.983 | Snow Crab | 0.000 | 100.000 |
| Wolffish | 0.004 | 99.986 | Sculpins | 0.000 | 100.000 |
| Winter fl. | 0.004 | 99.990 | Wolffish | 0.000 | 100.000 |
| Saury | 0.003 | 99.993 | Winter fl. | 0.000 | 100.000 |
| Haddock | 0.002 | 99.995 | Saury | 0.000 | 100.000 |
| Octopus | 0.001 | 99.996 | Haddock | 0.000 | 100.000 |
| Y.T Flounder | 0.001 | 99.998 | Octopus | 0.000 | 100.000 |
| Lumpfish | 0.001 | 99.999 | Y.T Flounder | 0.000 | 100.000 |
| Hagfish | 0.001 | 99.999 | Hagfish | 0.000 | 100.000 |
| Smelt | 0.001 | 100.000 | Smelt | 0.000 | 100.000 |

Table 10. Percent occurrence (# sets with species/total sets) for all bycatch species for each shrimp survey.

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | | | | | | | | | | | |
| Capelin | 0.843 | 0.983 | 0.814 | 0.729 | 0.903 | 1.00 | 0.92 | 0.867 | 0.75 | 0.89 | 0.87 |
| Turbot | 0.863 | 0.933 | 0.864 | 0.786 | 0.919 | 0.90 | 0.84 | 0.75 | 0.73 | 0.72 | 0.83 |
| Plaice | 0.922 | 0.65 | 0.881 | 0.586 | 0.774 | 0.49 | 0.67 | 0.733 | 0.62 | 0.62 | 0.69 |
| Witch | 0.451 | 0.683 | 0.797 | 0.371 | 0.565 | 0.83 | 0.77 | 0.317 | 0.62 | 0.79 | 0.62 |
| Vahl's Eelpout | 0.569 | 0.467 | 0.458 | 0.514 | 0.677 | 0.73 | 0.65 | 0.533 | 0.58 | 0.48 | 0.57 |
| Herring | 0.824 | 0.667 | 0.373 | 0.457 | 0.468 | 0.63 | 0.39 | 0.15 | 0.20 | 0.34 | 0.45 |
| Redfish | 0.392 | 0.367 | 0.407 | 0.414 | 0.29 | 0.58 | 0.44 | 0.433 | 0.38 | 0.66 | 0.44 |
| Sea Poacher | | 0.35 | 0.424 | 0.243 | 0.339 | 0.25 | 0.21 | 0.117 | 0.10 | 0.23 | 0.25 |
| Snake Blenny | | 0.217 | 0.525 | 0.314 | 0.258 | 0.24 | 0.12 | 0.117 | 0.22 | 0.18 | 0.24 |
| 4 Brd. Rockling | 0.333 | 0.25 | 0.119 | 0.129 | 0.339 | 0.25 | 0.16 | 0.267 | 0.25 | 0.28 | 0.24 |
| Cod | | | | 0.071 | 0.274 | 0.42 | 0.43 | 0.033 | 0.10 | 0.18 | 0.22 |
| Hake | 0.059 | | | 0.114 | 0.129 | 0.49 | 0.13 | 0.333 | 0.28 | 0.10 | 0.21 |
| Longfin Hake | | 0.267 | 0.271 | 0.314 | 0.226 | 0.24 | 0.15 | 0.067 | 0.08 | 0.10 | 0.19 |
| White Hake | | 0.283 | 0.542 | 0.043 | | | | 0.033 | 0.03 | | 0.19 |
| Silver Hake | 0.471 | | | | | 0.03 | 0.04 | | 0.02 | | 0.14 |
| Shad | 0.059 | 0.417 | | | 0.016 | 0.07 | | | | 0.02 | 0.12 |
| Smelt | | | | 0.057 | 0.113 | 0.37 | 0.03 | 0.017 | 0.05 | | 0.11 |
| Skate | 0.255 | | | | | 0.02 | 0.09 | 0.017 | | | 0.10 |
| Gaspereau | 0.02 | | | 0.243 | 0.113 | | 0.01 | | | 0.05 | 0.09 |
| Pollock | 0.176 | 0.233 | 0.153 | 0.014 | 0.032 | 0.02 | | 0.05 | 0.02 | | 0.09 |
| Haddock | 0.157 | 0.2 | | 0.057 | | 0.07 | 0.04 | 0.05 | 0.03 | 0.07 | 0.08 |
| Saury | 0.196 | | | 0.043 | | 0.05 | 0.01 | 0.017 | 0.02 | 0.07 | 0.06 |
| Sculpins | | | | 0.057 | 0.032 | | 0.03 | 0.017 | | 0.11 | 0.05 |
| Hagfish | | | | | 0.016 | | 0.04 | 0.1 | | 0.02 | 0.04 |
| Alligatorfish | | | | | 0.032 | 0.03 | | | | | 0.03 |
| Wolffish | | | | 0.014 | 0.032 | 0.03 | | | | | 0.03 |
| Lumpfish | | | | 0.043 | | 0.02 | | | 0.02 | | 0.03 |
| Y.T Flounder | 0.02 | | | | | | | | | | 0.02 |
| Winter fl. | 0.02 | | | | | | | | | | 0.02 |
| Sea Snail | | | | | | 0.02 | | | | | 0.02 |
| Illex | | | | | | 0.02 | | | | | 0.02 |
| Octopus | | | | | 0.016 | | 0.01 | 0.017 | | | 0.02 |
| Snow Crab | | | | 0.014 | 0.016 | 0.02 | 0.01 | | | | 0.02 |
| Other | | | | | | | 0.01 | | | | 0.01 |

Table 11. Percent bycatch by weight for each survey

| | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Shrimp (kg)** | 10483 | 8565 | 10874 | 17699 | 13792 | 13110 | 11979 | 8799 | 12169 | 19308 | **12678** |
| **Bycatch kg** | 212 | 143 | 118 | 455 | 313 | 1076 | 402 | 986 | 270 | 712.5 | **469** |
| **% bycatch by weight** | **2.0** | **1.6** | **1.1** | **2.5** | **2.2** | **7.6** | **3.2** | **10.1** | **2.2** | **3.6** | **3.6** |

Table 12. Estimated total weight (mt) and numbers of each bycatch species caught by commercial shrimp trawlers from 1995-2004.

| | | | | | Weight (mt) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **ave** |
| Capelin | 36.0 | 16.9 | 6.8 | 15.9 | 14.0 | 1.2 | 36.9 | 238.9 | 7.7 | 15.2 | 38.9 |
| S. Hake | | | | 0.1 | 3.9 | 217.2 | 1.8 | 0.4 | 4.5 | 10.6 | 23.9 |
| Plaice | 8.7 | 14.9 | 13.0 | 41.5 | 34.2 | 38.8 | 31.3 | 8.9 | 12.6 | 29.3 | 23.3 |
| Herring | 1.0 | 1.2 | 0.4 | 21.8 | 2.3 | 17.9 | 8.9 | 6.1 | 4.1 | 21.4 | 8.5 |
| Turbot | 1.2 | 8.2 | 8.4 | 3.5 | 12.9 | 31.4 | 19.1 | 1.5 | 6.9 | 19.1 | 11.2 |
| Witch | 5.9 | 4.4 | 4.8 | 5.9 | 18.1 | 32.9 | 20.9 | 6.9 | 8.4 | 11.9 | 12.0 |
| Redfish | 1.5 | 0.6 | 0.5 | 1.8 | 7.1 | 24.7 | 16.6 | 4.2 | 9.7 | 3.1 | 7.0 |
| V. Eelpout | 7.1 | 4.9 | 1.3 | 2.7 | 5.2 | 13.5 | 4.6 | 0.1 | 0.5 | 2.0 | 4.2 |
| Gasper. | | 0.0 | | 0.4 | 0.9 | 12.7 | 0.2 | 3.6 | 1.5 | 1.8 | 2.1 |
| Flounder | | | | | | | | | 3.6 | | 0.4 |
| W. Hake | | | | | 1.2 | 3.8 | 0.5 | | | | 0.6 |
| Cod | | | | 0.3 | 0.9 | 1.3 | 3.0 | 1.1 | 0.5 | 1.1 | 0.8 |
| Poacher | | | | | 0.3 | | | | | 1.0 | 0.1 |
| S. Blenny | | | 1.1 | 0.2 | 2.0 | | | | | 0.8 | 0.4 |
| 4 Brd. Rock | | | 0.5 | 1.1 | 0.9 | 0.7 | 0.5 | | | 0.4 | 0.4 |
| Hake | 0.7 | 0.3 | 1.4 | | | | | | | | 0.2 |
| Illex | | | | 0.9 | 0.6 | | | | | | 0.1 |
| Pollock | | | | | | | 1.5 | | | | 0.1 |
| Skate | | 0.4 | | | 0.6 | 0.3 | 0.3 | | | | 0.2 |
| Alligatorfish | 0.4 | | | | | | | | | | 0.0 |
| S. Snail | | | | | | | | | | 0.2 | 0.0 |
| LF Hake | | | | | | | | 0.2 | | | 0.0 |
| Shad | | 0.0 | | | | 0.3 | | | | | 0.0 |
| S. Crab | | 0.2 | | | | | | | | | 0.0 |
| Sculpins | | | | | | | | | | | |
| Wolffish | | | | | | | | | | | |
| Winter fl. | | | | | | | | | | | |
| Smelt | | | | | | | | | | | |
| Haddock | | | | | | | | | | | |
| Saury | | | | | | | | | | | |
| Hagfish | | | | | | | | | | | |
| Lumpfish | | | | | | | | | | | |
| Yellopwtail | | | | | | | | | | | |
| Octopus | | | | | | | | | | | |
| **total** | **63** | **52** | **38** | **96** | **105** | **397** | **146** | **272** | **60** | **118** | **135** |

Table 12 Cont.

| | | | | | | Numbers | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **ave** |
| Capelin | 7,149,812 | 2,365,108 | 1,865,618 | 1,460,098 | 1,004,689 | 117,532 | 1,607,440 | 12,743,722 | 342,393 | 163,384 | 2,881,979 |
| Plaice | 1,035,420 | 491,912 | 683,764 | 715,713 | 580,369 | 470,129 | 313,271 | 152,103 | 268,940 | 228,402 | 494,002 |
| Witch | 959,625 | 417,191 | 384,389 | 470,725 | 612,691 | 894,176 | 345,690 | 109,901 | 121,650 | 73,089 | 438,913 |
| S. Hake | 0 | 0 | 0 | 9,437 | 77,002 | 2,826,984 | 21,499 | 3,517 | 73,645 | 0 | 301,208 |
| Turbot | 43,312 | 557,737 | 245,654 | 44,166 | 197,259 | 740,401 | 133,771 | 10,770 | 87,526 | 170,236 | 223,083 |
| Redfish | 97,451 | 30,244 | 54,764 | 75,497 | 266,656 | 618,468 | 257,646 | 65,061 | 90,225 | 21,318 | 157,733 |
| V. Eelpout | 822,922 | 211,709 | 45,897 | 81,537 | 96,966 | 188,569 | 68,251 | 4,836 | 5,784 | 15,836 | 154,231 |
| Herring | 37,898 | 37,805 | 21,384 | 263,787 | 27,093 | 159,989 | 109,884 | 44,400 | 31,425 | 32,585 | 76,625 |
| Gasp. | 2,030 | 0 | 0 | 28,311 | 14,260 | 148,598 | 5,801 | 50,555 | 21,978 | 8,375 | 27,991 |
| S. Blenny | 0 | 27,576 | 109,527 | 43,033 | 33,748 | 14,497 | 7,508 | 3,517 | 5,591 | 14,161 | 25,916 |
| Poacher | 0 | 28,910 | 38,074 | 16,232 | 37,550 | 17,604 | 6,484 | 2,418 | 3,085 | 21,622 | 17,198 |
| Hake | 49,402 | 12,009 | 49,548 | 377 | 1,426 | 518 | 0 | 659 | 386 | 54,512 | 16,884 |
| Cod | 25,716 | 12,009 | 4,172 | 4,152 | 27,093 | 14,497 | 21,840 | 9,671 | 7,904 | 5,177 | 13,223 |
| 4 Brd. Rock | 0 | 13,343 | 21,384 | 19,629 | 14,260 | 10,355 | 5,119 | 879 | 1,157 | 2,436 | 8,856 |
| Illex | 677 | 0 | 0 | 41,523 | 20,439 | 0 | 341 | 2,198 | 0 | 457 | 6,564 |
| Alligatorfish | 47,372 | 0 | 0 | 0 | 0 | 1,036 | 1,024 | 0 | 386 | 0 | 4,982 |
| W. hake | 0 | 0 | 0 | 1,510 | 14,735 | 28,477 | 683 | 220 | 1,157 | 0 | 4,678 |
| S. Crab | 7,444 | 27,131 | 0 | 0 | 475 | 3,107 | 0 | 0 | 0 | 305 | 3,846 |
| Skate | 6,767 | 7,116 | 0 | 5,662 | 6,179 | 2,589 | 2,389 | 1,099 | 578 | 1,066 | 3,345 |
| Pollock | 11,505 | 0 | 0 | 0 | 0 | 518 | 20,134 | 1,099 | 0 | 0 | 3,326 |
| Sculpins | 9,474 | 0 | 0 | 1,132 | 0 | 2,071 | 1,024 | 220 | 193 | 761 | 1,488 |
| LH hake | 0 | 0 | 0 | 0 | 475 | 0 | 6,143 | 3,517 | 0 | 152 | 1,029 |
| S. Snail | 0 | 0 | 0 | 3,020 | 951 | 0 | 683 | 220 | 0 | 2,741 | 761 |
| Wolffish | 0 | 0 | 0 | 0 | 1,426 | 1,036 | 0 | 0 | 0 | 0 | 246 |
| Haddock | 0 | 0 | 0 | 377 | 951 | 1,036 | 0 | 0 | 0 | 0 | 236 |
| Saury | 0 | 0 | 0 | 1,510 | 0 | 518 | 0 | 0 | 193 | 0 | 222 |
| Hagfish | 0 | 0 | 0 | 377 | 475 | 518 | 341 | 0 | 0 | 0 | 171 |
| Winter fl. | 1,353 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 135 |
| Octopus | 0 | 0 | 0 | 0 | 475 | 0 | 683 | 0 | 0 | 0 | 116 |
| Smelt | 0 | 0 | 0 | 0 | 0 | 0 | 683 | 0 | 0 | 0 | 68 |
| Yellowtail | 677 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 68 |
| Lumpfish | 0 | 0 | 0 | 0 | 0 | 518 | 0 | 0 | 0 | 0 | 52 |
| Shad | 0 | 0 | 0 | 0 | 0 | 518 | 0 | 0 | 0 | 0 | 52 |

