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An update of information pertaining to Northern Shrimp (*Pandalus borealis*, Kroyer) and Groundfish in NAFO Divisions 3LNO

by

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Abstract:

This paper describes the 2006 northern shrimp (*Pandalus borealis*, Kroyer) assessment completed for NAFO Divisions 3LNO. Status of the resource was inferred by examining trends in commercial catch, catch per unit effort, fishing pattern and size, sex and age compositions of catches, as well as, Canadian multi-species survey bottom trawl indices. The catch table (to October 2006) and biomass estimates (autumn 1995-spring 2006) are updated within this report. Preliminary data indicate that 14,137 tons of shrimp were taken against a 13 000 TAC in 2005 while 23 886 tons were taken against a 22 000 ton TAC in 2006.

The autumn 2005 biomass index was estimated to be 264 000 tons (95% C.I. = ±65 000 tons), the highest on record. The spring 2006 biomass index could not be estimated for the entire of NAFO Div. 3LNO because shallow water strata 373 and 383 and most deepwater strata within Div. 3NO (depths greater than 93 m) were not surveyed. However, the offshore strata within Div. 3L (depths to 754 m) were completely surveyed during the spring of 2006. Historically greater than 97% of the Div. 3LNO shrimp biomass had been attributed to these strata within NAFO Div. 3L. The spring 2006 3L biomass index was 185 000 tons (95% C.I. = ±67 000 tons), the second highest in the spring time series. Indices derived from spring surveys are thought to be less precise because the confidence intervals are sometimes broad with negative lower confidence limits.

Biomass and abundance of shrimp increased significantly since 1999 and remained broadly distributed over the study area. Consequently standardized catch rates for large Canadian vessels have been fluctuating around the long term mean since 2000 with the 2006 catch rate above average but similar to the 2002-2004 catch rates. The Canadian small vessel standardized CPUE increased 112% between 2002-2005 and remained near that level during 2006.

The shrimp resource within 3LNO is currently healthy with high abundances of males and females that should support the fishery over the next few years.

Both multi-species survey and observer datasets were used in quantifying the potential impact of the shrimp fishery upon various commercially important groundfish species.

Introduction

The northern shrimp (*Pandalus borealis*) stock, in Div. 3LNO, extends beyond Canada's 200 Nmi limit, therefore, it is a NAFO regulated stock. Northern shrimp, within NAFO Div. 3LNO, have been under TAC regulation since 1999. At that time, a 6 000 ton quota was established and fishing was restricted to Div. 3L, at depths greater than 200 m. The 6 000 ton quota was established as 15% of the lower confidence limit below the autumn 1998 3L biomass index. This harvest level approximated those estimated for shrimp fishing areas along the coast of Labrador and off the east coast of Newfoundland (NAFO Div. 2HJ+3K) (Orr *et al*., 2003). It was recommended that this harvest level be maintained for a number of years until the response of the resource to this catch level could be evaluated (NAFO, 1999). The proportion of biomass in 3LNO within the NAFO Regulatory Area (NRA), over the period 1995-1998, was approximately 17%. Therefore, a 5 000 ton quota was established in the Exclusive Economic Zone (EEZ) for Canada while a 1 000 ton quota was established in the NRA for all other Contracting Parties.

During November 2002, Scientific Council (SC) noted that there had been a significant increase in biomass and recruitment in Div. 3LNO shrimp since 1999. Applying a 15% exploitation rate to the lower 95% confidence interval of biomass estimates, averaged over the autumn 2000-2001 and spring 2001-2002 surveys, resulted in a catch of approximately 13 000 tons. Accordingly, SC recommended that the TAC for shrimp in Div. 3LNO in 2003 and 2004 should not exceed 13 000 tons. At that time, SC reiterated its recommendation that the fishery be restricted to Div. 3L and that the use of a sorting grate with a maximum bar spacing of 22 mm be mandatory for all vessels in the fishery (NAFO, 2002).

In 2004, an analysis was completed to determine a TAC for the 2006 fishery. Due to the highly variable nature of the spring survey indices, Scientific Council (SC) felt it was necessary to change the methodology used in determining TACs as follows. The TAC within an adjacent Canadian stock had been 12% of the fishable biomass since 1997. Applying this percentage to the inverse variance weighted average fishable biomass from the autumn 2002-spring 2004 surveys resulted in a TAC of 22 000 tons. Had this new method been used in 2003, it is likely that the adviced TAC calculated for 2005 would have been around 22 000 tons instead of the 13 000 tons actually advised. However, SC noted that the TAC recommendation for this stock has always included advice that "the development of any fishery in the Div. 3L area take place in a gradual manner with conservative catch limits imposed and maintained for a number of years in order to monitor stock response." The initial TAC of 6 000 tons was in place for 3 years, however the current TAC of 13,000 tons had been in place since the beginning of 2003. A two year period was insufficient to determine the impact of a 13,000 ton catch level upon the stock; therefore SC recommended that the 13 000 TAC be maintained through 2005. Scientific Council recommended that the 2006 TAC for shrimp in Divs. 3LNO should not exceed 22 000 tons. At that time, SC reiterated its recommendation that the fishery be restricted to Div. 3L and that the use of a sorting grate with a maximum bar spacing of 22 mm be mandatory for all vessels in the fishery. During the November 2005 shrimp assessment, SC decided that this advice should extend through 2007, and that the advice would be reviewed in September 2006 (NAFO, 2005).

Biomass and abundance indices and length frequencies were estimated using stratified area expansion calculations (Cochran, 1997; using SAS programs written by D. Orr).

Numerous studies indicate that pandalid shrimp have neither a fixed size nor a fixed age at sex change and that age or size at sex change is altered in response to yearly changes in the environment. Environmental changes may include age and size distribution of breeding adults, in which case, size at sex change may be positively correlated with the maximum size of mature shrimp (Charnov and Anderson, 1989; Skúlladóttir and Pétursson, 1999; Charnov and Skúlladóttir, 2000). Localized decreases in size at sex change could be an attempt by the species to compensate for a reduction in reproductive potential at times when there are temporary decreases in female biomass, or a very large year-class of males (Charnov, 1982). Faster growth and earlier maturation are positively related to higher temperatures (Skúlladóttir and Pétursson, 1999;Wieland, 2004; 2004), within the optima of 1-6°C (Shumway *et al.*, 1985). Koeller *et al.* (2000) and Wieland (2004) found that size at sex change could decrease at times of high density when there is competition for resources. Regardless of the mechanism(s) causing changes in growth rates and size at sex reversal, faster growth and early maturation are normally associated with lower fecundity. Therefore it is important that 3LNO shrimp stock assessments include change in maturation schedule.

Full assessments of this stock are completed during the annual October - November shrimp assessment meetings. Results from these assessments provide necessary input for quota decisions made during Fishery Commission meetings, held during September. Canadian autumn and spring multi-species bottom trawl surveys are completed in 3LNO in the time between the assessment and the commission meetings. The additional biomass information derived from these surveys is provided, within interim monitoring reports, to NAFO SC just prior to the annual Fishery Commission meetings. The last interim monitoring report was presented to NAFO SC during September 2006.

The present document was produced for the November 2006 SC assessment meeting and therefore provides a full assessment of the Div. 3LNO shrimp resource.

The fishery overlaps the distribution of several groundfish stocks that are presently under moratoria. Hence, this paper also assesses the impact that the fishery may have upon groundfish co-existing in the area.

Methods and Materials

Data were collected from the following sources:
Canadian observer databases;
Canadian logbook databases;
International observer/ logbook databases; and
Canadian autumn and spring multi-species research surveys.

Canadian observer database:

Approximately 12 large (>500 ton) fishing vessels and more than 300 smaller (<=500 ton; <100') vessels fish shrimp within Davis Strait, along the coast of Labrador and off the east coast of Newfoundland. There is 100% mandatory observer coverage of the large vessels, but less than 10% coverage of the small vessels.

Observers working on large vessels collect detailed maturity stage length frequency information from random sets. Those working on small vessels collect ovigerous/ non-ovigerous length frequencies from random sets and one detailed maturity stage length frequency per trip. Observers on both types of vessels record: shrimp catches, effort, amount of discarding, weights and length frequencies of by-caught species.

The Observer database was used to determine the catch-per-unit effort (CPUE) for the large vessel shrimp fishing fleet. Observed data were used to present results accounting for number of trawls and usage of windows (escape openings). The number of trawls and usage of windows are captured in the observer data set but not in the logbooks. Raw catch/ effort data was standardized by multiple regression, weighted by effort, in an attempt to account for variation due to year, month, number of trawls, gross registered tonnage (grt) etc. The multiplicative model has the following logarithmic form:

$$\mathrm{Ln}(\mathrm{CPUE}_{\mathrm{ijkml}}) = \ln(u) + \ln(\mathrm{S}_j) + \ln(\mathrm{V}_k) + \ln(\mathrm{T}_m) + \ln(\mathrm{Y}_l) + e_{ijkml}$$

where: $\mathrm{CPUE}_{\mathrm{ijkml}}$ is the CPUE for grt k, fishing x number of trawls, in month j during year l (k=1,…..,a; j=1,…..,s; l=1,…..,y);
$ln(u)$ is the overall mean ln(CPUE);
S_j is the effect of the j^{th} *month;*
V_k is the effect of the k^{th} grt;
T_m is the effect of m number of trawls;
Y_l is the effect of the l^{th} *year;*
e_{ijkml} is the error term assumed to be normally distributed $\mathrm{N}(0,\sigma^2/n)$ where n is the number of observations in a cell and σ^2 is the variance.

Standardized CPUE indices are the antilog of the year coefficient. Final models included all significant class variables with the YEAR effect used to track the trend in stock size over time. The difference (or similarity) between the 2006 YEAR parameter estimate and those of previous years was inferred from the output statistics.

In order to track only experienced fishers, the standard data set included only data from vessels with more than two years of shrimp fishing experience. This increased our confidence when interpreting results.

The observer database also provides information used to determine the potential impacts that shrimp fishing may have upon groundfish species. Groundfish by-catch is recorded to 1 kg. precision for all observed fishing sets. Wherever possible, sexed length frequencies (1 cm. precision) were taken from randomly selected samples of commercial groundfish species. Using a ratio of weight of fish measured to by-catch weight, the length frequencies were corrected on a set by set basis. Length frequencies were added together on a species by species basis. An average length frequency distribution per kg. of by-catch was produced and then merged with the catch records. The frequencies were multiplied by the by-catch weights in an effort to produce length frequency data on a set by set, species by species, basis. The length frequencies were aggregated to obtain total removals by species, year and size of vessel. Length frequencies were then applied to species specific population adjusted age length keys, from the previous autumn survey, to obtain estimates of number at age.

Canadian logbook database:

The small vessel CPUE dataset was created using logbook data because all shrimp fishing vessels must complete logbooks, whereas, observer coverage in the small vessel shrimp fishery may be as low as 2%.

The landings by small and large vessels allowed a comparison with the total observed catches for each fleet. This comparison provided an indication of percent of total catch observed. This percentage was used in estimating total groundfish by-catch on a species by species basis.

International observer and logbook information:

These data were made available by Contracting Parties that fish shrimp in Div. 3L. They were used in CPUE calculations and were added to the Canadian catches when determining a total catch. Where no information was provided by a Contracting Party, information was augmented through the use of Canadian surveillance data, as well as, NAFO STATLANT 21A and monthly provisional catch tables. Estonia, Iceland, Greenland, Norway and Russia provided catch and effort data over a number of years making it possible to derive standardized catch rates for the NRA. Spain and the Ukraine provided only a single year of catch rate data; therefore, raw CPUE indices were produced from these sources.

Canadian spring and autumn multi-species research surveys:

Spring and autumn multi-species research surveys, using a Campelen 1800 shrimp trawl, have been conducted onboard the Canadian Coast Guard vessels *Wilfred Templeman*, *Teleost* and *Alfred Needler* since 1995. Fishing sets of 15 minute duration, with a tow speed of 3 knots, were randomly allocated to strata covering the Grand Banks and slope waters to a depth of 1 462 m in the autumn and 731 m in the spring, with the number of sets in a stratum proportional to its size (Fig. 1). All vessels used a Campelen 1800 shrimp trawl with a codend mesh size of 40 mm and a 12.7 mm liner. SCANMAR sensors were employed to monitor net geometry. Details of the survey design and fishing protocols are outlined in (Brodie, 1996; McCallum and Walsh, 1996).

Due to operational difficulties it was not possible to survey all of the strata within NAFO Div. 3LNO during autumn 2004 (Brodie, 2005). The deepwater strata (deeper than 731 m) within 3LNO as well as several shallow water strata within 3L were not surveyed. Historically very few northern shrimp have been taken from the deepwater strata; therefore, the impact of not sampling the deepwater was felt to be negligible (Table 1). Strata that were missed in 3L (autumn 2004) are highlighted in Table 1 and Fig. 2. Analyses of the autumn 1995-2003 and 2005 survey data indicate that the 3L strata missed in 2004 (93-549 m) are important in determining the biomass indices. Typically these strata account for 25-61% of the 3L biomass (Table 1). Figures 3 and 4 confirm the importance of these strata and that catches, within these strata, vary both seasonally and annually.

Please note that all strata, within the NRA, that contained significant quantities of northern shrimp, in previous spring and autumn surveys, were surveyed during autumn 2004.

All strata were surveyed during autumn 2005.
Due to operational difficulties it was not possible to survey all of the strata within NAFO Div. 3NO during spring 2006. Strata 373 and 383 as well as most strata deeper than 92 m were not surveyed (Fig. 1).

Since 2003, shrimp species and maturity stage identifications, as well as length frequency determinations have been made at sea, whenever possible. Otherwise, shrimp were frozen and returned to the Northwest Atlantic Fisheries Centre where identification to species and maturity stage was made. Shrimp maturity was defined by the following five stages:

males;
transitionals;
primiparous females;
ovigerous females,

and multiparous females

as defined by Ramussen (1953), Allen (1959) and McCrary (1971). Oblique carapace lengths (0.1 mm) were recorded while number and weight per set were estimated from the sampling data. Inshore strata were not sampled in all years; therefore, the analysis was restricted to data collected from offshore strata only (Fig. 1). Length frequencies were estimated using stratified area expansion calculations (Cochran, 1997; using SAS programs written by D. Orr). During spring and autumn of 2004, carapace lengths and live weights of approximately 1500 *Pandalus borealis* were measured within 24 hours of capture. Lengths and weights were converted to $\log_{10}$ values, and regression models were developed for males, transitionals ovigerous and non-ovigerous females.

Modal analysis using Mix 3.1A (MacDonald and Pitcher, 1979) was conducted on male research length frequencies. Abundances of age 2 males_{year} were plotted against fishable biomass_{year+2} to determine whether a recruitment – stock relationship exists. Such a relationship could be used to predict stock prospects.

Exploitation indices were developed by dividing total catch by each of the following estimates:

lower 95% confidence interval below the biomass index,
spawning stock biomass (SSB), and
fishable biomass.

The fishable component of the population was defined as all animals greater than 17 mm CL. Male biomass was determined by converting abundances to biomass using the male models:

$Wt(g) = 0.00088*lt(mm)^{2.857}$ for autumn samples
$Wt(g) = 0.000966*lt(mm)^{2.842}$ for spring samples
(these models were derived from length weight relationships described above)

Spawning stock biomass (transitionals + primiparous females and ovigerous + multiparous females) was determined via stratified area expansion calculations. Female and male (>17 mm carapace length) biomasses were added together to obtain total fishable biomass.

Trends in size at sex change were examined by comparing autumn male with female spawning stock length frequencies from research survey data. A logistic model with a logit link function and a binomial error was fit to the data to estimate the size at 50% maturity by year. Estimation of parameters was performed using SAS Proc Probit. The hypothesis that size at transition changed over time was tested using SAS Proc Genmod with a logit link function and binomial error (SAS version 8.01, 1993). The model had the general form:

$$Pfe_{(Lt)} = 1/(1 + e^{(-(Int + Lteff(Lt) + Yreff))}$$

where $Pfe_{(Lt)}$ = percent female at length
Int = intercept
Lteff = length effect
Lt = length
Yreff = year effect

Similarly, trends in size at sex change were determined from the Canadian large vessel observer dataset.

The small and large vessel observer datasets were examined to determine the impacts of the shrimp fishery upon various commercially important groundfish stocks as previously discussed.

Both the observer and logbook data sets complement the research trawl survey data sets. Research data are collected during the spring and autumn using stratified random set allocations that cover the Grand Banks. Conversely, the observer and logbook data sets are treated as being representative of the commercial fishery. They focus upon fishing areas and cover a much broader seasonal scale than the research data. All three were used in determining an exploitation index (catch/biomass), which is a proxy for fishing mortality. These datasets also provide insight for the impact of shrimp fishing upon groundfish.

Logbook and research catches were plotted using Surfer 8.0 (Golden Software, 2002). The area fished each year was divided into 10 min. X 10 min. cells, catches were aggregated by cells, and aggregated catches were organized into a cumulative percent frequency (cpf). The cpf was used to determine the number of cells accounting for 95% of the catch each year (Swain and Morin, 1996). The plots and quantification of spatial coverage were used in describing changes in distribution thereby aiding the interpretation of CPUE trends.

Results and Discussion

Fishery Data

Catch trends

Canadian vessels caught 11 tons of shrimp in division 3L during 1989. However, Faroese fishermen are generally credited with starting the exploratory fishery for 3LNO shrimp within the NRA. The Faroese exploratory fishery began in 1993 and lasted until 1999. Over this 7 year period, the Faroese catches were 1789, 1865, 0, 171, 485, 544 and 706 tons respectively (STATLANT 21A).

During autumn 1995, the Canadian multi-species surveys began to use a Campelen 1800 shrimp trawl and shrimp were included in the multi-species survey data collections. As a result of Faroese and Canadian multi-species survey efforts, various nations became interested in exploiting shrimp in Div. 3LNO. During 1999, one Spanish and four Canadian exploratory fishing trips were made in 3LNO. The combined catch was 89 tons.

Catches increased dramatically since 1999, with the beginning of a regulated fishery. Since then, sixteen contracting nations have exercised their privileges to fish shrimp in 3L. Over the period 2000-2004, catches were 4 869, 10 566, 6 977, 11,947 and 12 622 tons, respectively (Table 2; Fig. 5). Catch data indicate that 14 137 tons of shrimp were taken against a 13 000 ton quota in 2005. Preliminary data indicate that by October 2006, 23 886 tons had been taken against a 22 000 ton TAC.

As per NAFO agreements, Canadian vessels took most of the catch during each year. Canadian catches increased from 4 250 tons in 2000 to 18 271 tons in 2006. Catches by Non Canadian nations increased from 619 tons to 5 5615 tons over this period.

Canadian fleet

Since 2000, large (>500 t) and small (<=500 t) shrimp fishing vessels catches have been taken from a broad area (Figs. 6 and 7) from the northern border with 3K south east along the 200-500 m contours to the NRA border. As noted in Orr *et al.* (2005) there are similarities between the distribution of small vessel logbook catches and autumn survey catches with a one year lag (Fig. 8). However, there was insufficient 2006 logbook data to provide an areal index update for small vessel catches during 2006 (Fig. 6).

The area occupied by large vessels has been fairly stable over much of the time series with a 66% increase in area fished after 2005. The area accounting for 95% of the autumn survey catches also showed stability with an increase after 2003 (no index in 2004; Fig. 8). Relative stability within each of the distribution time series is reflected in the small and large vessel CPUE time series. The distribution of large vessel catches also increased during 2006.

Large vessel catch rates were analyzed by multiple regression, weighted by effort, for year, month, number of trawls and vessel effects. The final model explained 79% of the variance in the catch rate data. Standardized catch rates for large Canadian vessels have been fluctuating around the long term mean since 2000 with the 2006 standardized catch rate index (2050 kg/hr; table 4) above average and similar to the catch rates for 2002-2004 catch rates (tables 3 and 4; Fig. 9). There were no trends in the residuals around parameter estimates (Fig. 10). The fact that the area fished by large vessels increased during 2006 at a time when CPUE increased implying that the resource is healthy.

Preliminary data exploration indicated that there was no relationship be length of small vessel (<=500t) and tonnage or horsepower. Therefore, small vessel CPUE was modeled using month and year as explanatory variables. The final model explained 95% of the variance in the data and indicated that the annual, standardized catch rates have increased significantly since 2001 with all estimates being significantly lower than the 2003-2006 estimates (645 kg/hr during 2006; Tables 5 and 6; Fig. 9). There may be a slight trend in the residuals around the year estimates, however, the range in residuals is very low (-.4 to .5) and the trend is being driven by a few good catches in the first two years of the small vessel catch rate series. Since 2002, there is relative stability in all of the residuals (Fig. 11).

International fleet

A standardized catch rate model was produced using data from Estonian, Greenlandic, Icelandic, Norwegian and Russian vessels fishing shrimp in the NRA. Ship, month, and year were used as independent variables and produced a model that explained 85% of the variance. Catch rates increased by 124% from 343 kg/hr in 2001 to 769 kg/hr in 2004 but then decreased by 50% over the next two year resulting in a 388 kg/hr catch rate during 2006 (Tables 7 and 8; Fig. 12). The 2006 model catch rate was similar to the 2000-2002 catch rates while lower than all others. There were no trends in the residuals around parameter estimates (Fig. 13).

Catch data were also available from Spain for 2005 and a Ukrainian vessel for 2006. The raw 2005 Spanish CPUE was 640 kg/hr was higher than the model rate of 546 kg/hr; similarly the 2006 Ukranian CPUE was 1 280 kg/hr during June-August, 2006 which was much higher than the model rate of 388 kg/hr (Fig. 12).

Size composition

Several length frequency observations were taken from large vessel catches (Fig. 14). Catch at length from samples taken by observers on large vessels consisted of a broad size range of males and females believed to be at least three years of age. The male modes overlapped to the extent that it was not possible to complete Mix distribution analysis; however, the male modes often had two faint sub-peaks implying the presence of more than one year-class. Given that the modes were usually near 18 mm and 20 mm, these animals were probably 3 and 4 years of age respectively. The female length frequency distributions were also broad indicating that the female portion of the catch probably consists of more than one age group. Catch rates had been maintained at over 200 000 animals per hour. The within year frequency weighted average carapace lengths for males ranged between 18.4 mm and 19.7 mm, while the weighted average carapace lengths for females ranged between 22.9 mm and 23.7 mm. There were no trends in the average size of either males or females.

Figures 15 and 16 present the length frequencies from the Icelandic and Ukranian catches.

These length frequencies also show broad male and female modes implying the presence of more than one year-class within each sex.

Probit analyses from winter (January-March) large vessel commercial and autumn survey carapace length frequency data are presented in Tables 10 and 11 as well as Fig. 17. Least squares difference comparisons presented in Table 10 indicate that size at transition within commercial samples decreased between 2001 and 2002, but has since been increasing with the 2006 estimates being the highest level in the time series (21.70 mm) (Fig. 17). The 2006 size at sex change is statistically similar to the 2001 value but is significantly greater than the value within each of the other years. The research survey data indicate that size at sex change decreased from 22.28 mm in 1998 to 21.48 mm in 2000, fluctuated near the long term average (21.8 mm) and then increased to 22.14 mm in 2005. The 2005 value is statistically similar to the 1996, 1998 and 2001 values and higher than all other values.

An increase in size at transition implies increased individual fecundity.

Research Survey Data

Stock size

Analyses of the autumn 1995 - 2003 survey data indicate that the 3L strata missed in 2004 (93-549 m; Fig. 2) are important in determining the biomass indices. Typically these strata account for 25-61% of the 3L biomass (Table 1). Figures 3 and 4 confirm the importance of these strata and that catches, within these strata, vary both seasonally and annually. Analyses from the spring 2005 survey indicated that the Div. 3LNO trawlable biomass was 155 627 tons (95% C.I. = ± 67 124 tons), the third highest value in the time series (Tables 13 and 15; Fig. 19). However, it must be noted that in general, the spring indices are thought to be less precise because the 95% confidence intervals are sometimes broad with negative lower confidence interval values. The autumn 2005 survey resulted in a biomass estimate of 263 815 tons (95% C.I. = ± 64 641 tons); the highest in the time series (Tables 12 and 14; Fig. 19). The spring 2006 biomass index was 180 642 tons (95% C.I. = ± 111 096 tons), the second highest in the time series.

Distribution of shrimp in Divisions 3L, 3N and 3O

Between 90.5 and 99.9% of the total 3LNO biomass was found within Div. 3L, mostly within depths from 185 to 550 m. Over the study period, the area outside 200 Nmi accounted for between 11 and 32% of the estimated total 3LNO biomass (Tables 14 and 15; Fig. 3 and 4). Three year running averages were estimated in order to smooth the peaks and troughs within the data. They indicate that 11-29% of the total 3LNO autumn biomass is within the NRA. Over the period 2000-2005 the overall average autumn percent biomass within the NRA was 20.2%. However, during the spring, the percent biomass within the NRA ranged between 11 and 29%. Over the period 1999 – 2004 the average spring percent biomass with the NRA was 20.2%.

In all surveys, Div. 3N accounted for .05-9% of the total 3LNO biomass. More than 74% of the 3N biomass was found outside the 200 Nmi limit. Division 3O accounted for less than 1% of the 3LNO biomass. Less than 36% of the Div. 3O biomass was found outside the 200 Nmi limit.

Stock composition

Length distributions representing abundance-at-length from the autumn 1995-spring 2006 surveys are compared in Fig. 20 and 21. Modes increase in height as one moves from ages 1-3 indicating that modes become more overlapping and that catchability of the research trawl probably improves as the shrimp increase in size. Tables 16 and 17 provide the modal analysis and the estimated demographics from each survey.

These time series provides a basis for comparison of relative year-class strength and illustrate the changes in stock composition over time. There appear to be two regimes; one prior to 2000 at a time during which abundances at age are low and a second period after 1999 during which abundances are much higher. The 1997 year-class first appeared in the 1998 survey as one year old shrimp and was the first in a series of strong year-classes. This year-class was strong and could be followed throughout the next three years. However, it is important to note that the age 1 modes do not always give a clear recruitment signal. For instance, the 1998 age 1 mode appeared weak in 1999, but was almost as strong as the 1997 year-class in later years. Strong age 2 modes appear strong throughout their history, conversely weak year-classes such as the 1995 and 1996 appear weak as 2 males and remain weak throughout their history.

Modal length at age varies between years reflecting different growth rates for the different cohorts. However, there is some inter-annual consistency in modal positions and the relative strength of cohorts is maintained from one year to the next (Tables 16 and 17; Fig. 20 and 21).

Shrimp aged 3 and 4 dominated the male component of the length frequencies in spring 2005 (2002 and 2001 year-classes) survey with carapace length frequency modes at 16.94 and 19.55 mm, respectively. Similarly, abundance estimates from the autumn 2005 survey were dominated by shrimp aged 3 and 4 (2002 and 2001 year-classes) with modes at 17.00 and 19.59 mm, respectively. While shrimp aged 2-4 dominated the spring 2006 survey (2004, 2003 and 2002 year-classes). The 2004 year-class, as seen in the spring 2006 survey, the most abundant age 2 year-class in any of the length frequency analyses.

The spring and autumn surveys showed an increase in the abundance of female (transitionals + females) shrimp over the full time series. Autumn male abundance indices increased until 2001 and have since remained stable at a high level while spring male abundance indices have varied over time (Tables 18 and 19; Fig. 22).

Fishable biomass has been increasing throughout both the spring and autumn time series (Table 20; Fig. 23). Similarly, the autumn spawning stock biomass (transitionals and all females) index has been steadily increasing since 1999 (Table 18; Fig. 24) while the spring survey index increased from 1999-2003 and varied without trend thereafter (Table 9; Fig. 25).