Table 13  Shrimp catch and bycatch by fishing set for all commercial shrimp sets on the observer database.

| | 1996 (Sable) | | | | | | 1999 (inshore) | | | | | 2004 (Louisbourg, Sable, Canso) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PANDALUS BOREALIS** | 2771 | 3682 | 3960 | 4490 | 7295 | | 7437 | 3674 | 6705 | 5207 | | 1956 | 7924 | 4737 | 1470 |
| **SILVER HAKE** | 20 | 90 | 100 | 120 | 155 | | | | | | | | | | 2.00 |
| **TURBOT** | | | | | | | 9 | 3 | | | | 212.63 | 65.80 | 26.00 | 0.18 |
| **WITCH FLOUNDER** | | 6 | 4 | 35 | 14 | | 17 | 9 | | | | 0.08 | 1.49 | 2.02 | 23.00 |
| **AMERICAN PLAICE** | | 6 | 6 | 35 | 14 | | 43 | 4 | 3 | 6 | | | 0.35 | 0.38 | 0.00 |
| **WINTER FLOUNDER** | | | | | | | | | | | | | 0.81 | 1.68 | 1.50 |
| **SHORT-FIN SQUID** | 4 | 4 | 25 | 20 | 22 | | | | | | | | | | 0.05 |
| **HERRING** | 3 | | 5 | | | | 2 | | 2 | 5 | | 0.78 | 3.81 | 2.58 | 4.00 |
| **REDFISH** | | | | | | | 16 | 1 | | | | | 0.15 | 0.49 | 0.18 |
| **SQUID** | | | | | | | | | 1 | 29 | | | | | |
| **OCEAN POUT** | | | | | | | | | | | | | | | |
| **CAPELIN** | 2 | 12 | | | | | 6 | | | 1 | | | | 0.06 | |
| **SNOW CRAB** | | | | | | | 2 | 3 | 10 | | | | | | |
| **AMERICAN EEL** | | | | | | | | | | | | | | | 2.50 |
| **EELPOUTS** | | | | | | | | | | | | | | | 1.00 |
| **COD** | | | | | | | 10 | | | | | | 0.21 | 0.17 | |
| **SEA POACHER** | | | | | | | | | | | | | | | |
| **RIBBED SCULPIN** | | | | | | | | | | | | | | | |
| **PERISTEDION SP.** | | | | | | | 8 | 1 | | | | | | | |
| **WRYMOUTH** | | | | | | | 8 | 1 | | | | | | | |
| **ASTEROIDEA S.C.** | | | | | | | 5 | 1 | | | | | | 1.00 | |
| **YELLOWTAIL** | | | | | | | | | | | | | | | |
| **WHITE HAKE** | | | | | | | 4 | | | | | 0.05 | | 0.17 | |
| **MUD SHRIMP** | | | | | | | | | 1 | 3 | | | | | |
| **EELPOUT(VAHL)** | | | | | | | | | | | | | | | |
| **RED HAKE** | | | | | | | | | | | | | | | |
| **FOURBEARD ROCKLING** | | | | | | | | | | | | | | | |
| **SNAKE BLENNY** | | | | | | | | | | | | | | | |
| **ALEWIFE** | | | | | | | | | | | | | | | |
| **THORNY SKATE** | | | | | | | | | | | | | | 0.01 | 0.02 |
| **SAURY** | | | | | | | | | | | | 0.04 | 0.07 | | |
| **ALLIGATORFISH** | | | | | | | | | | | | | | | |
| **ARCTIC COD** | | | | | | | | | 1 | | | | | | |
| **NYBELIN S SCULPIN** | | | | | | | | | | | | | | | |
| **PALE EELPOUT** | | | | | | | | | | | | | | | |
| **PONTASTER SP.** | | | | | | | | 1 | | | | | | | |
| **SCULPIN** | | | | | | | | | 1 | | | | | | |
| **SHAD** | | | | | | | | 1 | | | | | | | |
| **WOLFFISH** | | | | | | | | | | | | | | | |
| **CUSK** | | | | | | | | | | | | | 0.25 | | |
| **OFF-SHORE HAKE** | | | | | | | | | | | | 0.13 | 0.04 | | |
| **SAND LANCES** | | | | | | | | | | | | | | | |
| **SEA SCALLOP** | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **Perc. bycatch by weight** | **1.05** | **3.20** | **3.54** | **4.68** | **2.81** | | **1.75** | **0.68** | **0.28** | **0.85** | | **10.93** | **0.92** | **0.73** | **2.34** |

Table 13 Cont.

| | 2004 con't (Louisbourg, Sable, Canso) | | | | | | | 2005 (Sable) | | | | | 2006 (Canso) | | | Total (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PANDALUS BOREALIS** | 6868 | 9576 | 3023 | 2160 | 1910 | 2109 | | 880 | 1677 | 2448 | | 1031 | 9799 | 9888 | 2041 | **114718.0** |
| **SILVER HAKE** | 3.00 | 1.00 | 1.80 | 1.80 | 6.00 | 7.00 | | 3 | 3 | 5 | | 33 | 176 | 96 | 35 | **858.6** |
| **TURBOT** | 0.30 | | | | 26.00 | 78.00 | | 8 | 5 | 10 | | | 1 | | | **444.9** |
| **WITCH FLOUNDER** | 55.00 | 6.00 | 30.00 | 39.00 | 6.00 | 7.00 | | 3 | 3 | 9 | | 15 | 44 | 40 | 10 | **378.6** |
| **AMERICAN PLAICE** | | | | | | | | 6 | 8 | 14 | | 4 | 1 | | | **150.7** |
| **WINTER FLOUNDER** | 9.00 | 70.00 | 2.60 | 3.00 | 11.00 | 15.00 | | | | | | | | | | **114.6** |
| **SHORT-FIN SQUID** | 0.70 | 2.20 | 0.40 | 0.80 | 12.00 | 17.00 | | | | | | 2 | 2 | | | **112.2** |
| **HERRING** | 6.50 | 24.00 | 3.00 | 3.40 | 8.00 | 4.00 | | 4 | 3 | 5 | | 0 | 1 | | | **90.1** |
| **REDFISH** | 1.25 | 3.50 | 0.60 | 1.40 | 7.00 | 7.00 | | 6 | 6 | 6 | | 5 | 2 | | | **63.6** |
| **SQUID** | | | | | | | | 3 | 3 | 2 | | | | | | **38.0** |
| **OCEAN POUT** | | | | | | | | | | | | | 18 | 5 | 10 | **33.0** |
| **CAPELIN** | 0.40 | 0.10 | 0.10 | 0.02 | 4.00 | 7.00 | | | | | | | | | | **32.7** |
| **SNOW CRAB** | | 0.10 | | | 2.00 | 2.00 | | | | 1 | | 1 | 1 | 3 | 1 | **26.1** |
| **AMERICAN EEL** | 8.50 | 2.30 | 4.00 | 1.55 | | 3.00 | | | | | | | 2 | | | **23.9** |
| **EELPOUTS** | 2.40 | 1.30 | 3.20 | 1.10 | 4.00 | 5.00 | | | | | | | | | | **18.0** |
| **COD** | | 0.10 | | | | | | | | 2 | | 2 | 1 | | | **15.5** |
| **SEA POACHER** | | | | | | | | 1 | 3 | 6 | | 3 | | | | **13.0** |
| **RIBBED SCULPIN** | | 1.20 | | 0.11 | 4.00 | 5.00 | | | | | | | | | | **10.3** |
| **PERISTEDION SP.** | | | | | | | | | | | | | | | | **9.0** |
| **WRYMOUTH** | | | | | | | | | | | | | | | | **9.0** |
| **ASTEROIDEA S.C.** | | | | | | | | | | | | | | | | **7.0** |
| **YELLOWTAIL** | | 3.90 | | | | | | | | 2 | | | | | | **5.9** |
| **WHITE HAKE** | | | | | | | | | | | | | | | | **4.2** |
| **MUD SHRIMP** | | | | | | | | | | | | | | | | **4.0** |
| **EELPOUT(VAHL)** | | | | | | | | | | | | 4 | | | | **4.0** |
| **RED HAKE** | | | | | | | | | 1 | 3 | | | | | | **4.0** |
| **FOURBEARD ROCKLING** | | | | | | | | | | | | 2 | 1 | | | **3.0** |
| **SNAKE BLENNY** | | | | | | | | 2 | | 1 | | | | | | **3.0** |
| **ALEWIFE** | 0.70 | | | | | | | | | 1 | | 1 | | | | **2.7** |
| **THORNY SKATE** | 0.15 | 0.50 | | | 2.00 | | | | | | | | | | | **2.7** |
| **SAURY** | | | | | 2.00 | | | | | | | | | | | **2.1** |
| **ALLIGATORFISH** | | | | | | | | | 1 | 1 | | | | | | **2.0** |
| **ARCTIC COD** | | | | | | | | | | | | | | | | **1.0** |
| **NYBELIN S SCULPIN** | | | | | | | | | | 1 | | | | | | **1.0** |
| **PALE EELPOUT** | | | | | | | | | | 1 | | | | | | **1.0** |
| **PONTASTER SP.** | | | | | | | | | | | | | | | | **1.0** |
| **SCULPIN** | | | | | | | | | | | | | | | | **1.0** |
| **SHAD** | | | | | | | | | | | | | | | | **1.0** |
| **WOLFFISH** | | | | | | | | | | 1 | | | | | | **1.0** |
| **CUSK** | | | | | | | | | | | | | | | | **0.3** |
| **OFF-SHORE HAKE** | | | | | | | | | | | | | | | | **0.2** |
| **SAND LANCES** | 0.05 | | | | | | | | | | | | | | | **0.1** |
| **SEA SCALLOP** | | 0.05 | | | | | | | | | | | | | | **0.1** |
| | | | | | | | | | | | | | | | | |
| **% bycatch** | **1.28** | **1.21** | **1.51** | **2.42** | **4.92** | **7.44** | | **4.09** | **2.15** | **2.90** | | **6.98** | **2.55** | **1.46** | **2.74** | **2.17** |