Given the relative strength of the 2002-2004 year-classes, size at sex change remained stable over a number of years and has increased during the past year, fishable biomass has been increasing over time and the female portion of the population is relatively abundant, probably consisting of more than one year-class, the present fishery should be sustainable over the next few years.

Recruitment Index

Recruitment indices (age 2 abundance) were constructed from the autumn 1995-2005 and spring 1999-2006 surveys. Due to the incomplete survey in autumn 2004, this value was excluded from the autumn time series. Recruitment indices were based upon modal analysis of length frequencies. The autumn 93 to 98 year-classes appeared progressively stronger, the 99 year-class remained strong; however, since then there has been a general decrease in autumn age 2 abundance. The 03 year-class as seen in the autumn 2005 survey is the second lowest in the time series (Tables 16 and 21; Fig. 26). Spring recruitment indices have been fluctuating around the mean with the 04 year-class being the strongest in the time series.

Figure 27 presents fishable biomass with various lags regressed against the recruitment indices (age 2 abundance) using Canadian autumn survey data. The graph with a lag of one years and two years resulted in similar regression coefficients while the three year lag resulted in a much lower regression coefficient. The two year lag was used to predict fishable biomass for 2007. This predictive relationship is presented in Fig. 28; it is statistically significant and may be written as the following model:

$$\text{Fishable biomass}_{\text{year}+2} = 20.854(\text{autumn recruitment index}_{\text{year}}) + 13156.$$

If the autumn 2005 recruitment index (2.887 X 10^9 animals) is applied to this simple model then the predicted fishable biomass will be 73 361 tons in 2007.

A similar regression analysis using spring survey data provided a statistically insignificant relationship.

Exploitation Rates

Exploitation levels using ratios of catch divided by the previous year's Canadian survey index, in this case: lower 95% confidence interval below the biomass estimate, spawning stock biomass fishable biomass. In general, they all follow similar trajectories (Table 22). Overall, exploitation has been low even though catches have increased over time because the stock parameters also increased. Figure 27 presents the exploitation rate index determined as catch/ previous year's autumn fishable biomass. The 2006 exploitation rate index was 11.2%.

By-catch

Tables 23 and 24 indicate that relatively low numbers and weights of Atlantic cod (*Gadus morhua*) and American plaice (*Hippoglossoides platessoides*) had been taken by Canadian shrimp fishing fleets. The 2006 total estimated by-catch of Atlantic cod and American plaice were approximately 0.5, 4.8 tons, respectively.

Relative to other species, high levels of redfish (*Sebastes* spp.) and Greenland halibut (*Rheinhardtius hippoglossoides*) are taken in the shrimp fishery. The 2006 total estimated by-catch of redfish and Greenland halibut were 19.0 and 9.4 tons compared to a NAFO Div. 3L autumn 2005 biomass indices of ?? tons, respectively (Healey and Dwyer, 2005). High spatial overlap with shrimp, fusiform shape and the fact that Greenland halibut swim upright allowing relatively large animals to pass through the Nordmore Grate, result in a higher Greenland halibut by-catch within the shrimp fishery. As with the other groundfish species, the biomass of Greenland halibut in 3L has been declining over the past few years.

Tables 23 and 24 provide an estimate of groundfish removals at age. This is important because each kg of fish removed may represent several juvenile fish. Caution should be used in reading these tables because observed weights are recorded in kilograms. If a single fish was caught, and it weighed 5 grams, the weight was recorded as 1 kg. Thus by-catch levels presented in this document may be artificially high.

Levels of observer coverage are provided by the correction factors (logbook catch/ observer catch). Almost 100% of the large vessel fishing sets were observed, as indicated by correction factors that were just slightly above 1. Thus there should be high confidence in the large vessel by-catch values for the period 2003-2006. Small vessel observer coverage ranged between 4.8% (correction factor = 20.6 in 2005) and 3.2% (correction factor = 38.6 in 2006). There is less confidence in whether the small vessel by-catch estimates are representative of the fishery.

Due to the number of tasks undertaken by observers, and because conditions on vessels are not always conducive for detailed sampling of several species, few length measurements were taken. Where number of fish measured are low (<200), it is not clear whether the number at age were representative of the by-catch.

Resource Status

Canadian large (>500 t) fishing vessel catch rates have fluctuated around the long term mean since 2000 with the 2006 catch rate index above average and similar to the 2002-2004 catch rates. The Canadian small vessel standardized CPUE increased by 86% between 2003-2005 and remained near that level during 2006. The large vessel CPUE increased at a time when the distribution of this portion of the fishery and the resource has been expanding. However, there was not sufficient small vessel data to complete an analysis of distribution for 2006.

The standardized non-Canadian CPUE made use of data from Estonia, Greenland, Iceland and Norway. It increased by 258% from 330 kg/hr in 2001 to 1 108 kg/hr in 2004 but then decreased by 61% over the next two year resulting in a 431kg/hr catch rate during 2006. The 2006 model catch rate was significantly lower than the 2003 and 2004 catch rates while similar to all other rates.

Based on Canadian surveys, over 90% of the biomass was found in Div. 3L, distributed mainly along the northeast slope in depths from 185-550 m. There was a significant increase in autumn shrimp biomass indices between 1995 and 2001 and this index has since remained stabilized at a high level. The autumn 2005 index was 264 000 tons (53 billion animals), the highest in the autumn time series. The spring 2006 biomass index was 180 000 tons (35 billion animals), the second highest in spring time series. Due to broad confidence limits around these estimates, spring survey indices are not thought to be as reliable as the autumn survey indices.

The spring and autumn surveys showed an increase in the abundance of female (transitionals + females) shrimp over the full time series. Autumn male abundance indices increased until 2001 and have since remained stable at a high level while spring male abundance indices have varied over time.

The autumn 93 to 98 year-classes appeared progressively stronger, the 1999 year-class remained strong; however, since then there has been a general decrease in year-class strength. The 2003 year-class as seen in the autumn 2005 survey is the second lowest in the time series. Spring recruitment indices have been fluctuating around the mean with the 2004 year-class being the strongest in the time series

Shrimp aged 3 and 4 dominated the male component of the length frequencies in spring 2005 (02 and 01 year-classes) survey with carapace length frequency modes at 16.94 and 19.55 mm, respectively. Similarly, abundance estimates from the autumn 2005 survey were dominated by shrimp aged 3 and 4 (02 and 01 year-classes) with modes at 17.00 and 19.59 mm, respectively. While shrimp aged 2-4 dominated the spring 2006 survey (2002-2004 year-classes). A broad mode of females was present in all surveys implying the presence of more than one year-class of females.

Size at sex change as determined from large vessel observer and autumn survey data indicated stability throughout most of each time series with an increase in the final year that was statistically significant over several of the previous years. This would imply that individual female fecundity has increased at the time of transition.

Fishable biomass has been increasing throughout both the spring and autumn time series. Due to the increase in fishable biomass, the exploitation rate index has remained low in spite of increased catches.

Given the relative strength of this 2002-2004 year-classes, size at sex change remained stable over a number of years and has increased during the past year, fishable biomass has been increasing over time and the female portion of the population is relatively abundant, probably consisting of more than one year-class, the present fishery should be sustainable over the next few years.

Caution should be used in the fishery because it may also affect other important fish stocks. Even though groundfish by-catch due to Canadian shrimp fishing activities has been low many of the species that were studied are at low enough stock levels that fishing moratoria have been imposed upon them. For this reason, it is important that by-catch continue to be monitored and that the exercise should extend to by-catch from foreign fleets.

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Table 1. Biomass estimates (tons) of northern shrimp (*Pandalus borealis*) from Canadian autumn surveys in Div. 3L using a Campelen research shrimp trawl over the period 1995 -2005. Light shading indicates strata not fished during 2004. The inshore strata were not consistently sampled over the years therefore this table includes only offshore strata. (standard 15 min. tows).

Depth range (m)	Area	Stratum	1995	1996	1997	19981	1999	2000	2001	2002	2003	2004	2005
57 - 92	2071	350	0	0	1	3	1	1	2	31	38	4	2
	1780	363	0	1	1	2	0	7	19	18	622	1	0
	1121	371	0	0	1	0	0	7	5	10	23	0	3
	2460	372	0	3	12	6	1	7	7	106	166	8	0
	1120	384	0	2	1	1	2	12	5	489	38	6	0
93 - 183	1519	328	32	57	92	15	41	12	14	28	73	38	24
	1574	341	0	81	41	4	18	27	21	52	58	37	1
	585	342	0	1	0	25	4	444	4	35	48	1	0
	525	343	0	1	1	5	1	5	4	5	4	19	24
	2120	348	4	18	20	56	291	361	435	675	195	5,309	6,419
	2114	349	0	3	6	16	12	30	40	466	298	37	38
	2817	364	1	3	44	14	5	120	190	316	92	26	748
	1041	365	1	3	105	179	63	.	3,385	3,405	99	.	10,161
	1320	370	2	1	57	712	134	84	3,011	129	103	.	12
	2356	385	1	9	1,471	205	1,274	2,078	4,307	3,629	7,381	5,367	8,411
	1481	390	0	0	10	6	12	152	2,498	3,520	7,928	1,330	2,555
184 - 274	1582	344	8	29	104	2,858	5,068	3,192	1,971	7,549	2,084	14,774	15,440
	983	347	21	45	25	4,850	1,547	7,372	10,450	8,516	1,743	21,775	13,749
	1394	366	674	560	11,878	5,425	7,673	24,193	25,316	27,047	22,959	.	34,421
	961	369	23	182	1,843	6,319	3,939	3,353	10,842	6,694	21,994	.	28,648
	983	386	18	304	9,299	5,981	7,884	6,161	15,245	25,131	22,962	.	21,600
	821	389	42	2,007	1,630	6,917	10,065	25,088	32,443	34,321	17,502	11,248	12,341
	282	391	0	391	236	166	246	3,643	353	106	7,838	2,312	2,072
275 - 366	1432	345	723	2,030	5,976	9,954	4,361	18,288	17,904	31,885	16,945	20,045	27,257
	865	346	1,802	7,069	5,608	3,510	5,328	6,251	18,983	35,886	29,796	11,056	35,328
	334	368	77	1,232	483	358	101	27	16,985	457	10,162	.	11,151
	718	387	1,199	2,393	4,258	7,197	3,908	12,013	43,798	11,890	44,725	.	23,107
	361	388	363	1,599	2,117	1,485	570	4,326	13,612	7,204	3,747	.	8,845
	145	392	210	324	73	187	123	387	320	44	881	906	694
367 - 549	186	729	0	3	2	0	51	1	603	0	15	1	1
	216	731	0	.	16	11	14	112	92	772	0	1,496	130
	468	733	8	212	170	12	66	0	243	4	0	262	32
	272	735	134	2	166	2	57	119	8	12	147	.	57
550 - 731	170	730	0	1	0	0	0	0	1	0	0	0	29
	231	732	12	0	0	0	1	0	2	9	0	866	4
	228	734	0	0	1	0	0	0	1	9	0	.	1
	175	736	1	0	8	2	2	27	13	0	18	.	1
732 - 914	227	737	0	0	0	0	0	1	0	0	0	.	1
	223	741	.	0	0	0	0	0	0	0	21	.	.
	348	745	.	0	0	0	0	0	10	0	8	.	.
	159	748	.	0	0	0	0	1	3	0	1	.	.
915 -1097	221	738	0	0	0	0	0	0	0	0	0	.	.
	206	742	.	0	0	0	0	0	0	0	0	.	.
	392	746	.	0	0	0	0	0	4	0	1	.	.
	126	749	.	0	0	0	.	0	0	0	0	.	.
1098 -1280	254	739	.	0	0	0	0	0	0	0	0	.	.
	211	743	.	0	0	0	0	0	0	0	0	.	.
	724	747	.	0	0	0	0	0	0	1	0	.	.
	556	750	.	0	0	0	0	0	0	1	0	.	.
1281 -1463	264	740	.	0	0	0	0	0	0	0	0	.	.
	280	744	.	0	0	0	.	0	0	0	0	.	.
	229	751	.	0	0	0	.	0	0	0	0	.	.
Biomass estimate			5358	18,566	45,758	56,485	52,864	117,902	223,149	210,453	220,711	96,926	263,307
Upper 95% CL.			7397	28,893	66,426	76,064	69,804	142,948	369,574	299,083	337,973	118,670	327,947
Lower 95% CL.			3318	8,238	25,090	36,905	35,923	92,855	76,725	121,821	103,549	75,182	198,667
% of 3L autumn biomass index within the missing strata			39.73%	25.19%	61.40%	46.34%	44.95%	39.00%	53.15%	35.53%	55.81%	???	49.05%

Table 2. Annual nominal catches by contracting party of northern shrimp (*Pandalus borealis*) caught in NAFO Div. 3L.