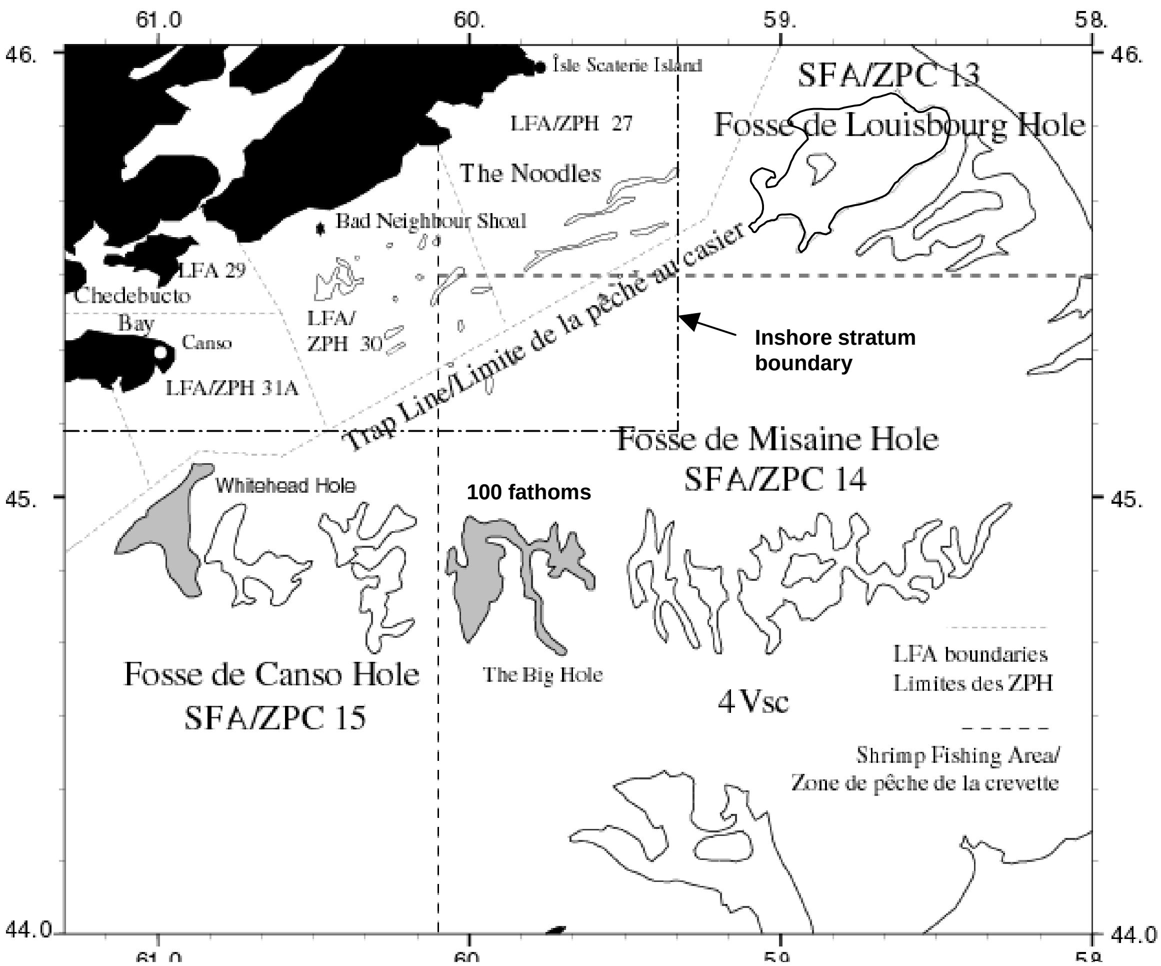



Figure 1. Shrimp Fishing Areas (SFAs) on the Eastern Scotian Shelf. The lobster Fishing Areas (LFAs) used to allocate shrimp trap licences, and the shrimp trap line are also shown. Trappers are prohibited from fishing seaward of this line. Another line (not shown) prohibits trawlers from fishing inside Chedebucto Bay during the trapping season (fall to spring). Note the distinction between SFAs used to report catches and survey strata defined by the 100 fathom contour (except the inshore stratum, whose boundary is also shown).

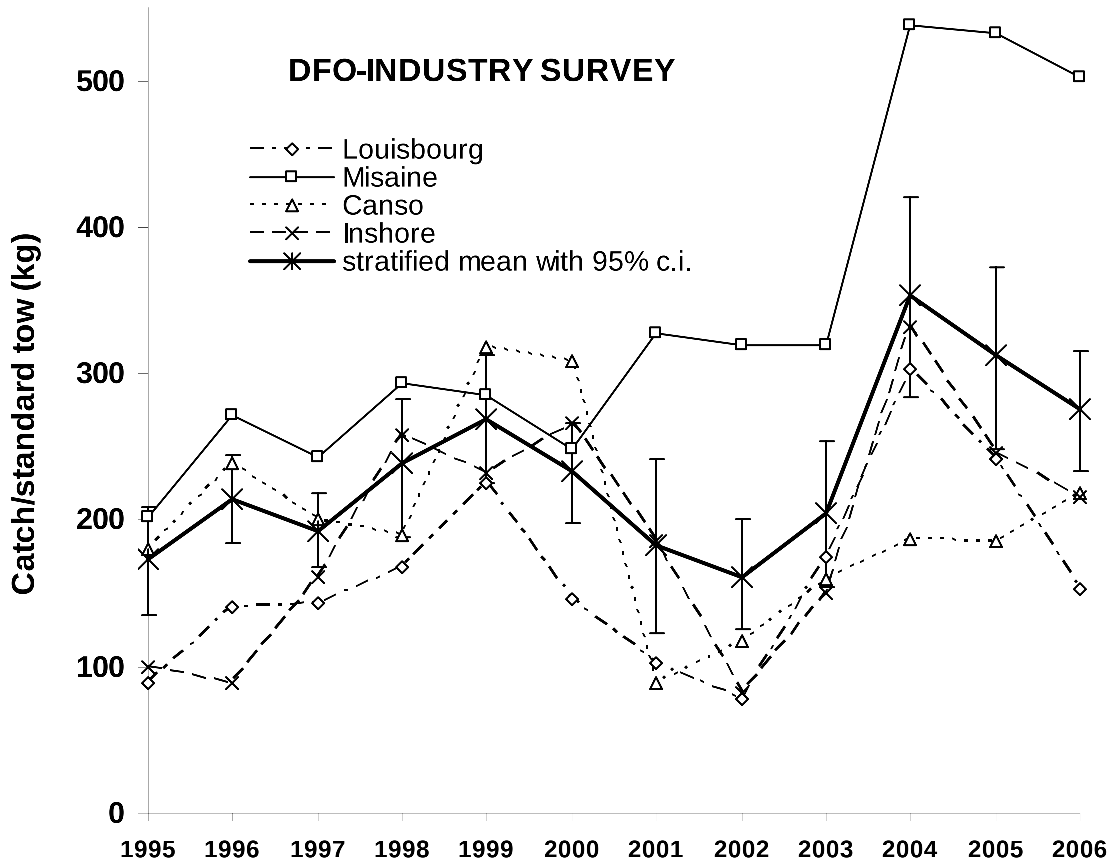



Figure 2. Stratified catch/standard tow for DFO-industry co-operative surveys, 1995-2006 and estimates for the individual strata, which approximately correspond to the main shrimp holes and SFAs. Stratum 13 - Louisbourg Hole and SFA 13; Stratum 14 - Misaine Holes and SFA 14; Stratum 15 - Canso Holes and the offshore part of SFA 15. The Inshore, or Stratum 17, is comprised of inshore parts of SFA 13-15.

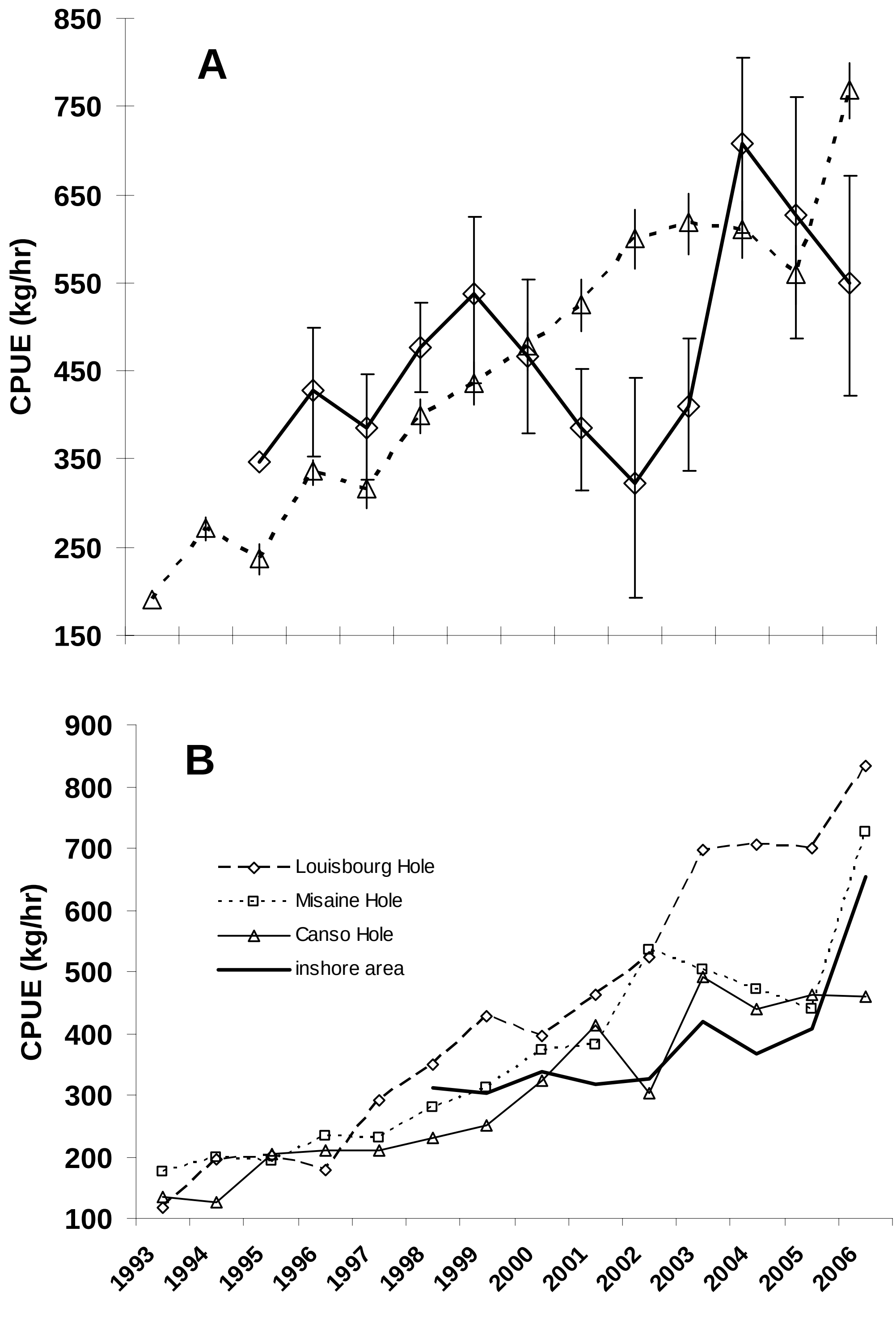



Figure 3. A - Survey stratified estimate (solid line) and standardised CPUE with 95% confidence intervals (dashed line), and B - unstandardised commercial CPUE for each fishing area. Note that SFA15 includes the inshore, but the latter is also shown separately since fishing began there in 1998.

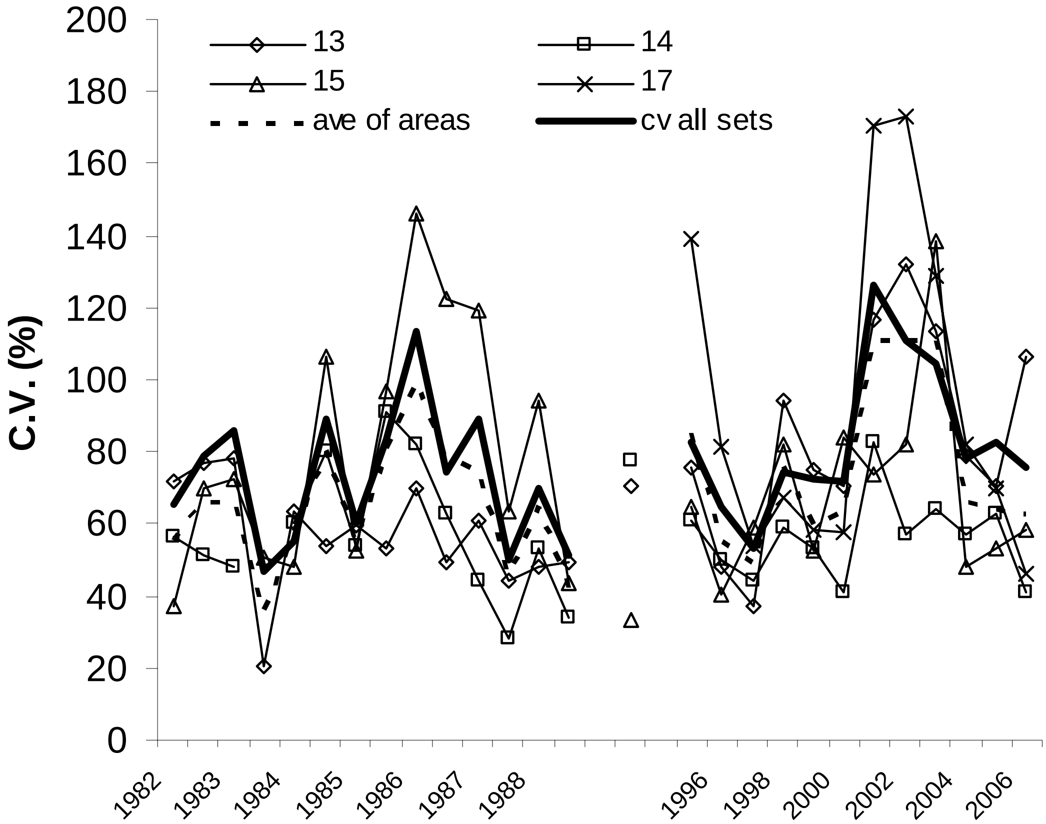
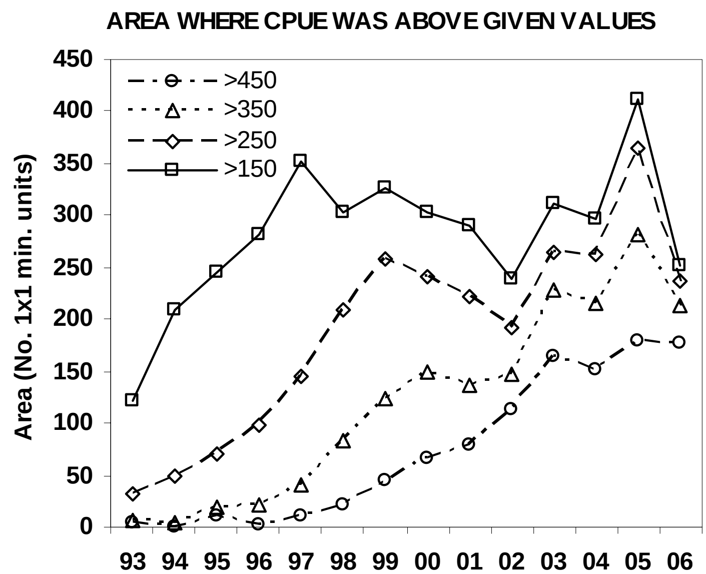



Figure 4. Coefficients of variation (C.V.) for shrimp survey strata 13, 14, 15 and 17. Note that the earlier survey series has two values per year, one for the spring and one for the fall survey.



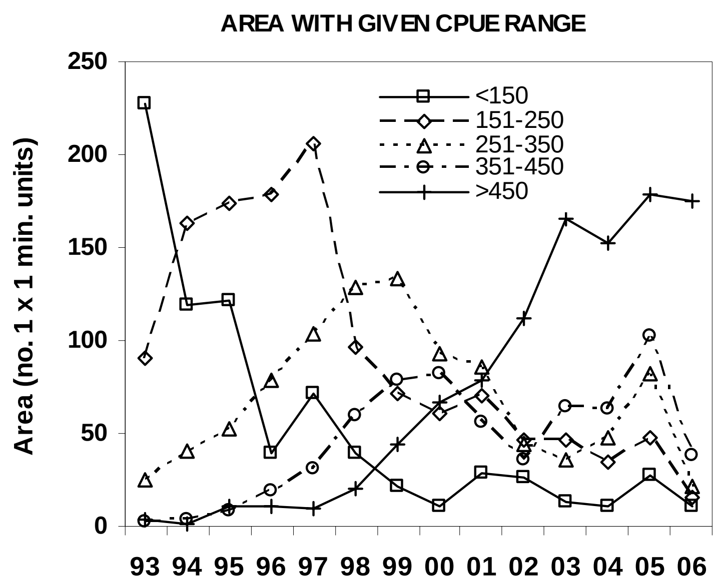




Figure 5. Number of 1 minute square unit areas fished by the shrimp fleet with mean catch rates above (top) and within (bottom) the values or ranges specified in the legend.

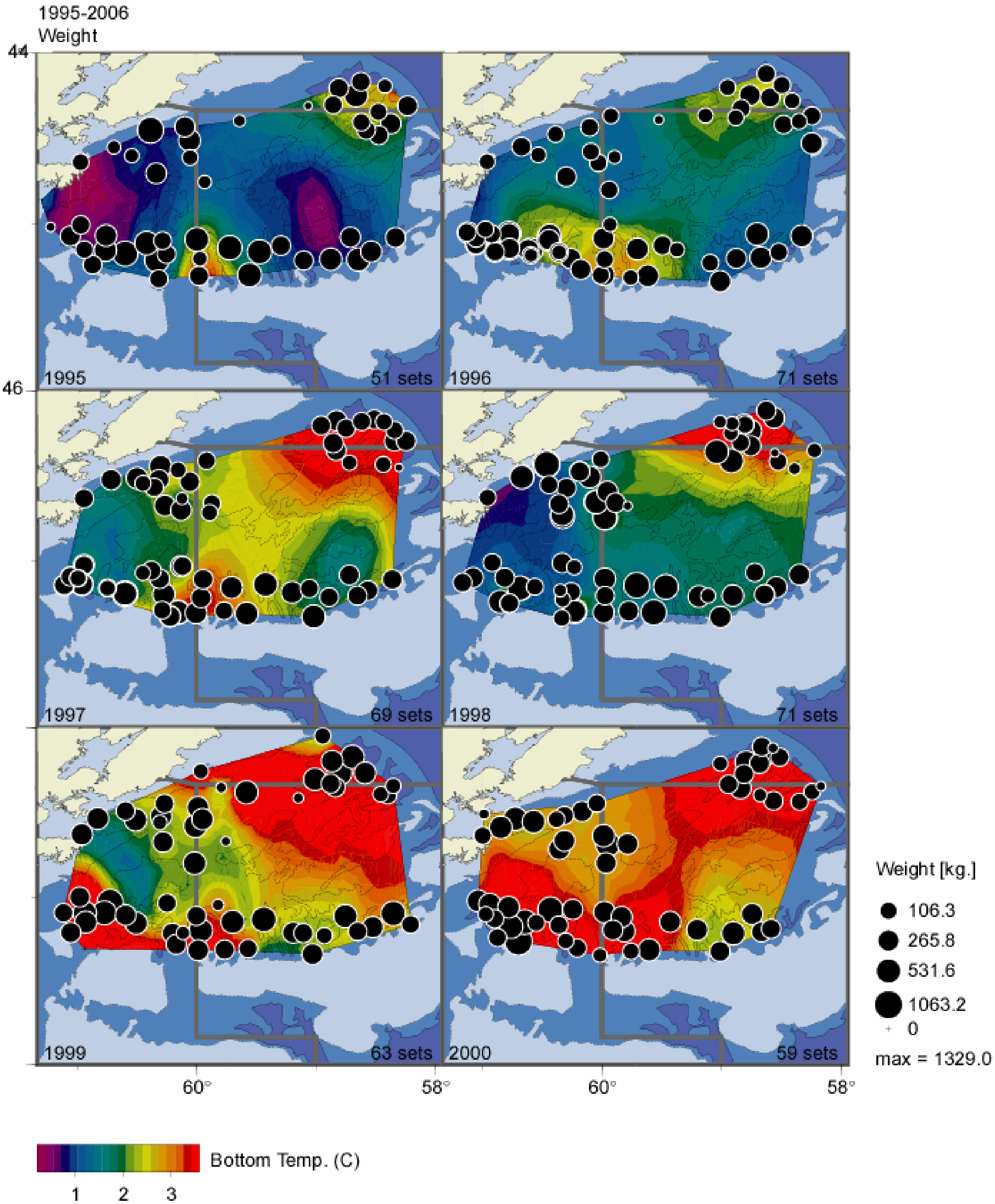



Figure 6. Distribution of catches and bottom temperatures from DFO-industry surveys 1995-2006.