	1999	2000	2001	2002	2003	2004	2005	2006	2007
Canada	78[1]	4,250[2]	5,129[2]	5,414[2]	10,008[2]	10,613[2]	11,176[2]	18,271[2]	
Cuba				70[3]	146[1]	145[1]	136[1]		
Estonia		64[1]	2,264[4]	450[5]	152[1]	87[1]			
European Union					117[1]	159[1]	767[1]	1751[1]	
Faroe Islands	706[1]	42[1]	2,052[4]	620[5]		614[1]	1044[1]	947[1]	
France (SPM)		67[1]		36[3]			147[1]		
Greenland		34[1]			672[8]	296[1]	302[1]	324[8]	
Iceland		97[1]	55[7]	55[7]	133[7]	105[7]	140[11]	226[7]	
Latvia		64[1]	67[1]	59[3]	144[1]	105[1]			
Lithuania		67[1]	51[3]	67[3]	142[1]	62[1]			
Norway		77[1]	78[6]	70[6]	145[9]	148[1]	144[1]		
Poland		40[1]	54[1]			144[1]			
Portugal			61[5]						
Russia		67[1]	67[1]	67[3]			144[1]	248[1]	
Spain	11[1]		699[4]						
Ukraine			57[1]		144[1]	144[1]		119[10]	
USA				69[3]	144[1]		137[1]		
Estimated additional catch								2,000[5]	
GRAND TOTAL	795	4,869	10,566	6,977	11,947	12,622	14,137	23,886	
TAC (tons)		6,000	6,000	6,000	13,000	13,000	13,000	22,000	22,000

Sources:

1 NAFO STATLANT 21A
2 Canadian Atlantic Quota Report, or other preliminary sources
3 NAFO monthly records of provisional catches
4 Value agreed upon in STACFIS
5 Canadian surveillance reports
6 Observer datasets
7 Icelandic logbook dataset.
8 Greenlandic logbook dataset.
9 Norwegian logbook dataset.
10 Ukranian logbook dataset
11 Data provided by Icelandic Scientist

Table 3. Multiplicative, year, month, ship and gear type model for Canadian large (>500 t) vessels fishing northern shrimp in NAFO Div. 3LNO over the period 2000-2006. (Weighting by effort, single trawl, no windows, observer data, history of at least two years for each vessel)

The GLM Procedure
Class Level Information

Class	Levels	Values
year	7	2000 2001 2002 2003 2004 2005 2006
month	6	1 2 3 4 5 6
cfv	13	
gear	2	66 99

Number of observations 128

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	24	1801.742336	75.072597	15.89	<.0001
Error	103	486.708037	4.725321		
Corrected Total	127	2288.450373			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.787320	29.53145	2.173780	7.360898

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	6	947.3352918	157.8892153	33.41	<.0001
month	5	204.1795998	40.8359200	8.64	<.0001
cfv	12	604.7907367	50.3992281	10.67	<.0001
gear	1	45.4367080	45.4367080	9.62	0.0025

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	6	320.3646034	53.3941006	11.30	<.0001
month	5	206.9444239	41.3888848	8.76	<.0001
cfv	12	479.8813051	39.9901088	8.46	<.0001
gear	1	45.4367080	45.4367080	9.62	0.0025

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		7.654545941 B	0.12607920	60.71	<.0001
year	2000	-0.668527998 B	0.12661663	-5.28	<.0001
year	2001	-0.482342605 B	0.10535890	-4.58	<.0001
year	2002	-0.148562287 B	0.11460988	-1.30	0.1978
year	2003	0.207044870 B	0.11817920	1.75	0.0828
year	2004	-0.174164128 B	0.11311125	-1.54	0.1267
year	2005	-0.315574374 B	0.09274942	-3.40	0.0010
year	2006	0.000000000 B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
2000	6.957248	6.765336	7.149160
2001	7.143433	6.979533	7.307334
2002	7.477214	7.295962	7.658465
2003	7.832821	7.648247	8.017395
2004	7.451612	7.270258	7.632965
2005	7.310202	7.172659	7.447744
2006	7.625776	7.482290	7.769262

Table 4. Large vessel (>500 t) shrimp fishing fleet catch rate indices for NAFO Div. 3L, 2000-2006.

YEAR	TAC (t)	CATCH[1] (t)	PERCENT[2] CATCH OBSERVED	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE INDEX	EFFORT[3] (HR)	STANDARDIZED RELATIVE CPUE	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1998		82							
1999		61							
2000	2,500	982	77	841	0.451	1,168	0.513	1,051	935
2001	2,500	2,394	78	1,279	0.686	1,871	0.617	1,266	1,891
2002	2,500	2,455	85	1,862	0.998	1,318	0.862	1,767	1,389
2003	4,267	3,956	68	3,695	1.980	1,071	1.230	2,522	1,569
2004	4,267	4,037	37	2,052	1.100	1,968	0.840	1,723	2,344
2005	4,267	4,037	65	1,755	0.940	2,301	0.730	1,495	2,699
2006	5,268	3,868	87	1,866	1.000	2,073	1.000	2,050	1,886

[1] CATCH (TONS) AS REPORTED IN ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY AND FROM YEAR-END QUOTA REPORTS AND/OR LOGBOOK RECORDS.

[2] PERCENT CATCH OBSERVED IN CALENDAR YEAR AS REPORTED IN STANDARDIZED OBSERVER CPUE DATASET.

[3] EFFORT CALCULATED (CATCH/CPUE) FROM LARGE VESSEL OBSERVER DATA, SINGLE + DOUBLE TRAWL, NO WINDOWS.

Multiplicative, year month and size class model for Canadian small (<=500 t)

Table 5. Multiplicative, year and model for Canadian small (<=500 t) vessels fishing northern shrimp in NAFO Divs. 3LNO over the period 2000-2006. (Weighting by effort, single trawl, logbook data, history of at least two years for each vessel)

The GLM Procedure

Class Level Information

Class	Levels	Values
Year	7	2000 2001 2002 2003 2004 2005 2006
Month	6	5 7 8 9 10 99

Number of observations 30

Dependent Variable: lncpue
Weight: wfactor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	4565.508710	415.046246	29.65	<.0001
Error	18	251.943785	13.996877		
Corrected Total	29	4817.452495			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.947702	61.70799	3.741240	6.062813

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Year	6	4280.368199	713.394700	50.97	<.0001
Month	5	285.140511	57.028102	4.07	0.0119

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Year	6	2025.418758	337.569793	24.12	<.0001
Month	5	285.140511	57.028102	4.07	0.0119

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		6.589923830 B	0.24818723	26.55	<.0001
Year	2000	-0.646930373 B	0.24999700	-2.59	0.0186
Year	2001	-0.671148787 B	0.25160289	-2.67	0.0157
Year	2002	-0.631391700 B	0.25146108	-2.51	0.0218
Year	2003	-0.458850167 B	0.25061624	-1.83	0.0837
Year	2004	-0.275625998 B	0.25172850	-1.09	0.2880
Year	2005	0.082600512 B	0.25261520	0.33	0.7475
Year	2006	0.000000000 B	.	.	.

Year	lncpue LSMEAN	95% Confidence Limits	
2000	5.823593	5.708559	5.938627
2001	5.799374	5.693079	5.905670
2002	5.839132	5.732607	5.945656
2003	6.011673	5.936040	6.087306
2004	6.194897	6.085528	6.304266
2005	6.553124	6.437279	6.668969
2006	6.470523	5.953421	6.987625

Table 6. Small vessel (<=500 t) shrimp fishing fleet catch rate indices for NAFO Div. 3L, 2000-2006.

YEAR	TAC (t)	CATCH[1] (t)	PERCENT OF[2] CATCH IN STANDARD DATASET	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE INDEX	EFFORT[3] (HR)	STANDARDIZED RELATIVE CPUE	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1999		17							
2000	2,500	3,247	79.6	372	0.478	8,722	0.524	338	9,601
2001	2,500	2,482	91.3	319	0.427	7,785	0.511	330	7,518
2002	2,500	2,861	92.0	331	0.473	8,635	0.532	343	8,331
2003	6,566	6,457	86.4	394	0.897	16,368	0.632	408	15,820
2004	6,566	6,576	80.6	545	0.661	12,067	0.759	490	13,414
2005	6,566	7,147	69.8	778	0.503	9,186	1.086	701	10,189
2006	12,297	11,946	1.3	655	1.000	18,249	1.000	646	18,497

[1] CATCH (TONS) AS REPORTED IN ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY AND FROM YEAR-END QUOTA REPORTS AND/OR LOGBOOK RECORDS.

[2] PERCENT CATCH FROM LOGBOOK DATASETS AS CAPTURED BY THE MODEL FOR EACH CALENDAR YEAR.

[3] EFFORT CALCULATED (CATCH/CPUE) FROM SMALL VESSEL LOGBOOK DATASET, ALL WERE SINGLE TRAWL.

Table 7. Multiplicative, ship, year and month model for Non Canadian vessels fishing northern shrimp in NAFO Div. 3LNO over the period 2000-2006.

(Data from Estonia, Greenland, Iceland, Norway, and Russia, single and double trawl data only)

Class Level Information

Class	Levels	Values
year	7	2000 2001 2002 2003 2004 2005 2006
ship	21	1 2 3 4 5 6 7 9 11 12 13 15 16 17 18 19 20 21 22 23 26
month	12	1 2 3 4 5 6 7 8 9 10 11 12

Number of observations 109

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	37	2203.487569	59.553718	11.02	<.0001
Error	71	383.838954	5.406182		
Corrected Total	108	2587.326523			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.851646	35.21721	2.325120	6.602225

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	6	631.932795	105.322132	19.48	<.0001
ship	20	1449.979318	72.498966	13.41	<.0001
month	11	121.575456	11.052314	2.04	0.0363

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	6	165.122636	27.520439	5.09	0.0002
ship	20	1075.747223	53.787361	9.95	<.0001
month	11	121.575456	11.052314	2.04	0.0363

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		5.890959912	B	0.15369420	38.33	<.0001
year	2000	0.050625412	B	0.26697748	0.19	0.8501
year	2001	-0.123252689	B	0.21504302	-0.57	0.5684
year	2002	0.214205013	B	0.25089525	0.85	0.3961
year	2003	0.573973681	B	0.15341375	3.74	0.0004
year	2004	0.684054694	B	0.18327432	3.73	0.0004
year	2005	0.342003042	B	0.12350972	2.77	0.0072
year	2006	0.000000000	B	.	.	.
ship	1	0.276242041	B	0.16267014	1.70	0.0939
ship	2	-0.660512540	B	0.17241633	-3.83	0.0003
ship	3	0.182927252	B	0.12467556	1.47	0.1467
ship	4	-1.053363634	B	0.22612339	-4.66	<.0001
ship	5	0.295457959	B	0.13540520	2.18	0.0324
ship	6	0.525083314	B	0.41773467	1.26	0.2129

Table 7. Multiplicative, ship, year and month model for Non Canadian vessels fishing northern shrimp in NAFO Divs. 3LNO over the period 2000-2006.(Data from Estonia, Greenland, Iceland, Norway, and Russia, single and double trawl data only). (Continued)

Parameter		Estimate		Standard Error	t Value	Pr > |t|
ship	7	1.102244262	B	0.17143722	6.43	<.0001
ship	9	1.095272615	B	0.17556974	6.24	<.0001
ship	11	-1.130729238	B	0.71639473	-1.58	0.1189
ship	12	-0.457179869	B	0.26717781	-1.71	0.0914
ship	13	-0.299540895	B	0.40222118	-0.74	0.4589
ship	15	0.196088308	B	1.65334171	0.12	0.9059
ship	16	0.116560565	B	0.37309145	0.31	0.7556
ship	17	0.938156735	B	0.24902281	3.77	0.0003
ship	18	-0.399860625	B	0.96591298	-0.41	0.6801
ship	19	0.213458325	B	0.29124108	0.73	0.4660
ship	20	-0.738471029	B	0.29829349	-2.48	0.0157
ship	21	-1.586540386	B	0.90459067	-1.75	0.0838
ship	22	-0.139052880	B	0.26964399	-0.52	0.6077
ship	23	-1.168488163	B	0.35259464	-3.31	0.0015
ship	26	0.000000000	B	.	.	.
month	1	0.380638630	B	0.18658292	2.04	0.0451
month	2	0.392761651	B	0.18430862	2.13	0.0366
month	3	0.317764698	B	0.15719545	2.02	0.0470
month	4	-0.126593312	B	0.49990246	-0.25	0.8008
month	5	-0.044457476	B	0.58281679	-0.08	0.9394
month	6	0.022627382	B	0.34961676	0.06	0.9486
month	7	0.500987925	B	0.15526307	3.23	0.0019
month	8	0.364377657	B	0.16468888	2.21	0.0301
month	9	0.606800193	B	0.15817785	3.84	0.0003
month	10	0.227248926	B	0.30355931	0.75	0.4566
month	11	-0.261386441	B	1.16929716	-0.22	0.8238
month	12	0.000000000	B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
2000	6.011781	5.533548	6.490013
2001	5.837902	5.384071	6.291733
2002	6.175360	5.681850	6.668870
2003	6.535129	6.171303	6.898955
2004	6.645210	6.218915	7.071504
2005	6.303158	5.922912	6.683404
2006	5.961155	5.535300	6.387011

Table 8. Catch rates for non Canadian vessels fishing for Northern shrimp (*Pandalus borealis*) within the Div. 3L NRA; 2000-2006. (Model made use of single and double trawl catch rate data from Estonia, Greenland, Iceland, Norway and Russia.)

YEAR	TAC (t)	CATCH (t)	PERCENT CATCH OBSERVED	UNSTANDARDIZED			STANDARDIZED		
				CPUE (KG/HR)	CPUE INDEX	EFFORT (HR)	RELATIVE CPUE	MODELLED CPUE	EFFORT (HRS)
2000	1,000	619	36	559	0.72	1,108	1.05	408	1,516
2001	1,000	5505	4	505	0.65	10,898	0.88	343	16,047
2002	1,000	1563	8	577	0.74	2,710	1.24	481	3,251
2003	2,167	1939	68	1,488	1.91	1,303	1.78	689	2,815
2004	2,167	2009	42	1,690	2.17	1,189	1.98	769	2,612
2005	2,167	2961	38	870	1.12	3,402	1.41	546	5,420
2006	3,675	3474	32	780	1.00	4,454	1.00	388	8,952

Table 10. A probit analysis of winter (January-March) 2001 – 2006 observed large vessel length frequency data to determine the size at sex transition for northern shrimp (*Pandalus borealis*) within NAFO Div. 3L.

The GENMOD Procedure
Model Information

Data Set	WORK.ALL_SHRIMP
Distribution	Binomial
Link Function	Logit
Response Variable (Events)	female_lt
Response Variable (Trials)	total
Observations Used	211
Number Of Events	39711
Number Of Trials	67648

Class Level Information

Class	Levels	Values
year	6	2001 2002 2003 2004 2005 2006

Parameter Information

Parameter	Effect	year
Prm1	Intercept	
Prm2	length	
Prm3	year	2001
Prm4	year	2002
Prm5	year	2003
Prm6	year	2004
Prm7	year	2005
Prm8	year	2006

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	204	1336.1718	6.5499
Scaled Deviance	204	204.0000	1.0000
Pearson Chi-Square	204	1805.5960	8.8510
Scaled Pearson X2	204	275.6693	1.3513
Log Likelihood		-2684.8891	

Algorithm converged.