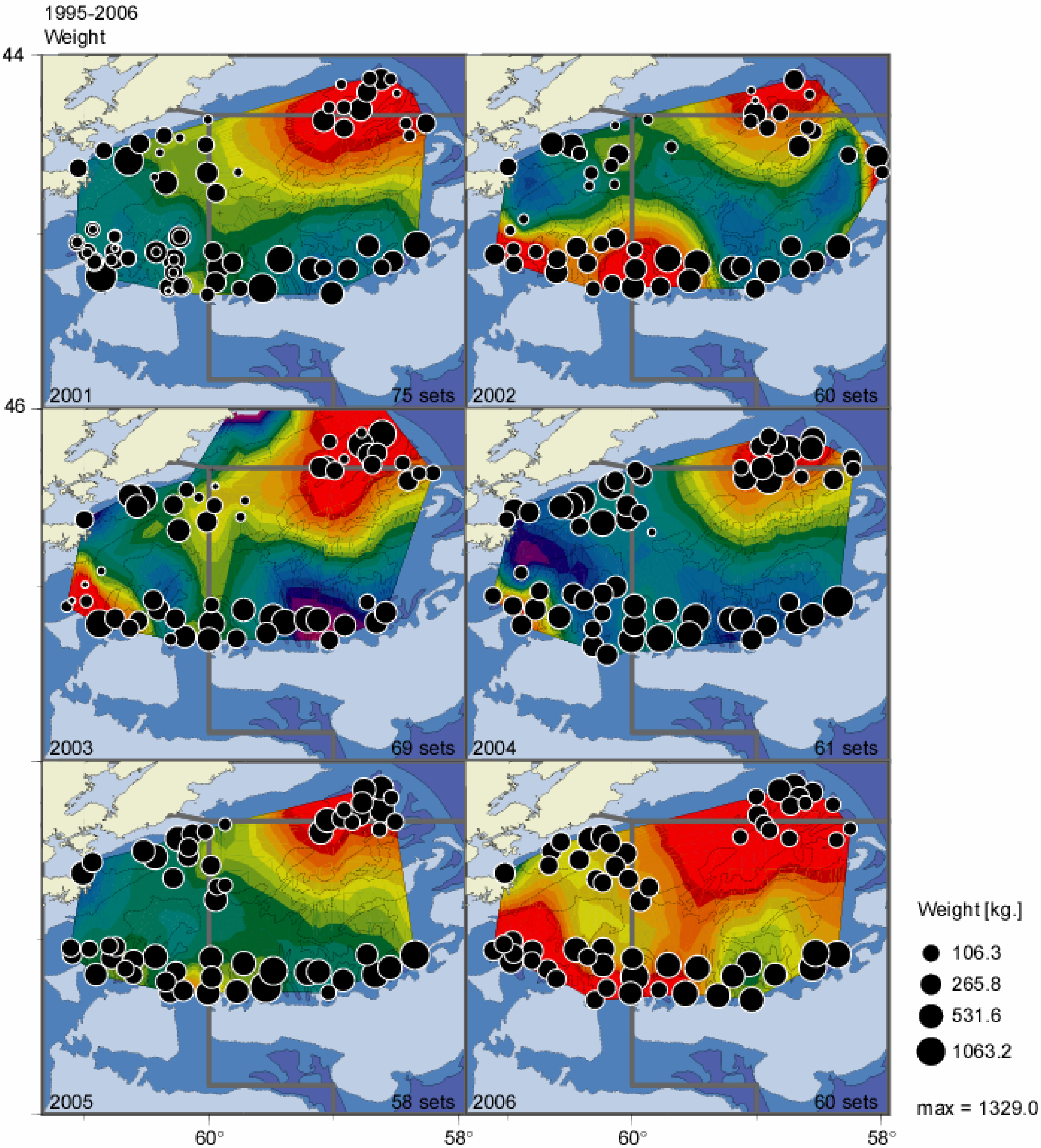



Figure 6. Continued

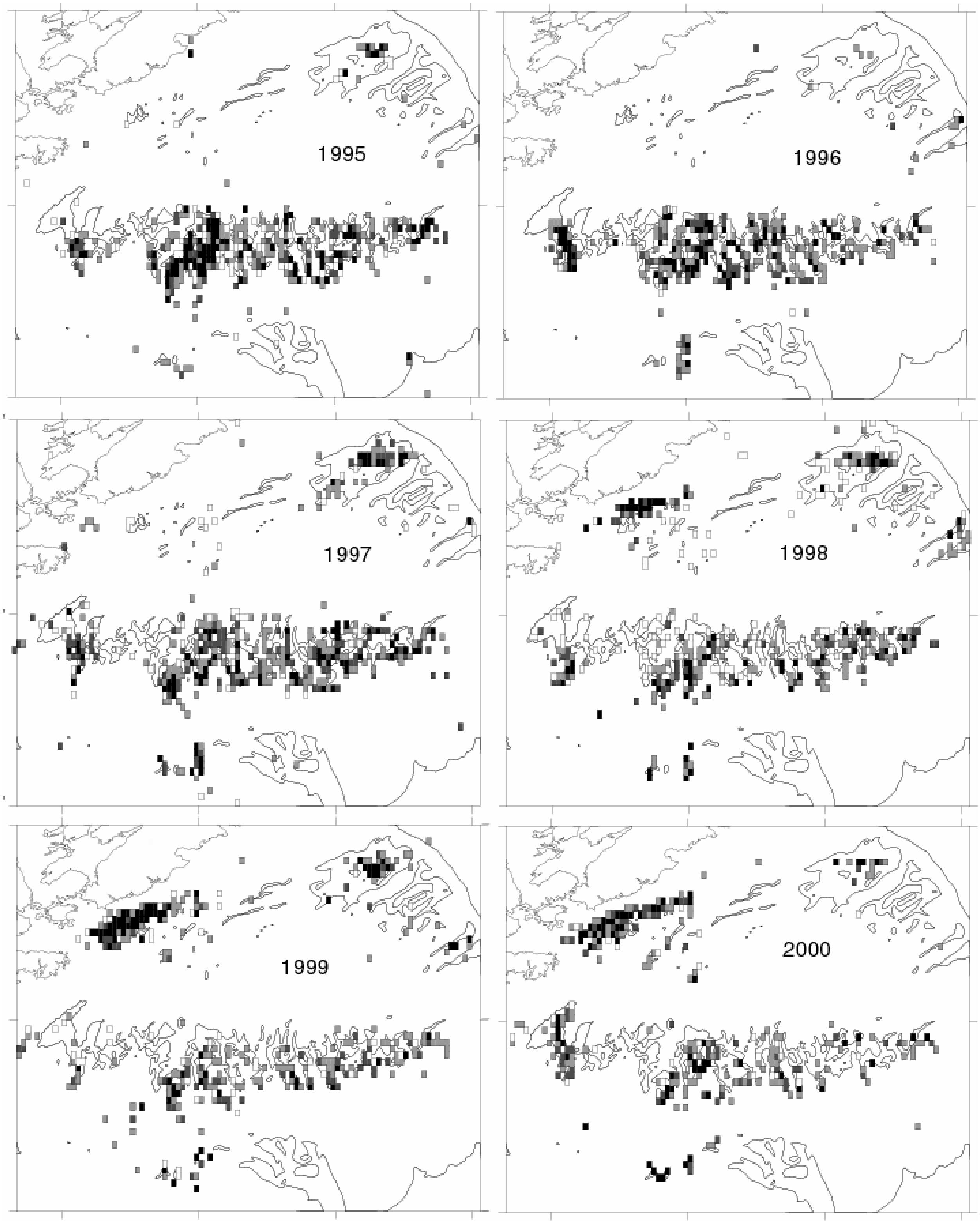



Figure 7. Annual effort by trawlers 1995-2006, cumulative by one minute squares.

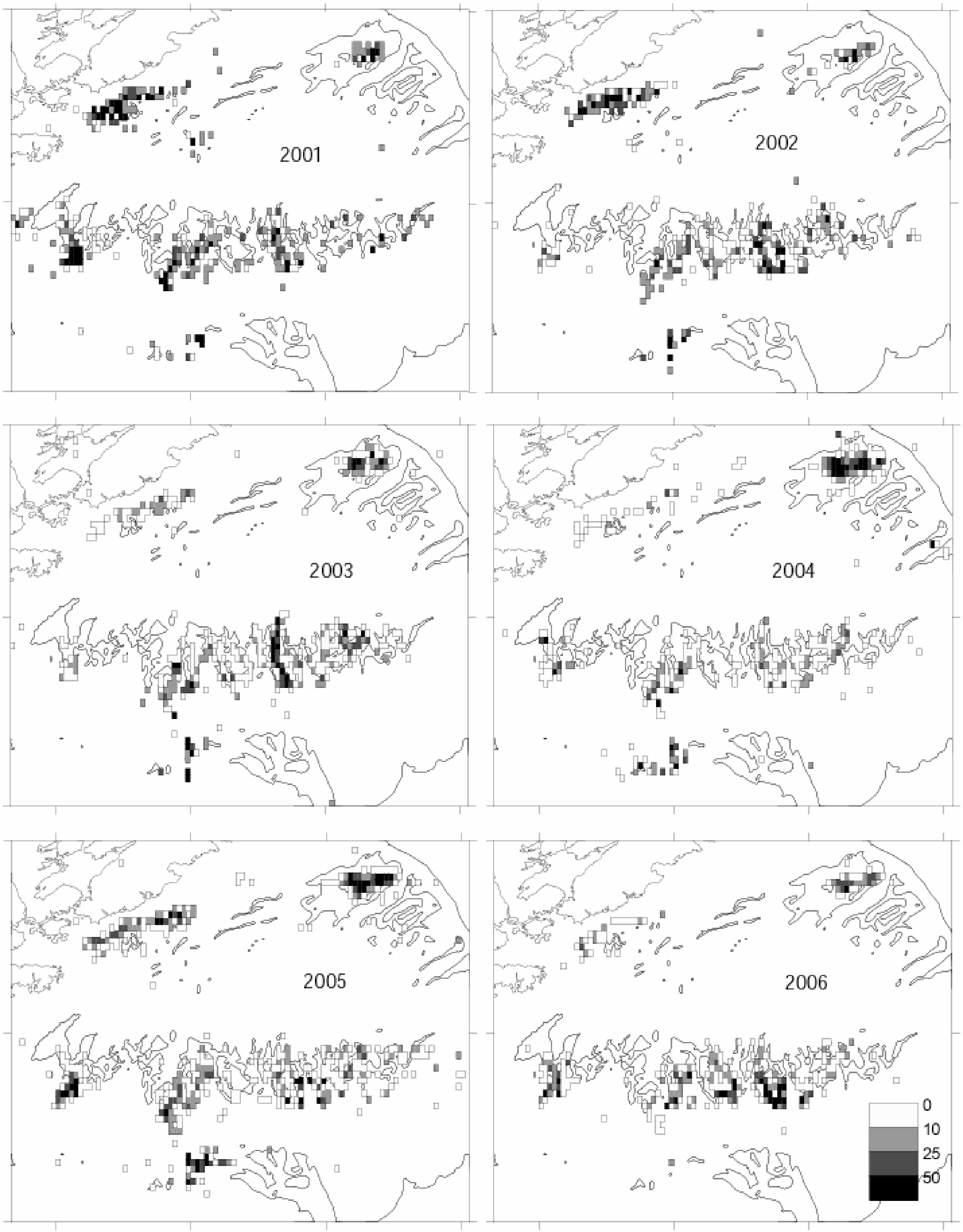



Figure 7 continued.

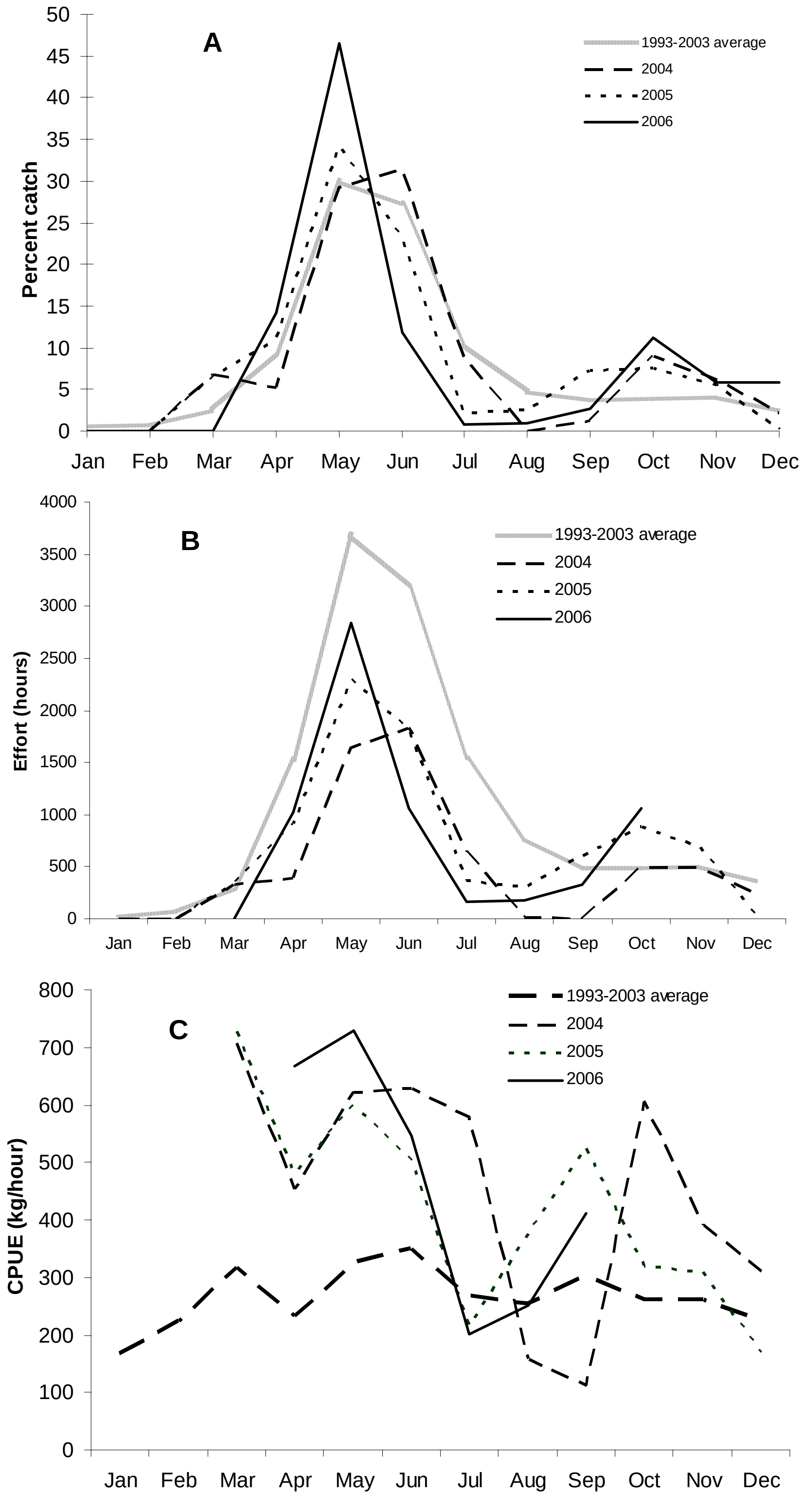



Figure 8. A - catches from the shrimp fishery as a percentage of the total catch, B - average CPUEs and C - total effort, by month.

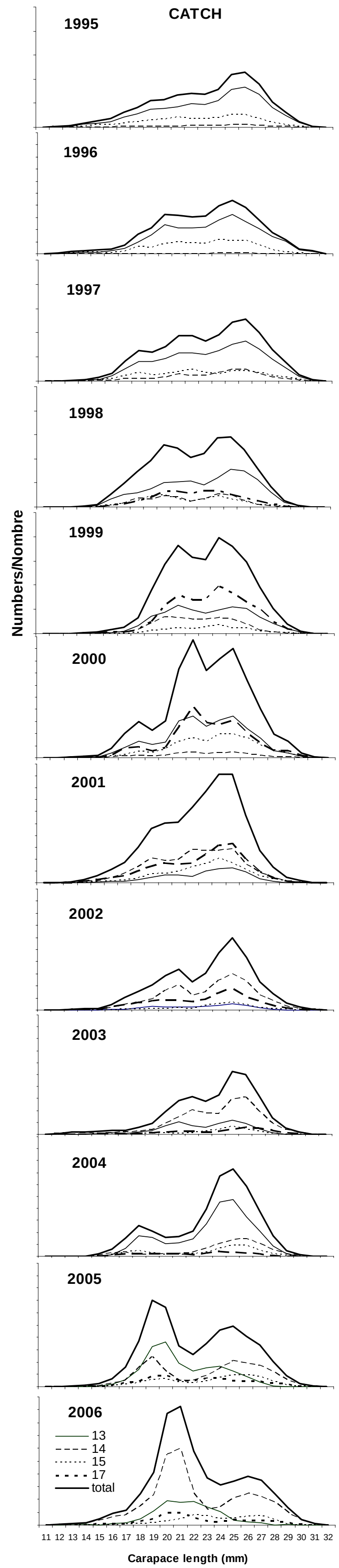



Figure 9. Catch at length from commercial sampling, 1995-2006.

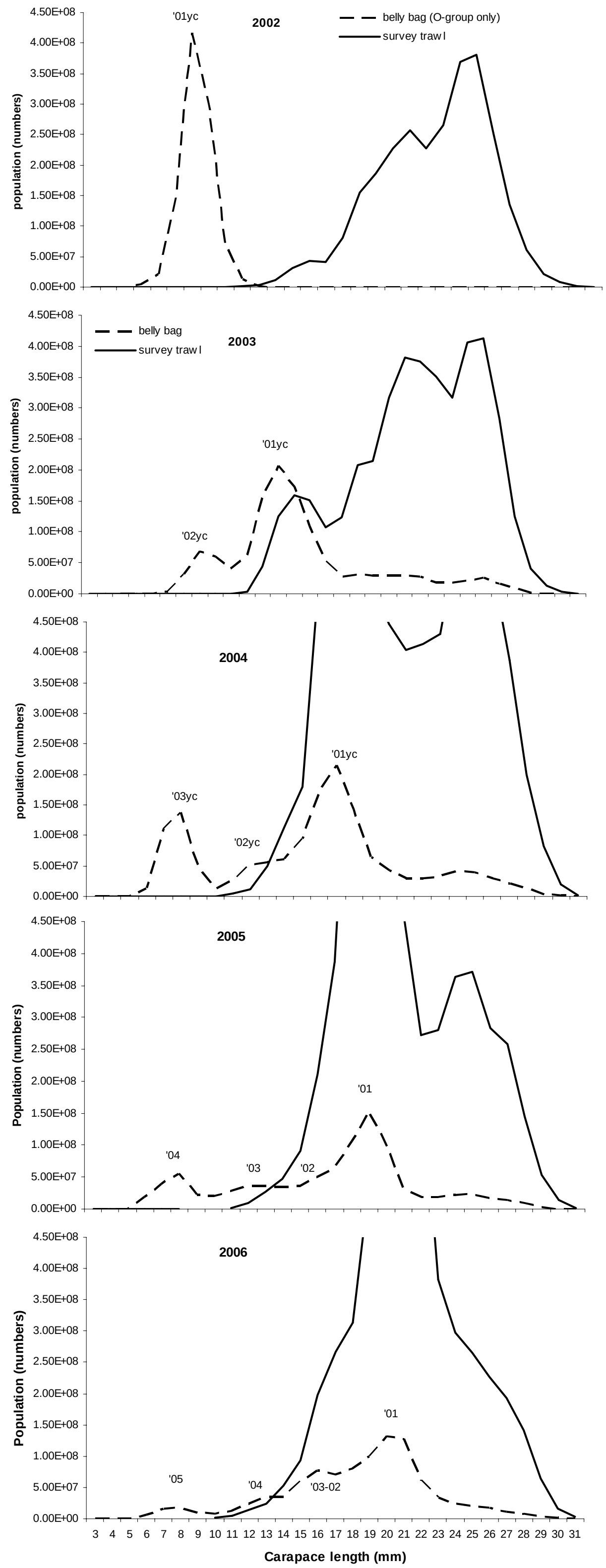



Figure 10. Population estimates from belly bag and main trawl catches for the 2002-2006 survey. Note that the 2002 belly bag estimate was made only for 1-year olds.

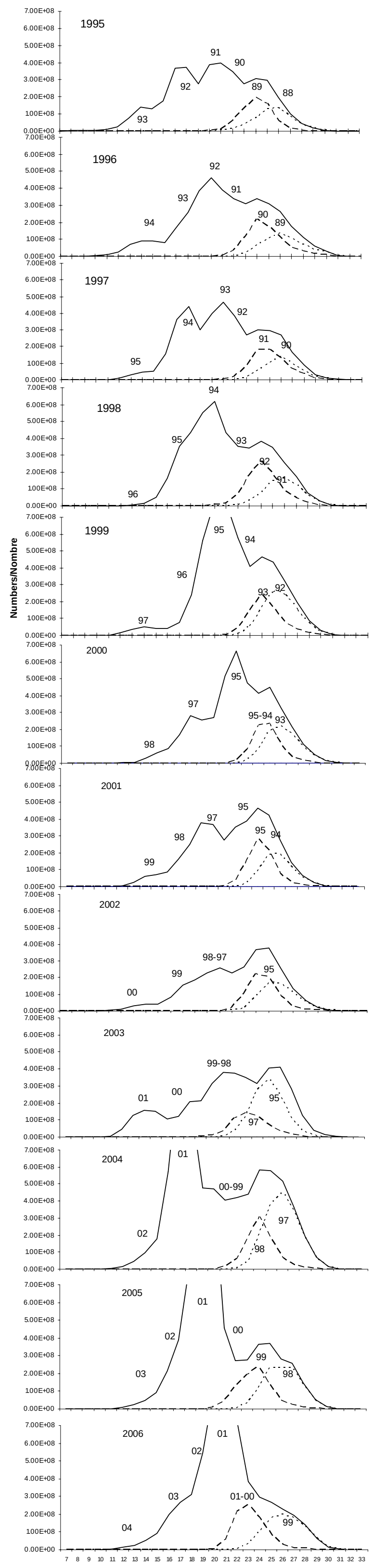


Figure 11. Population estimates at length from DFO-industry surveys 1995-2006. The heavy dotted line in each figure represents transitional and primiparous shrimp, and the stippled line represents multiparous shrimp.

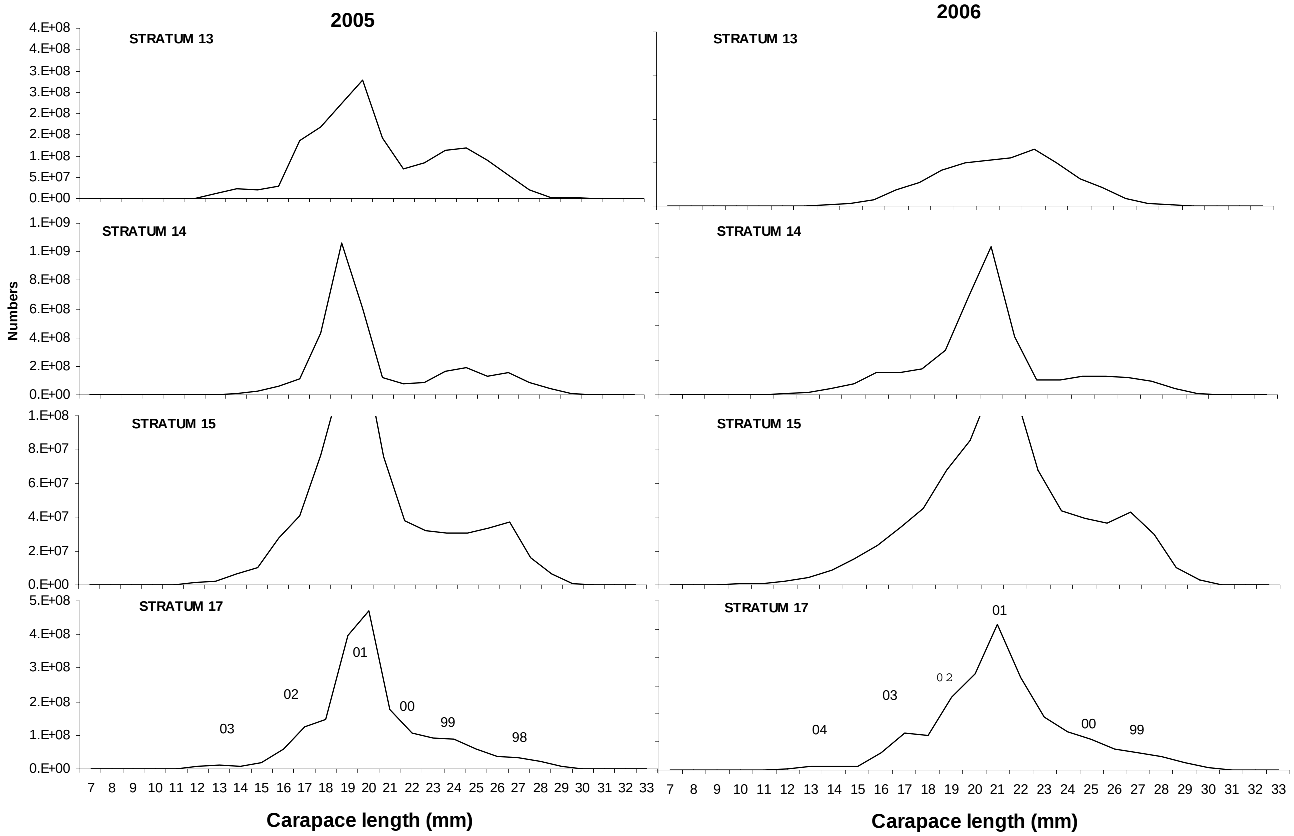



Figure 12. Population at length estimates by Shrimp Fishing Area from the DFO-Industry survey conducted in June, 2005 and 2006.

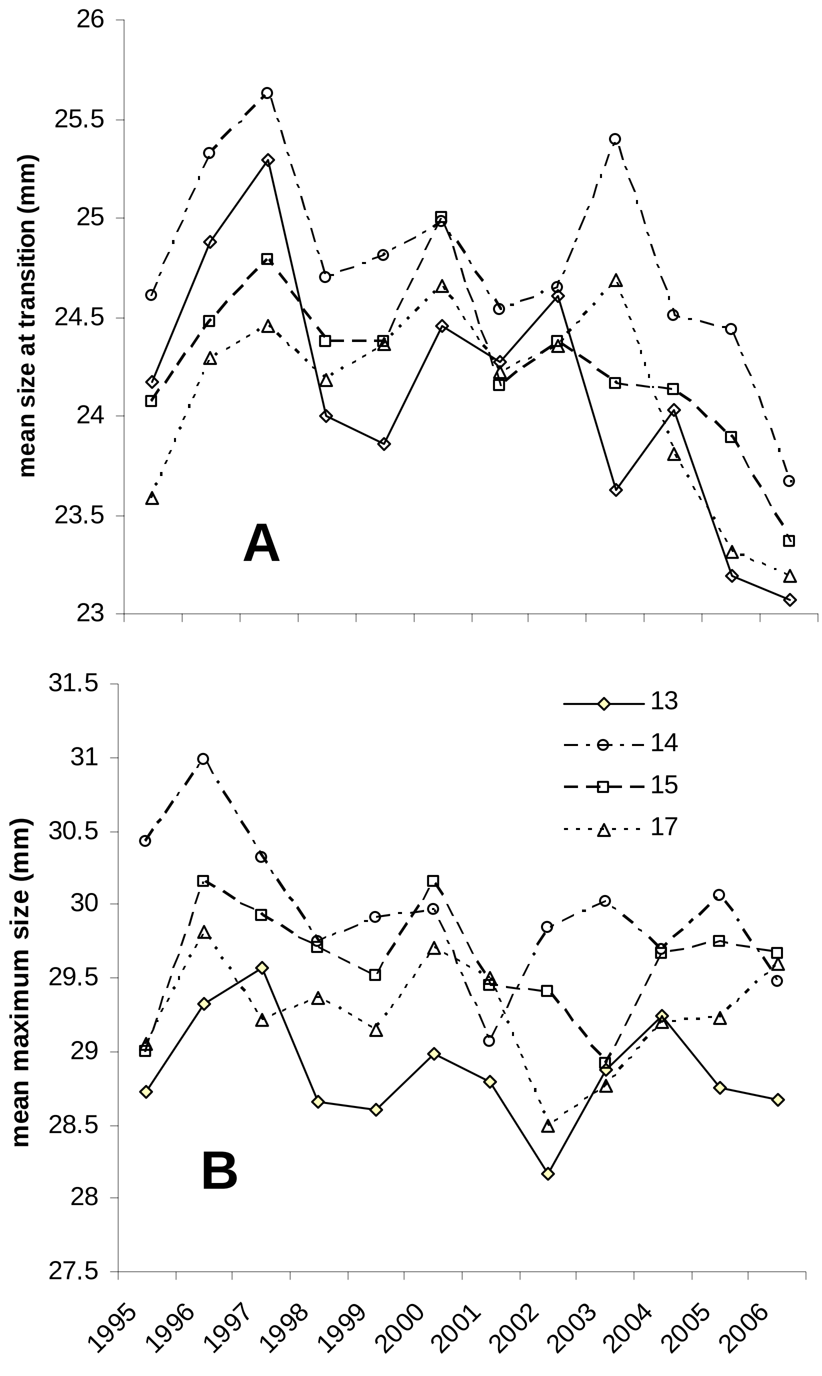



Figure 13. Average size at A - sex transition and B - maximum size by shrimp fishing area for the DFO-industry surveys 1995-2006.