Table 10. A probit analysis of winter (January-March) 2001-2006 observed large vessel length frequency data to determine the size at sex transition for northern shrimp (*Pandalus borealis*) within NAFO Div. 3L.

Analysis Of Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-35.3305	0.7434	-36.7874	-33.8735	2258.93	<.0001
length	1	1.6327	0.0338	1.5665	1.6989	2335.16	<.0001
year 2001	1	0.3220	0.1950	-0.0601	0.7042	2.73	0.0986
year 2002	1	1.2840	0.1500	0.9901	1.5780	73.30	<.0001
year 2003	1	0.9076	0.2170	0.4823	1.3329	17.50	<.0001
year 2004	1	0.9515	0.1179	0.7203	1.1826	65.10	<.0001
year 2005	1	0.2627	0.0852	0.0957	0.4296	9.51	0.0020
year 2006	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale	0	2.5593	0.0000	2.5593	2.5593		

NOTE: The scale parameter was estimated by the square root of DEVIANCE/DOF.

LR Statistics For Type 1 Analysis

Source	Deviance	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
Intercept	57885.1931						
length	2151.9455	1	204	8509.07	<.0001	8509.07	<.0001
year	1336.1718	5	204	24.91	<.0001	124.55	<.0001

Least Squares Means

Effect	year	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq
year	2001	-1.3599	0.1845	1	54.32	<.0001
year	2002	-0.3979	0.1279	1	9.68	0.0019
year	2003	-0.7744	0.2056	1	14.19	0.0002
year	2004	-0.7305	0.0962	1	57.62	<.0001
year	2005	-1.4193	0.0630	1	507.28	<.0001
year	2006	-1.6820	0.0805	1	436.90	<.0001

Differences of Least Squares Means

Effect	year	_year	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq
year	2001	2002	-0.9620	0.2240	1	18.44	<.0001
year	2001	2003	-0.5856	0.2743	1	4.56	0.0328
year	2001	2004	-0.6294	0.2052	1	9.40	0.0022
year	2001	2005	0.0594	0.1896	1	0.10	0.7543
year	2001	2006	0.3220	0.1950	1	2.73	0.0986
year	2002	2003	0.3764	0.2418	1	2.42	0.1196
year	2002	2004	0.3326	0.1595	1	4.34	0.0371
year	2002	2005	1.0213	0.1416	1	52.03	<.0001
year	2002	2006	1.2840	0.1500	1	73.30	<.0001
year	2003	2004	-0.0439	0.2253	1	0.04	0.8456
year	2003	2005	0.6449	0.2118	1	9.27	0.0023
year	2003	2006	0.9076	0.2170	1	17.50	<.0001
year	2004	2005	0.6888	0.1083	1	40.47	<.0001
year	2004	2006	0.9515	0.1179	1	65.10	<.0001
year	2005	2006	0.2627	0.0852	1	9.51	0.0020

Table 11. A probit analysis of autumn 1995-2005 research survey length frequency data to determine the size at sex transition for northern shrimp (*Pandalus borealis*) within NAFO Div. 3LNO.

The GENMOD Procedure

Model Information

Data Set	WORK.PERCENT_FE
Distribution	Binomial
Link Function	Logit
Response Variable (Events)	num_fem
Response Variable (Trials)	total
Observations Used	480
Number Of Events	37208.7839
Number Of Trials	137342.0000

Class Level Information

Class	Levels	Values
year	10	1995 1996 1997 1998 1999 2000 2001 2002 2003 2005

Parameter Information

Parameter	Effect	year
Prm1	Intercept	
Prm2	length	
Prm3	year	1995
Prm4	year	1996
Prm5	year	1997
Prm6	year	1998
Prm7	year	1999
Prm8	year	2000
Prm9	year	2001
Prm10	year	2002
Prm11	year	2003
Prm12	year	2005

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	469	9628.2284	20.5293
Scaled Deviance	469	469.0000	1.0000
Pearson Chi-Square	469	600857.8360	1281.1468
Scaled Pearson X2	469	29268.3464	62.4059
Log Likelihood		-1529.8106	

Algorithm converged.

Table 11. A probit analysis of autumn 1995-2005 research survey length frequency data to determine the size at sex transition for northern shrimp (*Pandalus borealis*) within NAFO Div. 3LNO (continued).

Analysis Of Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-26.5480	0.7523	-28.0224	-25.0735	1245.31	<.0001
length	1	1.1959	0.0337	1.1299	1.2620	1261.18	<.0001
year1995	1	6.2034	0.3083	5.5992	6.8075	404.96	<.0001
year1996	1	-0.3770	0.2997	-0.9644	0.2105	1.58	0.2085
year1997	1	1.4001	0.1949	1.0181	1.7820	51.62	<.0001
year1998	1	-0.1973	0.2140	-0.6168	0.2221	0.85	0.3565
year1999	1	0.5526	0.2086	0.1437	0.9615	7.02	0.0081
year2000	1	0.8888	0.2098	0.4776	1.3000	17.95	<.0001
year2001	1	0.2904	0.1987	-0.0992	0.6799	2.13	0.1440
year2002	1	0.7499	0.1836	0.3901	1.1096	16.69	<.0001
year2003	1	0.4853	0.1839	0.1248	0.8458	6.96	0.0083
year2005	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale	0	4.5309	0.0000	4.5309	4.5309		

NOTE: The scale parameter was estimated by the square root of DEVIANCE/DOF.

LR Statistics For Type 1 Analysis

Source	Deviance	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
Intercept	107279.243						
length	21009.1996	1	469	4202.29	<.0001	4202.29	<.0001
year	9628.2284	9	469	61.60	<.0001	554.38	<.0001

Least Squares Means

Effect	year	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq
year	1995	2.6052	0.2279	1	130.66	<.0001
year	1996	-3.9752	0.2790	1	202.99	<.0001
year	1997	-2.1981	0.1370	1	257.37	<.0001
year	1998	-3.7955	0.1865	1	414.21	<.0001
year	1999	-3.0456	0.1728	1	310.80	<.0001
year	2000	-2.7093	0.1649	1	270.09	<.0001
year	2001	-3.3078	0.1565	1	447.02	<.0001
year	2002	-2.8483	0.1330	1	458.43	<.0001
year	2003	-3.1129	0.1406	1	490.27	<.0001
year	2005	-3.5982	0.1686	1	455.72	<.0001

Table 11. A probit analysis of autumn 1995-2005 research survey length frequency data to determine the size at sex transition for northern shrimp (*Pandalus borealis*) within NAFO Div. 3LNO (continued).

The GENMOD Procedure

Differences of Least Squares Means

Effect	year	_year	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq
year	1995	1996	6.5803	0.3792	1	301.17	<.0001
year	1995	1997	4.8033	0.2803	1	293.66	<.0001
year	1995	1998	6.4007	0.3186	1	403.49	<.0001
year	1995	1999	5.6508	0.3071	1	338.49	<.0001
year	1995	2000	5.3145	0.2983	1	317.41	<.0001
year	1995	2001	5.9130	0.2964	1	398.09	<.0001
year	1995	2002	5.4535	0.2832	1	370.75	<.0001
year	1995	2003	5.7181	0.2897	1	389.57	<.0001
year	1995	2005	6.2034	0.3083	1	404.96	<.0001
year	1996	1997	-1.7770	0.2964	1	35.95	<.0001
year	1996	1998	-0.1797	0.3099	1	0.34	0.5621
year	1996	1999	-0.9296	0.3060	1	9.23	0.0024
year	1996	2000	-1.2658	0.3066	1	17.05	<.0001
year	1996	2001	-0.6673	0.2993	1	4.97	0.0258
year	1996	2002	-1.1269	0.2893	1	15.17	<.0001
year	1996	2003	-0.8623	0.2897	1	8.86	0.0029
year	1996	2005	-0.3770	0.2997	1	1.58	0.2085
year	1997	1998	1.5974	0.2104	1	57.66	<.0001
year	1997	1999	0.8475	0.2018	1	17.63	<.0001
year	1997	2000	0.5112	0.1994	1	6.57	0.0104
year	1997	2001	1.1097	0.1900	1	34.12	<.0001
year	1997	2002	0.6502	0.1727	1	14.17	0.0002
year	1997	2003	0.9148	0.1757	1	27.11	<.0001
year	1997	2005	1.4001	0.1949	1	51.62	<.0001
year	1998	1999	-0.7499	0.2231	1	11.30	0.0008
year	1998	2000	-1.0862	0.2242	1	23.47	<.0001
year	1998	2001	-0.4877	0.2139	1	5.20	0.0226
year	1998	2002	-0.9472	0.1998	1	22.46	<.0001
year	1998	2003	-0.6826	0.2001	1	11.63	0.0006
year	1998	2005	-0.1973	0.2140	1	0.85	0.3565
year	1999	2000	-0.3362	0.2171	1	2.40	0.1214
year	1999	2001	0.2622	0.2071	1	1.60	0.2053
year	1999	2002	-0.1973	0.1922	1	1.05	0.3046
year	1999	2003	0.0673	0.1932	1	0.12	0.7276
year	1999	2005	0.5526	0.2086	1	7.02	0.0081
year	2000	2001	0.5985	0.2065	1	8.40	0.0038
year	2000	2002	0.1389	0.1911	1	0.53	0.4672
year	2000	2003	0.4036	0.1931	1	4.37	0.0367
year	2000	2005	0.8888	0.2098	1	17.95	<.0001
year	2001	2002	-0.4595	0.1803	1	6.49	0.0108
year	2001	2003	-0.1949	0.1819	1	1.15	0.2839
year	2001	2005	0.2904	0.1987	1	2.13	0.1440
year	2002	2003	0.2646	0.1647	1	2.58	0.1081
year	2002	2005	0.7499	0.1836	1	16.69	<.0001
year	2003	2005	0.4853	0.1839	1	6.96	0.0083

Table 12. Northern shrimp stock size estimates within NAFO Div. 3LNO as determined from annual Canadian autumn multi-species bottom trawl surveys, 1995-2005. (Offshore strata only; standard 15 min. tows). Please note that the autumn 2004 indices are not determined due to missing strata.

	Biomass (tons)			Abundance (numbers x 10-6)			Survey
Year	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1995	3,639	5,921	8,202	659	2,054	3,449	337
1996	10,230	20,088	29,948	1,985	5,867	9,748	304
1997	25,530	46,202	66,875	6,280	10,523	14,766	318
1998	40,011	59,914	79,816	10,787	15,326	19,866	347
1999	36,202	53,144	70,086	9,588	13,060	16,533	313
2000	93,132	118,180	143,227	25,840	32,066	38,292	337
2001	77,563	223,995	370,427	20,177	54,077	87,978	362
2002	126,180	215,008	303,837	30,469	50,257	70,044	365
2003	106,338	223,568	340,798	29,708	47,281	64,853	316
2004		???			???		
2005	199,173	263,815	328,456	40,080	52,964	65,847	333

Table 13. Northern shrimp stock size estimates within Nafo Divisions 3LNO as determined from annual Canadian spring multi-species bottom trawl surveys, 1999 – 2006. (Offshore strata only; standard 15 min. tows). Please note that strata deeper than 94 m were not surveyed in Nafo Divisions 3NO during spring 2006. At least 97% of the survey biomass may be attributed to Nafo Division 3L (Tables 14 and 15) therefore the spring 2006 are for 3L only.

	Biomass (tons)			Abundance (numbers x 10^{-6})			3LNO	3L	3NO
Year	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	No. Sets	No. Sets	No. Sets
1999	12,564	55,317	98,069	3,178	12,702	22,227	313	145	168
2000	-15,869	121,815	259,498	-54,743	25,012	104,768	298	134	164
2001	62,359	102,566	142,773	13,417	24,845	36,272	300	142	158
2002	121,067	159,491	197,916	28,311	37,512	46,714	300	142	158
2003	117,918	198,169	278,421	22,638	47,120	71,604	300	142	158
2004	-529,764	110,827	751,418	-97,747	21,696	141,395	296	139	157
2005	88,504	155,627	222,751	17,441	29,976	42,510	289	133	156
2006	69,546	180,642	291,738	56,127	35,199	14,271	195	141	54

Table 14. NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) biomass estimates for entire Divisions and outside the 200 Nmi limit. Shrimp were collected during the annual Canadian autumn multi-species research bottom trawl surveys using a Campelen 1800 shrimp trawl. (Standard 15 min tows; no estimate for 3L in 2004 due to an incomplete survey).