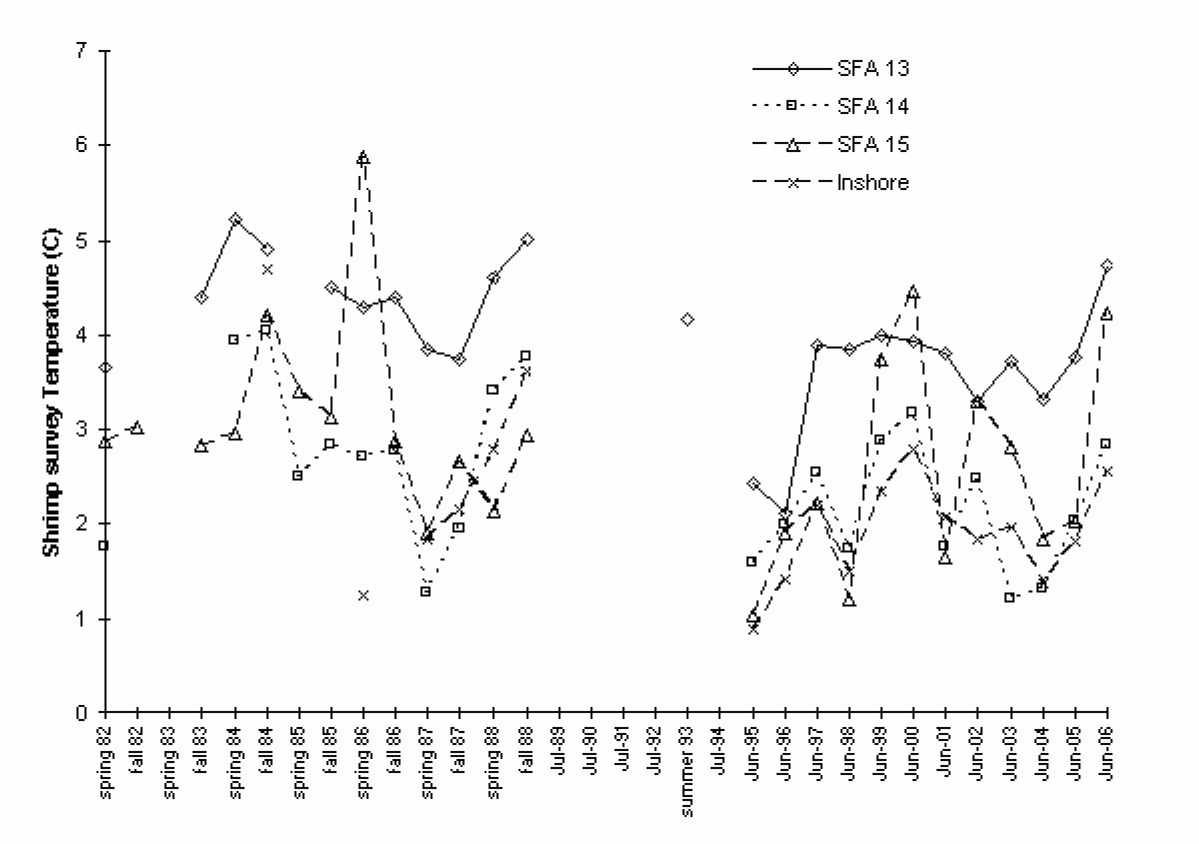



Figure 14. Mean bottom temperatures from shrimp surveys by SFA. Note that both spring and fall values were available from the earlier series (1982-88), but only one survey (June) was conducted annually in the recent series.

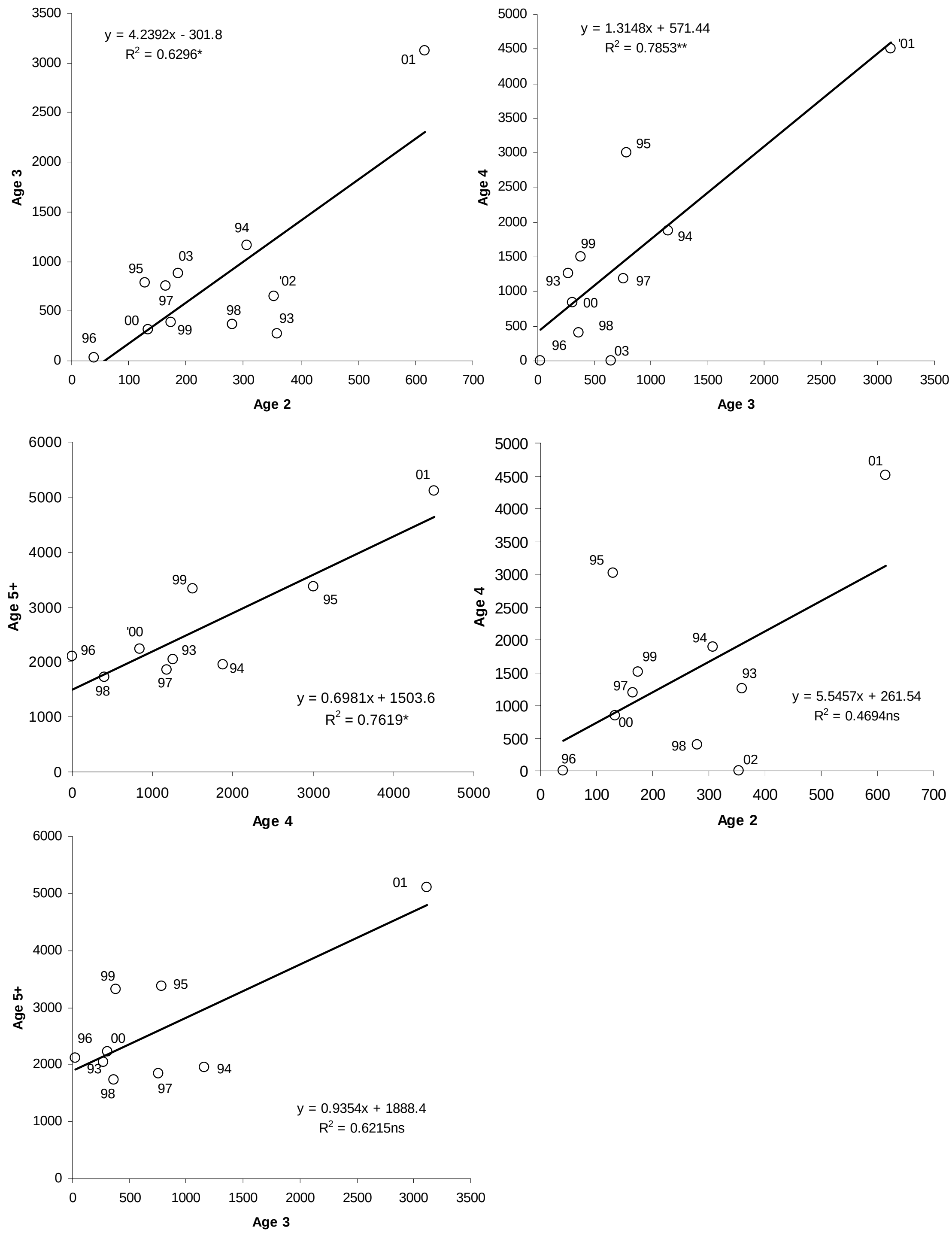



Figure 15. Regressions of age x versus x+1 survey population estimates from MIX analyses. These regressions were used to project the 2004 survey population at age to 2005 using current growth rates with limited success. Projections for 2006 and 2007 were not attempted.

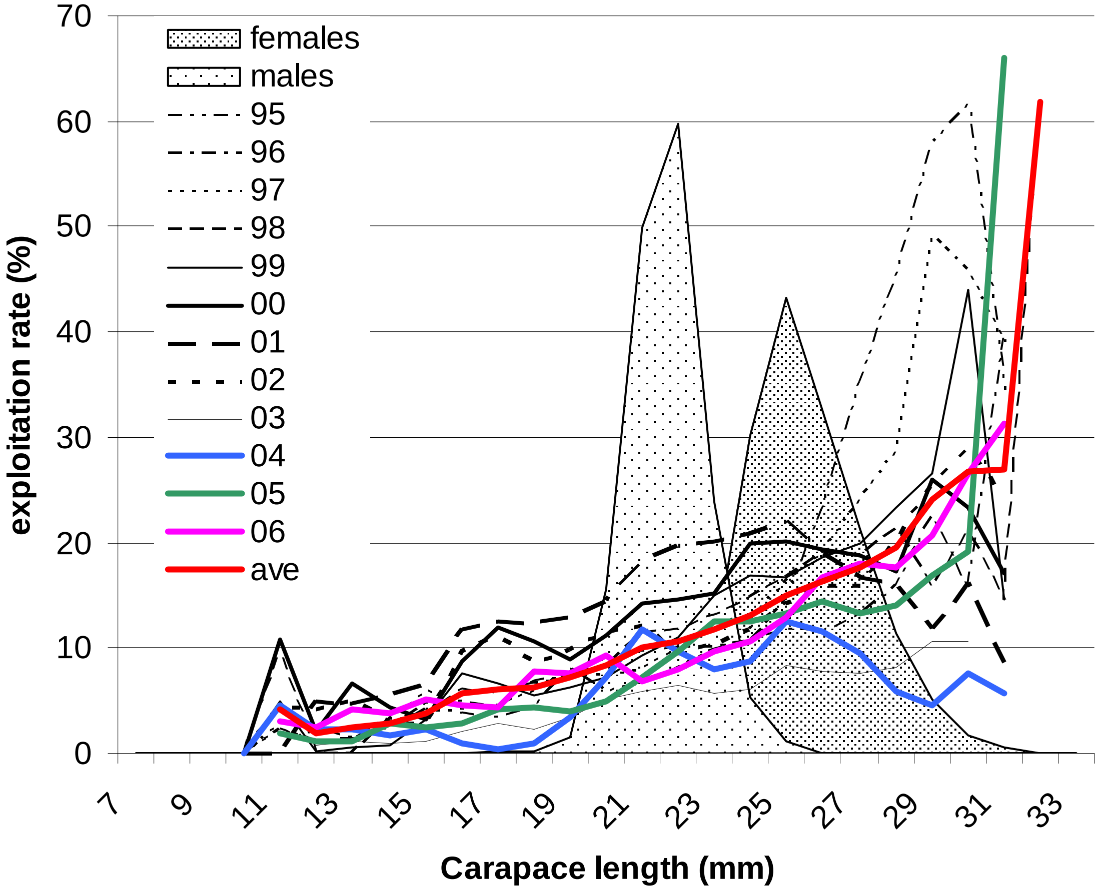



Figure 16. Exploitation at length from commercial sampling and DFO-industry surveys (1995-2006). The average exploitation rates were applied to the total projected population at length to determine a projected catch (Figure 20). The graph also shows the average size of age 4+ males and age 5+ females in the population.