Season	Year	Division	Entire Division Biomass estimate (Kg x 1000)	Entire Division Percent by division	Outside 200 Nmi limit Biomass estimate (Kg x 1000)	Outside 200 Nmi limit Percent biomass by division		percent biomass in NRA	3 year running average percent biomass in NRA
Autumn	1995	3L	5,357	90.48	1,039	67.63		19.40	19.40
Autumn	1996	3L	18,566	92.42	4,506	76.86		24.27	21.84
Autumn	1997	3L	45,758	99.04	5,115	92.83		11.18	18.28
Autumn	1998	3L	56,485	94.28	8,707	75.66		15.42	16.95
Autumn	1999	3L	52,863	99.47	8,734	97.38		16.52	14.37
Autumn	2000	3L	117,902	99.77	28,447	99.16		24.13	18.69
Autumn	2001	3L	223,149	99.62	52,292	98.47		23.43	21.36
Autumn	2002	3L	210,451	97.88	35,702	91.48		16.96	21.51
Autumn	2003	3L	219,643	98.72	45,383	94.92		20.66	20.35
Autumn	2004	3L	???	???	???	???		??	??
Autumn	2005	3L	263,307	99.81	29,409	98.55		11.17	15.92
			Overall average	97.15			overall average	18.31	
Autumn	1995	3N	533	9.00	497	32.34		93.29	93.29
Autumn	1996	3N	1,514	7.54	1,356	23.12		89.52	91.40
Autumn	1997	3N	427	0.92	391	7.09		91.52	91.44
Autumn	1998	3N	3,360	5.61	2,786	24.21		82.91	87.98
Autumn	1999	3N	272	0.51	232	2.59		85.57	86.67
Autumn	2000	3N	270	0.23	240	0.84		88.80	85.76
Autumn	2001	3N	836	0.37	809	1.52		96.77	90.38
Autumn	2002	3N	4,444	2.07	3,295	8.44		74.14	86.57
Autumn	2003	3N	2,785	1.25	2,421	5.06		86.93	85.95
Autumn	2004	3N	1,422	???	1,392	???		???	???
Autumn	2005	3N	423	0.16	403	1.35		95.27	91.10
			Overall average	2.77			overall average	88.47	
Autumn	1995	3O	31	0.52	1	0.04		1.82	1.82
Autumn	1996	3O	9	0.04	1	0.02		12.50	7.16
Autumn	1997	3O	17	0.04	4	0.07		23.79	12.70
Autumn	1998	3O	69	0.12	15	0.13		21.23	19.17
Autumn	1999	3O	9	0.02	3	0.03		33.59	26.21
Autumn	2000	3O	8	0.01	1	0.00		8.02	20.95
Autumn	2001	3O	10	0.00	3	0.01		30.00	23.87
Autumn	2002	3O	113	0.05	32	0.08		28.32	22.11
Autumn	2003	3O	72	0.03	8	0.02		11.11	23.14
Autumn	2004	3O	77	???	12	???		???	???
Autumn	2005	3O	84	0.03	30	0.10		35.71	23.41
			Overall average	0.09			overall average	20.61	
	all divisions								
Autumn	1995		5,921		1,537			25.96	25.96
Autumn	1996		20,089		5,862			29.18	27.57
Autumn	1997		46,202		5,509			11.92	22.35
Autumn	1998		59,914		11,508			19.21	20.10
Autumn	1999		53,144		8,969			16.88	16.00
Autumn	2000		118,180		28,687			24.27	20.12
Autumn	2001		223,995		53,104			23.71	21.62
Autumn	2002		215,008		39,029			18.15	22.04
Autumn	2003		222,499		47,813			21.49	21.12
Autumn	2004		???		???			???	???
Autumn	2005		263,815		29,842			11.31	16.40
							overall average	20.21	

Table 15. NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) biomass estimates for entire divisions and outside the 200 Nmi limit. Shrimp were collected during the annual spring Canadian multi-species research bottom trawl surveys using a Campelen 1800 shrimp trawl. (Standard 15 min tows; no estimates for 3NO in 2006 due to an incomplete survey).

Season	Year	Division	Entire Division Biomass estimate (Kg x 1000)	Entire Division Percent by division	Outside 200 Nmi limit Biomass estimate (Kg x 1000)	Outside 200 Nmi limit Percent biomass by division		percent biomass in NRA	3 year running average percent biomass in NRA
Spring	1999	3L	53,934	97.50	14,731	91.74		27.31	27.31
Spring	2000	3L	119,521	98.12	36,127	94.30		30.23	28.77
Spring	2001	3L	102,493	99.93	18,397	99.75		17.95	25.16
Spring	2002	3L	155,061	97.22	47,288	92.79		30.50	26.22
Spring	2003	3L	195,121	98.46	42,876	93.79		21.97	23.47
Spring	2004	3L	109,589	98.88	27,262	96.37		24.88	25.78
Spring	2005	3L	154,970	99.58	18,982	97.27		12.25	12.25
Spring	2006	3L	180,642	???	52,277	???		28.94	28.94
			Overall average	98.53			Overall average	24.25	
Spring	1999	3N	1,349	2.44	1,327	8.26		98.37	98.37
Spring	2000	3N	2,248	1.85	2,178	5.69		96.89	97.63
Spring	2001	3N	53	0.05	45	0.24		84.91	93.39
Spring	2002	3N	4,395	2.76	3,670	7.20		83.50	88.43
Spring	2003	3N	2,852	1.44	2,835	6.20		99.40	89.27
Spring	2004	3N	1,098	0.99	1,019	3.60		92.81	91.90
Spring	2005	3N	530	0.34	515	2.64		97.17	96.46
Spring	2006	3N	???	???	???	???		???	???
			Overall average	1.41			Overall average	93.29	
Spring	1999	3O	34	0.06	0	0.00		0.00	0.00
Spring	2000	3O	46	0.04	6	0.02		13.04	6.52
Spring	2001	3O	20	0.02	2	0.01		10.00	7.68
Spring	2002	3O	35	0.02	4	0.01		11.43	11.49
Spring	2003	3O	196	0.10	2	0.00		1.02	7.48
Spring	2004	3O	138	0.12	9	0.03		6.52	6.32
Spring	2005	3O	127	0.08	17	0.09		13.39	6.98
Spring	2006	3O	???	???	???	???		???	???
			Overall average	0.06			Overall average	7.91	
	all divisions								
Spring	1999		55,317		16,058	100.00		29.03	29.03
Spring	2000		121,815		38,311	100.00		31.45	30.24
Spring	2001		102,566		18,444	100.00		17.98	26.15
Spring	2002		159,491		50,962	100.00		31.95	27.13
Spring	2003		198,169		45,713	100.00		23.07	24.33
Spring	2004		110,827		28,290	100.00		25.53	26.85
Spring	2005		155,627		19,514			12.54	20.38
Spring	2006		???		???			???	???
							Overall average	24.51	

Table 16. Modal analysis using Mix 3.01 (MacDonald and Pitcher, 1993) of *P. borealis* in NAFO Div. 3LNO,from autumn Canadian multi-species bottom trawl surveys.

Mean Carapace Length (Standard Error)

	Age			
Year	1	2	3	4
1995	11.05 (.048)	15.93 (.064)	19.99 (.308)	21.87 (.991)
1996	11.33 (.074)	15.94 (.036)	19.32 (.057)	21.38 (.402)
1997	10.59 (.002)	15.62 (.002)	18.45 (.010)	19.90 (.049)
1998	10.76 (.018)	15.83 (.102)	19.05 (.198)	20.86 (.248)
1999	11.23 (.078)	15.96 (.019)	19.18 (.118)	21.09 (.127)
2000	10.49 (.030)	15.23 (.032)	18.16 (.020)	20.51 (.121)
2001	9.51 (.001)	14.29 (.001)	16.18 (.001)	18.76 (.000)
2002	9.80 (.007)	13.96 (.001)	17.14 (.001)	19.5 (.001)
2003	10.03 (.014)	14.76 (.014)	17.63 (.021)	20.0 (.011)
2004	Incomplete survey			
2005	10.13 (.001)	14.33 (.001)	17.01 (.001)	19.59 (.001)

Estimated Proportions (Standard Error and constraints) contributed by each year-class

	Age				
Year	1	2	3	4	Total
1995	.465 (.012)	.420 (.017)	.092 (.037)	.022 (.030)	0.999
1996	.078 (.004)	.623 (.011)	.225 (.026)	.074 (.209)	1.000
1997	.070 (.000)	.397 (.000)	.451 (.007)	.081 (.064)	0.999
1998	.226 (.004)	.221 (.016)	.399 (.089)	.154 (.076)	1.000
1999	.060 (.003)	.527 (.007)	.223 (.020)	.191 (.023)	1.001
2000	.062 (.002)	.340 (.007)	.456 (.015)	.143 (.011)	1.001
2001	.014 (.000)	.199 (.000)	.296 (.000)	.491 (.000)	1.000
2002	.035 (.000)	.145 (.000)	.451 (.001)	.368 (.000)	0.999
2003	.044 (.001)	.146 (.002)	.250 (.004)	.561 (.044)	1.001
2004	Incomplete survey				
2005	.031 (.000)	.132 (.000)	.448 (.000)	.389 (.000)	1.000

Distributional Sigmas (Standard Error and constraints)

	Age			
Year	1	2	3	4
1995	1.25 (.036)	1.40 (.082)	.90 (.285)	.81 (.991)
1996	1.20 (fixed)	1.30 (.034)	.79 (.060)	1.20 (.170)
1997	1.09 (.001)	0.90 (.001)	.93 (.006)	.93 (.011)
1998	.97 (fixed)	1.13 (.059)	1.08 (.163)	.85 (.075)
1999	1.38 (.060)	.933 (.017)	1.01 (fixed)	.99 (.054)
2000	.94 (.023)	1.11 (.024)	.84 (.022)	1.24 (.054)
2001	1.01 (.000 Eq)	1.01 (.000 Eq)	1.01 (.000 Eq)	1.01 (.000 Eq)
2002	.73 (.001)	.98 (.001)	.97 (.001)	1.00 (.001)
2003	.50 (CV=.05)	.74 (CV=.05)	.88 (CV=.05)	1.0 (CV=.05)
2004	Incomplete survey			
2005	0.76 (CV=.075)	1.07 (CV=.075)	1.28 (CV=.068)	1.47 (CV=.068)

Table 16. Modal analysis using Mix 3.01 (MacDonald and Pitcher, 1993) of *P. borealis* in NAFO Div. 3LNO,from autumn Canadian multi-species bottom trawl surveys. (Continued)

Population at Age Estimates (10^6)

	Male Ages					Transitionals + Primiparous	Multiparous + Ovigerous	Total
Year	0	1	2	3	4			
1995	3	899	290	59	6	730	89	2,076
1996	2	449	3,971	838	208	159	230	5,857
1997	3	540	3,041	3,450	623	2,086	781	10,524
1998	0	3,545	3,108	5,341	1,329	463	1,544	15,330
1999	3	672	5,935	2,278	1,536	1,620	1,020	13,064
2000	9	1,944	9,230	14,891	1,745	1,867	2,466	32,152
2001	7	675	9,090	13,534	22,506	1,285	6,978	54,075
2002	0	1,401	5,802	17,913	14,640	1,309	9,191	50,256
2003	27	1,958	6,580	10,587	16,082	436	13,163	48,397
2004	Incomplete survey							
2005	18	928	2,887	14,750	21,221	436	12,727	52,967

Table 17. Modal analysis using Mix 3.01 (MacDonald and Pitcher, 1993) of *P. borealis* in NAFO Div. 3LNO,from spring Canadian multi-species bottom trawl surveys

Mean Carapace Length (Standard Error)

	Age			
Year	1	2	3	4
1999		14.08 (.001)	17.72 (.002)	20.04 (.002)
2000		13.41 (.001)	17.22 (.001)	19.69 (.002)
2001		13.42 (.001)	16.83 (.001)	19.10 (.001)
2002		12.32 (.001)	16.19 (.001)	18.66 (.001)
2003		12.97 (.000)	16.50 (.001)	18.83 (.001)
2004		13.52 (.002)	18.07 (.022)	19.92 (.004)
2005		13.83 (.001)	17.15 (.001)	19.58 (.001)
2006		13.27 (.000)	16.94 (.002)	19.55 (.001)

Estimated Proportions (Standard Error and constraints) contributed by each year-class

	Age				
Year	1	2	3	4	Total
1999		.444 (.001)	.193 (.000)	.363 (.000)	1.000
2000		.319 (.000)	.515 (.000)	.166 (.000)	1.000
2001		.210 (.000)	.290 (.000)	.500 (.000)	1.000
2002		.094 (.001)	.368 (.001)	.538 (.001)	1.000
2003		.158 (.000)	.301 (.000)	.541 (.000)	1.000
2004		.124 (.000)	.356 (.006)	.520 (.006)	1.000
2005		.137 (.000)	.445 (.000)	.418 (.000)	1.000
2006		.294 (.000)	.204 (.000)	.501 (.001)	.999

Distributional Sigmas (Standard Error and constraints)

	Age			
Year	1	2	3	4
1999		.914 (.001)	.796 (.001)	.932 (.001)
2000		.951 (CV=.071)	1.22 (CV=.071)	1.40 (CV=.071)
2001		1.12 (sigmas eq; .000)	1.12 (sigmas eq; .000)	1.12 (sigmas eq; .000)
2002		.739 (CV=.060)	.971 (CV=.060)	1.12 (CV=.060)
2003		1.08 (sigmas eq; 000)	1.08 (sigmas eq; 000)	1.08 (sigmas eq; 000)
2004		1.11 (.001)	1.44 (.010)	1.04 (.002)
2005		1.03 (CV = .075)	1.28 (CV = .075)	1.46 (CV=.075)
2006		.942 (CV=.071)	1.20 (CV=.071)	1.39 (CV=.071)

Population at Age Estimates (10^6)

	Male Ages					Transitionals + Primiparous	Multiparous + Ovigerous	Total
Year	0	1	2	3	4			
1999	6	132	4,268	1,832	3,485	2,339	642	12,704
2000	38	514	5,196	8,388	2,833	5,389	2,655	25,013
2001	7	99	4,648	6,369	8,102	3,096	2,673	24,994
2002	17	442	2,618	9,633	14,068	7,825	2,906	37,509
2003	47	430	4,704	8,090	20,029	7,838	5,960	47,098
2004	6	177	2,073	6,244	6,546	3,424	3,175	21,645
2005	11	264	2,975	8,227	5,954	6,481	6,061	29,973
2006	5	151	6,615	4,596	11,274	4,460	8,986	36,087

Table 18. Male and female biomass/ abundance indices estimated using areal expansion calculations from Candian autumn research bottom trawl survey data, 1995-2005. Please note that there was an incomplete survey during 2004 therefore that set of values is missing from the table.

	Biomass (tons)			Abundance (numbers x 10^6)		
	Males	Females	Total	Males	Females	Total
1995	2,155	3,766	5,921	1,235	819	2,054
1996	16,576	3,513	20,089	5,466	401	5,867
1997	26,637	19,565	46,202	7,655	2,868	10,523
1998	43,121	16,793	59,914	13,319	2,007	15,326
1999	34,617	18,527	53,144	10,420	2,640	13,060
2000	85,663	32,517	118,180	27,735	4,331	32,066
2001	159,918	64,077	223,995	45,814	8,263	54,077
2002	138,564	76,444	215,009	39,757	10,500	50,257
2003	132,084	91,484	223,568	35,347	11,934	47,281
2004	??	??	??	??	??	??
2005	149,937	113,877	263,815	39,801	13,163	52,964

Table 19. Male and female biomass/ abundance indices estimated using areal expansion calculations from Candian spring research bottom trawl survey data, 1995-2005. Please note that the spring 2006 survey was incomplete within NAFO Div. 3NO; however, Div. 3L was complete and normally accounts for at least 97% of the total biomass; therefore the 2006 values are for 3L data only.

	Biomass (tons)			Abundance (numbers x 10^6)		
	Males	Females	Total	Males	Females	Total
1999	33,055	22,262	55,317	9,722	2,981	12,703
2000	61,424	60,391	121,815	16,969	8,044	25,012
2001	62,778	39,788	102,566	19,130	5,714	24,845
2002	92,880	66,611	159,491	26,780	10,733	37,512
2003	112,201	85,969	198,169	33,323	13,798	47,121
2004	62,381	48,446	110,827	15,083	6,613	21,696
2005	61,773	93,854	155,627	17,432	12,544	29,976
2006	79,057	101,585	180,642	22,026	13,173	35,199

Table 20. Fishable biomass (t) indices (total weight of all females + the weight of all males with carapace lengths => 17.5 mm) as determined using areal expansion of autumn and spring Canadian research multi-species bottom trawl survey data (1995-2006).

	survey	
year	autumn	spring
1995	4,414	
1996	9,993	
1997	35,695	
1998	46,785	
1999	38,179	45,370
2000	85,003	92,808
2001	179,021	82,300
2002	174,720	129,540
2003	191,981	170,365
2004		97,869
2005	213,983	135,154
2006		162,210

Table 21. Recruitment indices (age 2 abundance) determined using Mix analysis of the length frequencies. The data were obtained from the annual Canadian spring and autumn bottom trawl surveys (1995-2006).

Year	Age 2 abundance ($X10^6$)	
	Autumn	Spring
1995	290	
1996	3,971	
1997	3,041	
1998	3,108	
1999	5,935	4,268
2000	9,230	5,196
2001	9,090	4,648
2002	5,802	2,618
2003	6,580	4,785
2004		2,073
2005	2,887	2,975
2006		6,615

Table 22. Exploitation rate indices for NAFO Div. 3LNO as determined using Canadian autumn survey and total catch data over the period 1996-2006.

Year	catch (t)	Lower 95% CL of biomass index (t)	spawning stock biomass (SSB) (t)	fishable biomass (t)
1995		3,639	3,766	4,414
1996	171	10,230	3,513	9,993
1997	485	25,530	19,565	35,695
1998	567	40,011	16,793	46,785
1999	795	36,202	18,527	38,179
2000	4,869	93,132	32,517	85,003
2001	10,566	77,563	64,077	179,021
2002	6,977	126,180	76,444	174,720
2003	11,947	106,338	91,484	191,981
2004	12,620	??	??	??
2005	14,137	199,173	113,877	213,983
2006	23,886			

Year	catch/lower CL biomass	catch/SSB	catch/fishable biomass
1995	0.047	0.045	0.039
1996	0.047	0.138	0.049
1997	0.022	0.029	0.016
1998	0.020	0.047	0.017
1999	0.134	0.263	0.128
2000	0.113	0.325	0.124
2001	0.090	0.109	0.039
2002	0.095	0.156	0.068
2003	0.119	0.138	0.066
2004			
2005	0.120	0.210	0.112
2006			

Table 23. Estimated bycatch (kg) within the Canadian large vessel (>500 t) fleeting fishing shrimp within the EEZ, over the period 2003-2006.

	Atlantic cod				American plaice				redfish				Greenland halibut			
Year	2003	2004	2005	2006	2003	2004	2005	2006	2003	2004	2005	2006	2003	2004	2005	2006
Observed shrimp catch (t)	3,930	4,060	4,057	3,094	3,930	4,060	4,057	3,094	3,930	4,060	4,057	3,094	3,930	4,060	4,057	3,094
Logbook shrimp catch (t)	3,956	4,037	4,039	3,898	3,956	4,037	4,039	3,898	3,956	4,037	4,039	3,898	3,956	4,037	4,039	3,898
correction factor	1.0000	1.0000	1.0000	1.2599	1.0000	1.0000	1.0000	1.2599	1.0000	1.0000	1.0000	1.2599	1.0000	1.0000	1.0000	1.2599
estimated bycatch (kg)	61	85	59	77	535	852	701	1,931	2,148	2,321	3,340	1,627	6,708	7,353	6,183	4,059
Bycatch (kg)/ (t) shrimp	0.02	0.02	0.01	0.02	0.14	0.21	0.17	0.50	0.54	0.57	0.83	0.42	1.71	1.82	1.53	1.04
Number of fish measured	37	25	12	0	251	383	87	817	217	312	1,667	519	1,995	4,014	603	1,693
	estimated number at age				estimated number at age				estimated number at age				estimated number at age			
Age																
0	0	0	0	0	0	0	0	0	0	0	0	0	2,561	2,014	500	4,732
1	38	59	71	0	62	318	17	239	0	0	0	164	13,698	32,607	15,059	14,581
2	61	80	46	0	850	1,971	585	1,574	914	538	864	3,661	27,036	34,473	25,564	17,366
3	6	4	2	0	1,045	2,166	1,084	2,304	7,420	3,398	4,174	9,692	13,274	8,406	8,825	4,742
4	1	1	1	0	2,655	4,282	3,271	7,107	27,107	19,651	15,962	21,979	5,639	4,205	6,402	2,137
5	0	0	0	0	1,833	2,698	2,594	6,103	15,211	16,128	6,828	9,243	1,327	242	1,485	557
6	0	0	0	0	215	428	260	1,158	4,808	10,482	8,447	3,833	73	2	125	40
7	0	0	0	0	35	59	25	176	1,217	2,443	8,865	690	21	0	0	0
8	0	0	0	0	20	29	19	81	777	368	3,981	82	2	0	0	0
9	0	0	0	0	2	9	0	21	247	18	1,159	23	0	0	0	0
10	0	0	0	0	2	0	0	1	26	0	190	4	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	74	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	106	144	120	0	6,719	11,960	7,855	18,765	57,727	53,026	50,544	49,370	63,631	81,949	57,960	44,156

Table 24. Estimated by-catch (kg) within the Canadian small vessel (<=500 t) fleeting fishing shrimp within the EEZ, over the period 2003-2006.

	Atlantic cod				American plaice				redfish				Greenland halibut			
Year	2003	2004	2005	2006	2003	2004	2005	2006	2003	2004	2005	2006	2003	2004	2005	2006
Observed shrimp catch (t)	248	318	182	380	248	318	182	380	248	318	182	380	248	318	182	380
Logbook shrimp catch (t)	6,549	6,576	7,070	12,006	6,549	6,576	7,070	12,006	6,549	6,576	7,070	12,006	6,549	6,576	7,070	12,006
correction factor	26.36	20.65	38.85	31.59	26.36	20.65	38.85	31.59	26.36	20.65	38.85	31.59	26.36	20.65	38.85	31.59
estimated bycatch (kg)	975	186	0	411	4,375	2,313	3,224	2,844	10,570	5,183	1,398	17,377	18,793	5,575	5,089	5,371
Bycatch (kg)/ (t) shrimp	0.15	0.03	0.00	0.03	0.67	0.35	0.46	0.24	1.61	0.79	0.20	1.45	2.87	0.85	0.72	0.45
Number of fish measured	48	2	0	0	0	35	0	0	311	580	0	383	616	277	0	426
	estimated number at age				estimated number at age				estimated number at age				estimated number at age			
age																
0	132	351	0	0	0	0	0	0	0	0	0	0	9,569	3,283	0	5,370
1	1,845	41	0	0	0	21	0	0	14,129	2,024	0	0	60,654	38,512	0	85,198
2	659	0	0	0	0	475	0	0	50,532	32,214	0	4,770	78,447	11,358	0	1,959
3	26	0	0	0	0	2,974	0	0	78,948	46,339	0	6,665	36,719	8,818	0	3,854
4	0	0	0	0	0	6,360	0	0	174,820	52,947	0	32,253	10,597	4,626	0	2,180
5	0	0	0	0	0	4,832	0	0	32,818	10,697	0	81,565	343	620	0	505
6	0	0	0	0	0	1,074	0	0	12,073	5,204	0	115,019	0	21	0	379
7	0	0	0	0	0	496	0	0	1,924	909	0	33,770	0	0	0	126
8	0	0	0	0	0	186	0	0	158	62	0	3,285	0	0	0	0
9	0	0	0	0	0	41	0	0	0	0	0	95	0	0	0	0
10	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
total	2,662	392	0	0	0	16,479	0	0	365,402	150,394	0	277,423	196,329	67,236	0	99,572

Table 23. By-catch (kg) taken within the NAFO Div. 3L NRA during 2006 by a Ukranian shrimp fishing vessel.

Total shrimp catch 119 t

Common Name	By-catch (kg)	By-catch kg /ton of shrimp
Redfish	564	4.74 kg/t
Greenland halibut	5	0.04 kg/t
White hake	4	0.03 kg/t
Capelin	8	0.07 kg/t
Yellowtail flounder	2	0.02 kg/t
American plaice	7	0.06 kg/t
Short-finned squid	4	0.03 kg/t
Other fish	329	2.76 kg/t
Total	923	7.76 kg/t

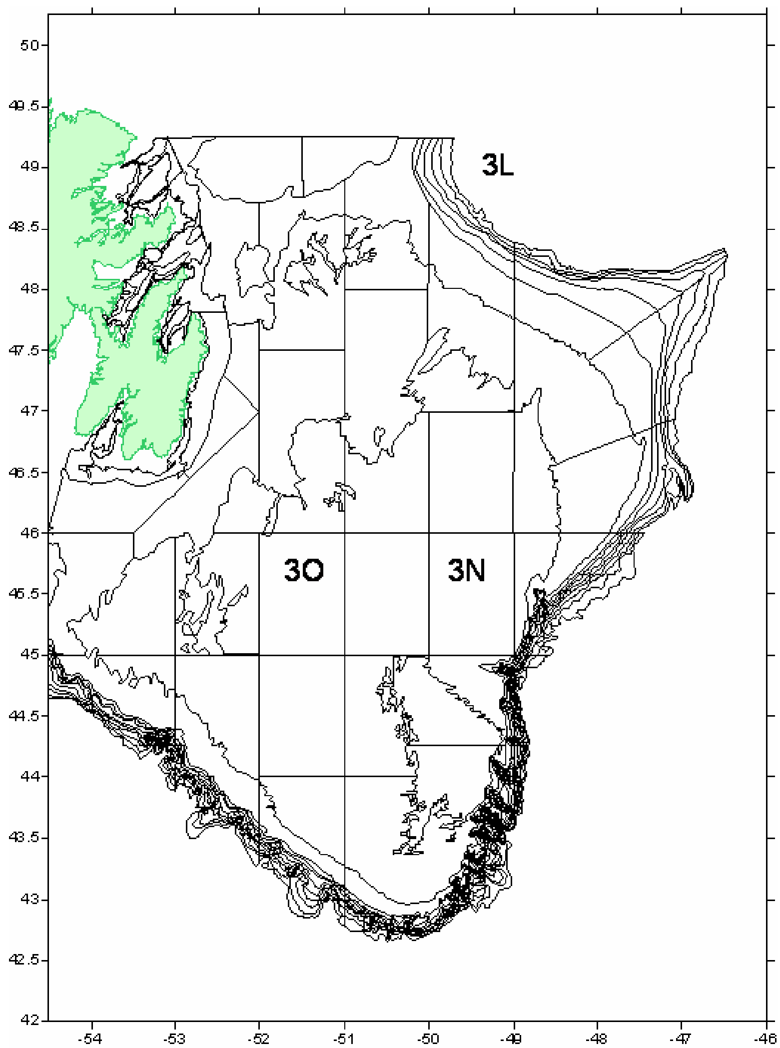


Fig. 1. The NAFO Div. 3LNO stratification scheme used in the Canadian multi-species research bottom trawl survey set allocation.

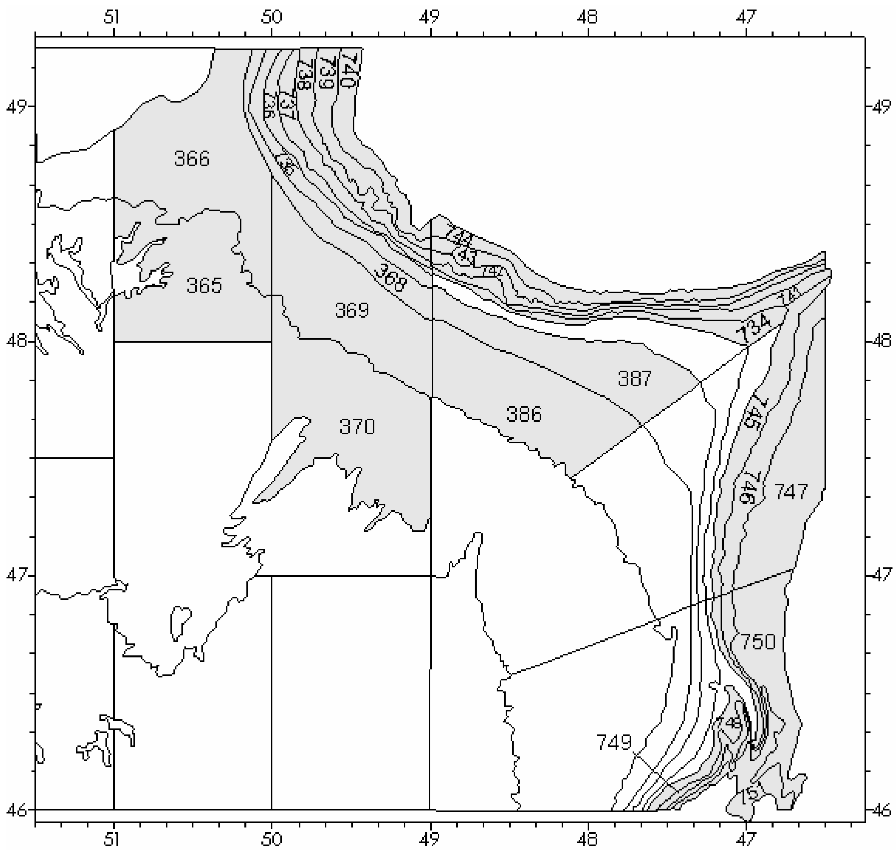


Fig. 2. Stata in Div. 3L that were not surveyed (numbered and shaded area) during autumn of 2004.