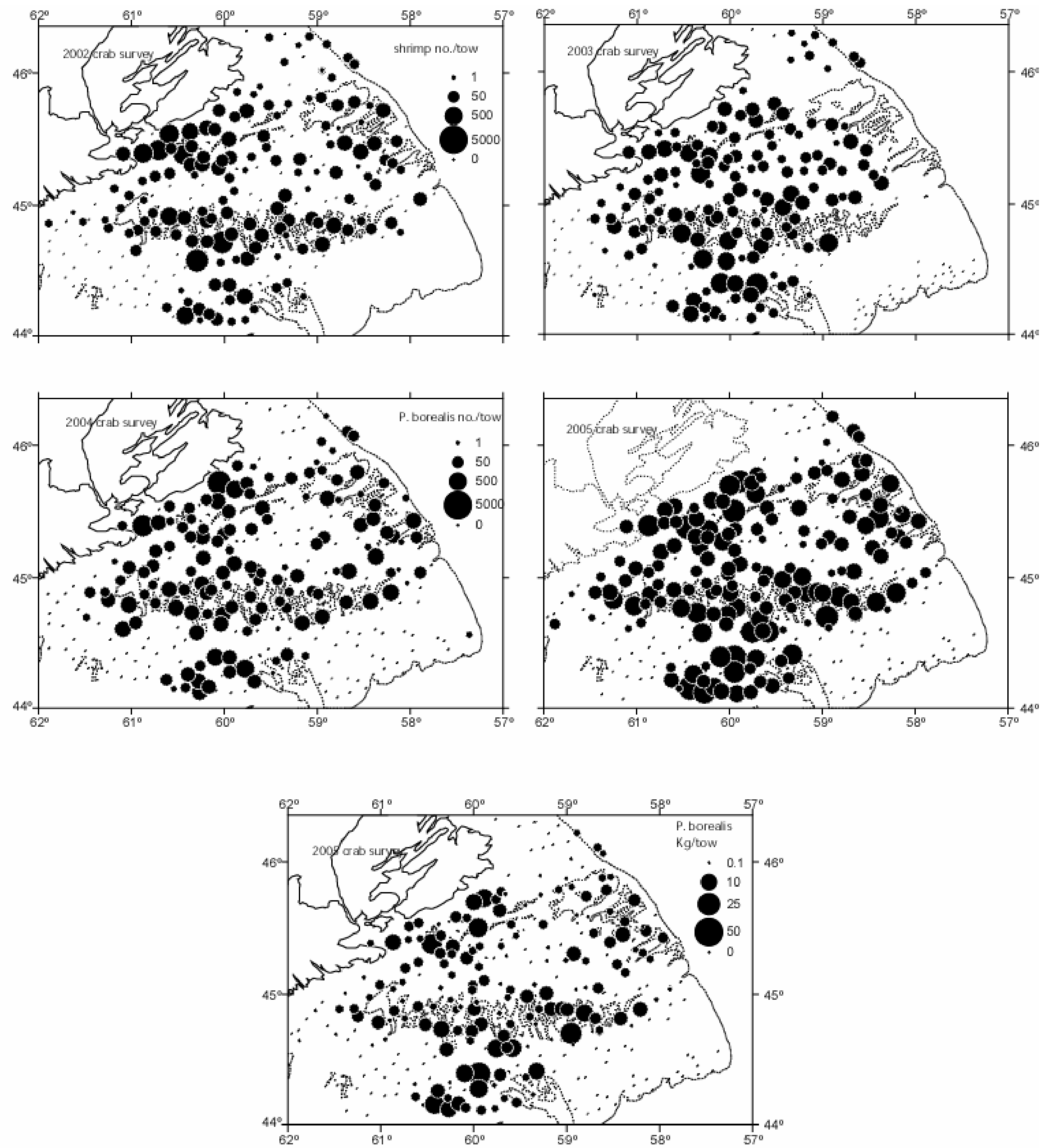
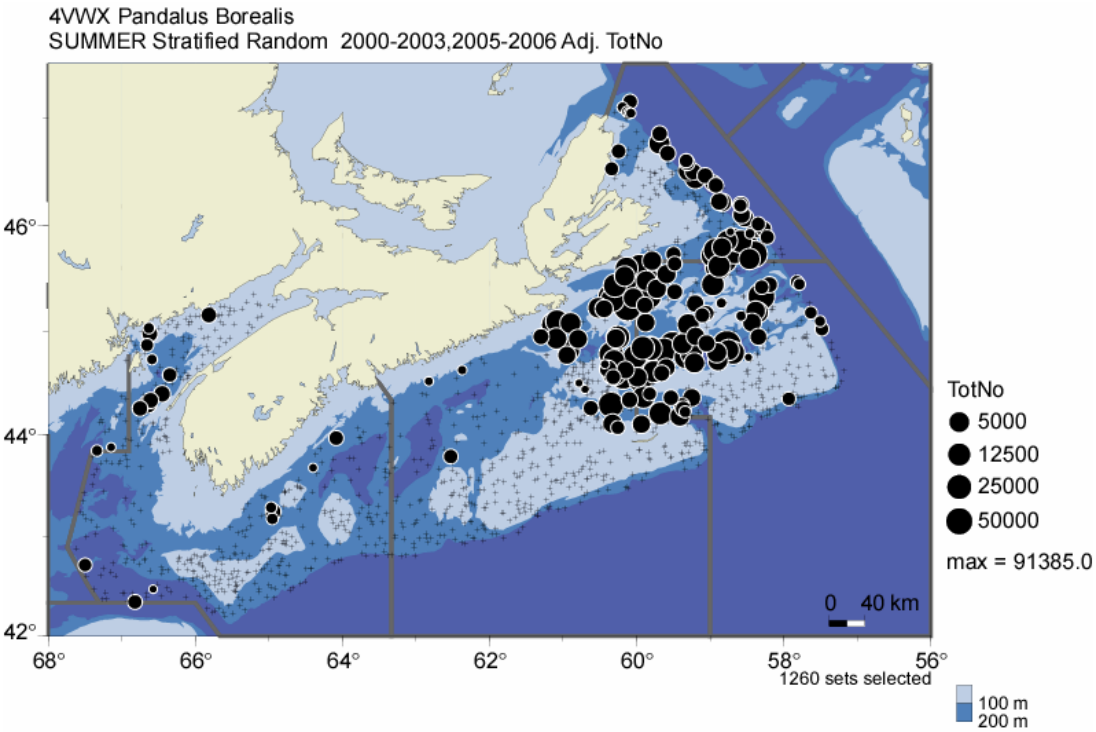



Figure 17. Distribution of *P. borealis* from snow crab surveys in which total numbers caught were estimated 2002-2005 and where total weight caught was recorded (2005 only).



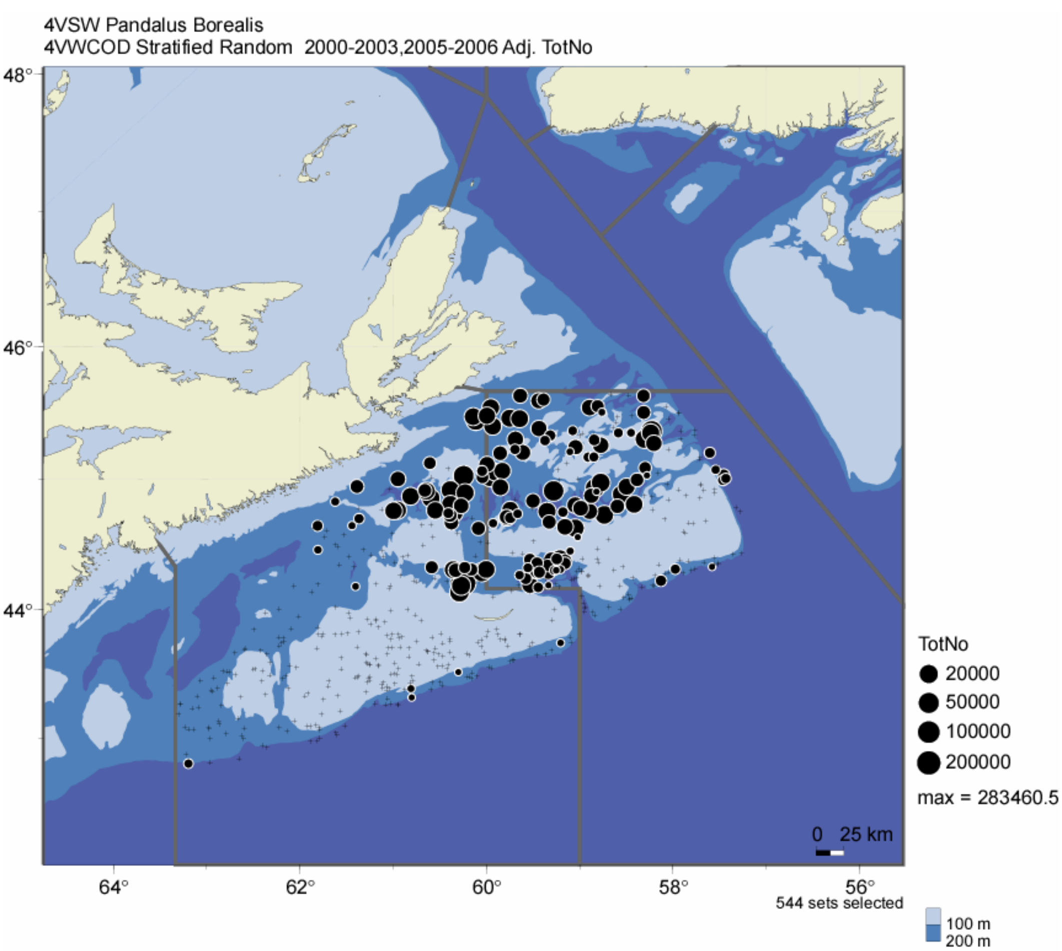




Figure 18. Distribution of shrimp catches from summer (top) and spring (bottom) groundfish surveys.

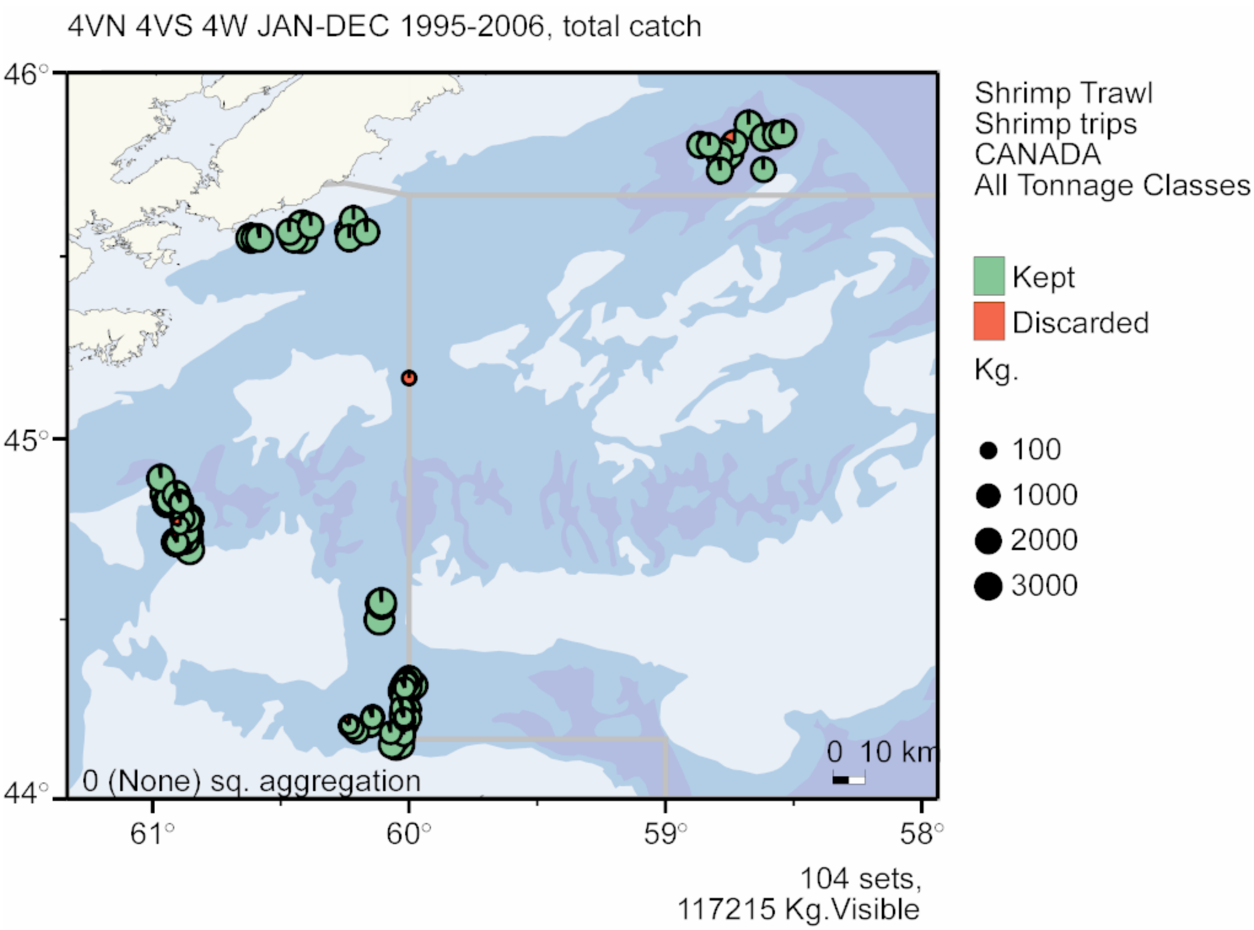



Figure 19. Distribution of all observed sets from commercial shrimp trawlers on the observer database