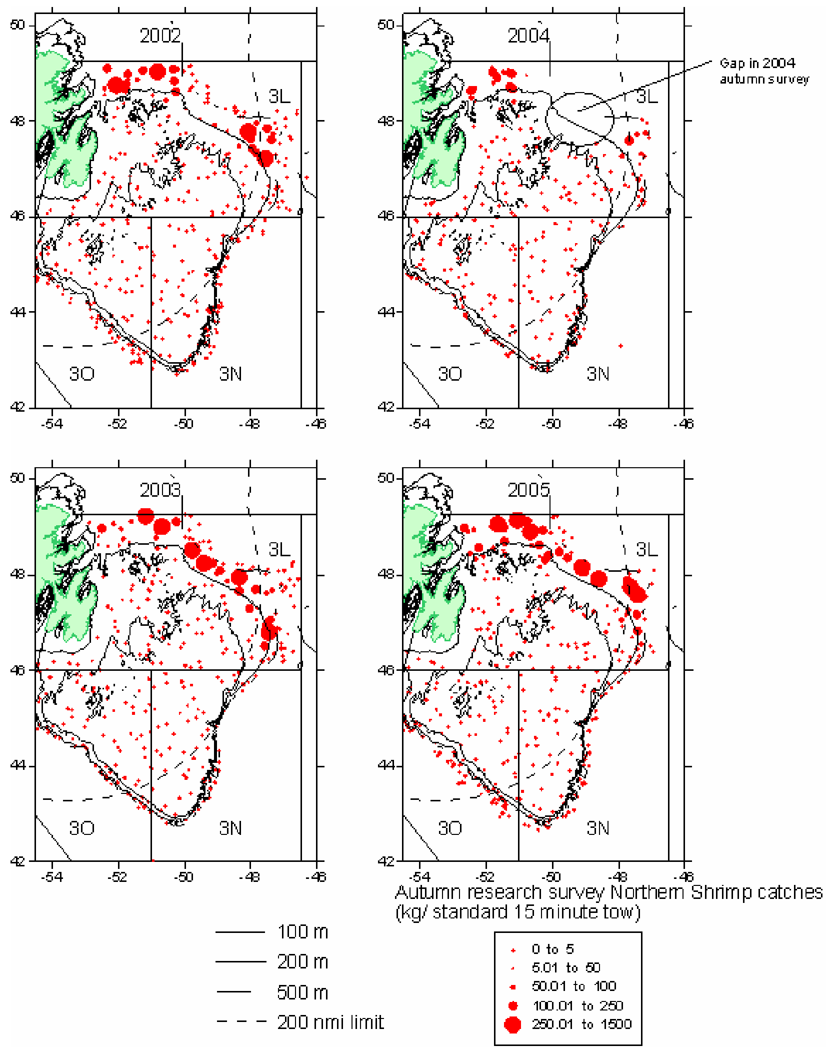


Fig. 3. Distribution of NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from autumn research bottom trawl surveys conducted over the period 2002-2005.

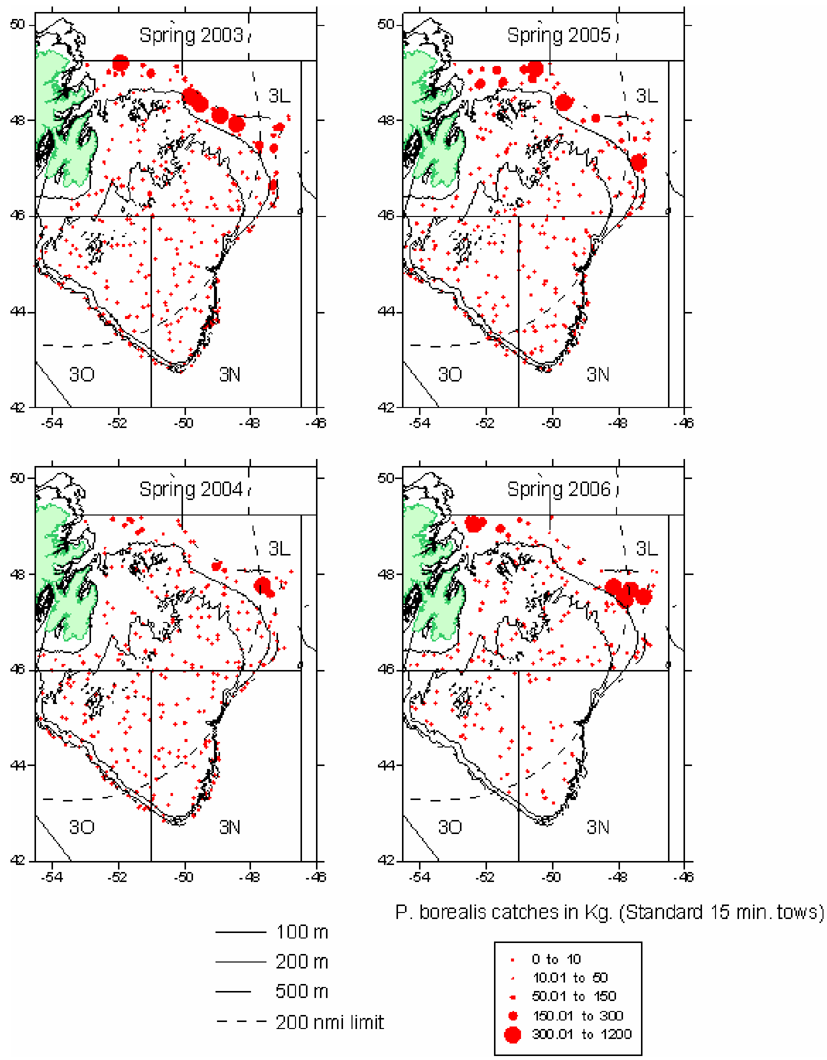


Fig. 4. Distribution of NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from spring research bottom trawl surveys conducted over the period 2003-2006.

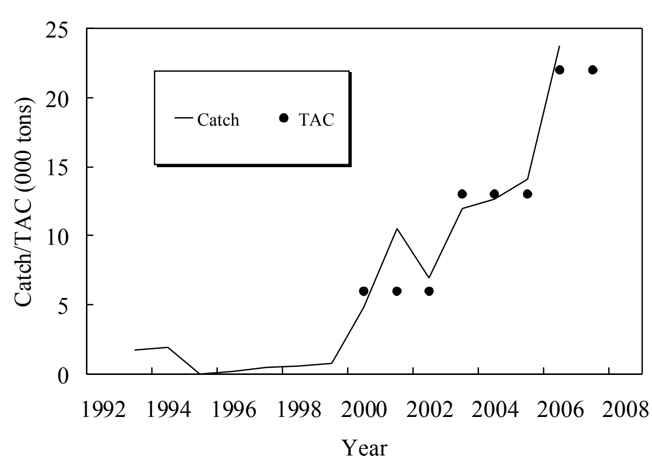


Fig. 5. Trends in NAFO Div. 3L northern shrimp (*Pandalus borealis*) catch and TAC over the period 1993-2006.

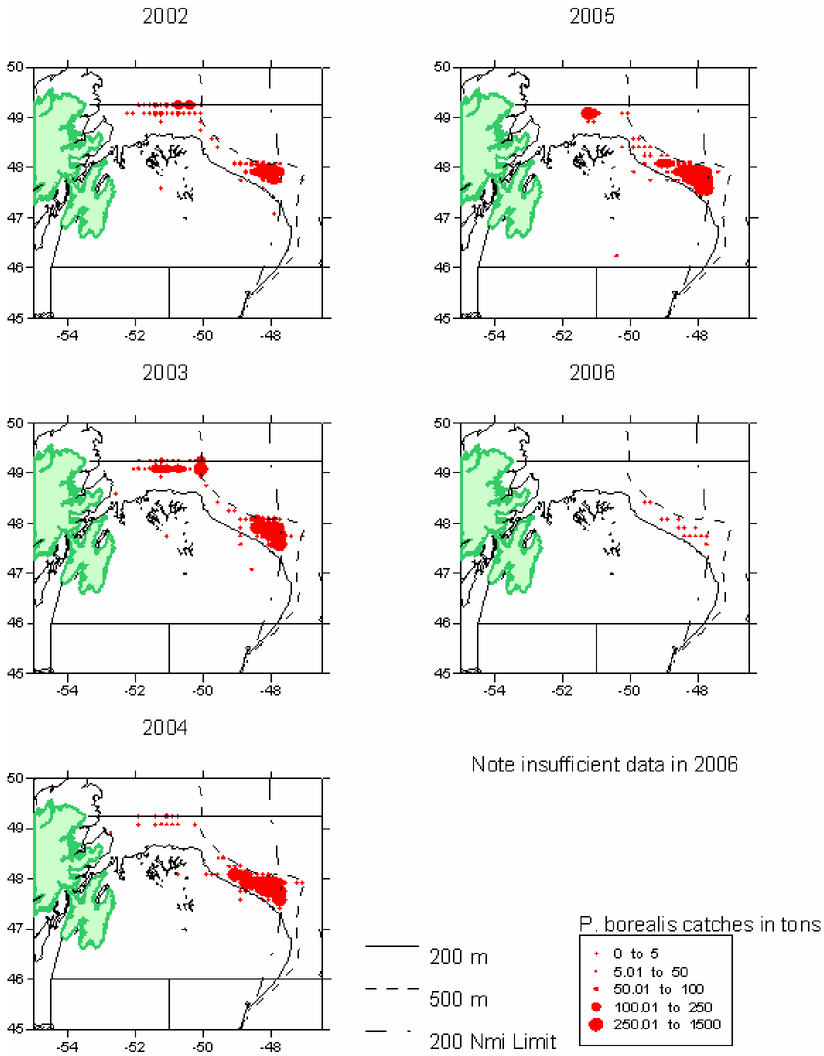


Fig. 6. Distribution of Canadian small vessel (<= 500 t) shrimp catches in NAFO Div. 3L, 2002-2006. (Logbook data aggregated into 10 min X 10 min cells).

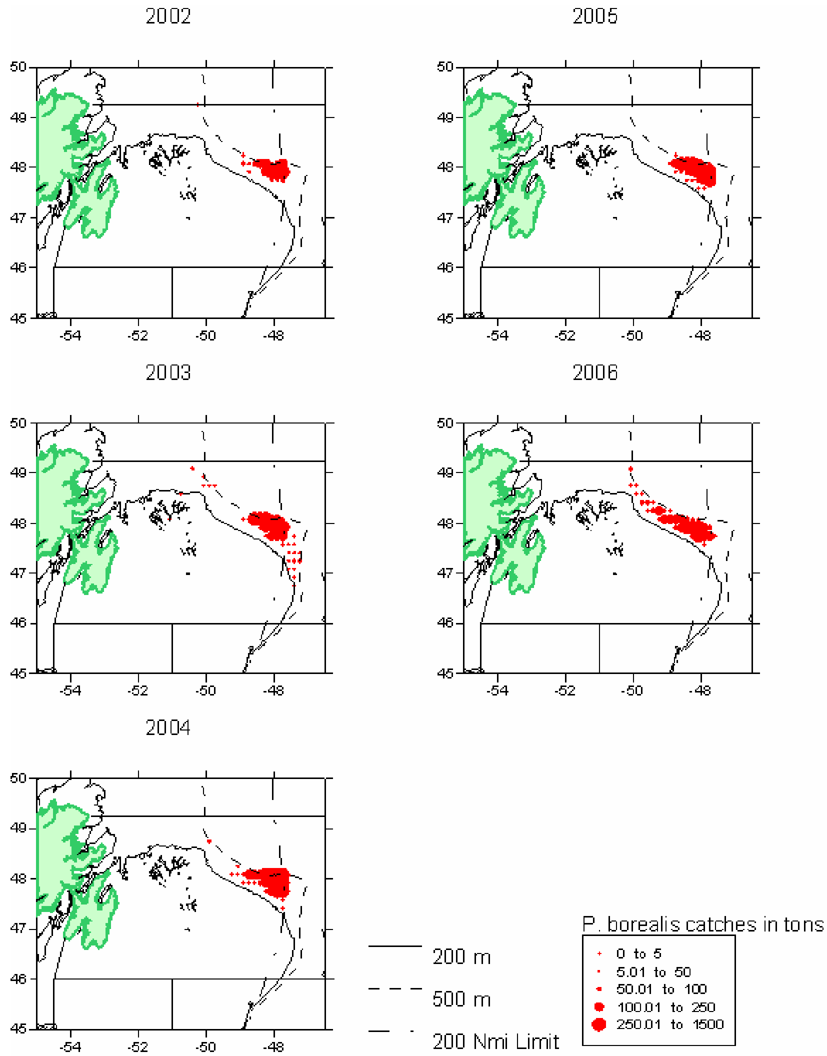


Fig. 7. Distribution of Canadian large vessel (> 500 t) shrimp catches in NAFO Div. 3L, 2002-2006. (Observer data aggregated into 10 min X 10 min cells).

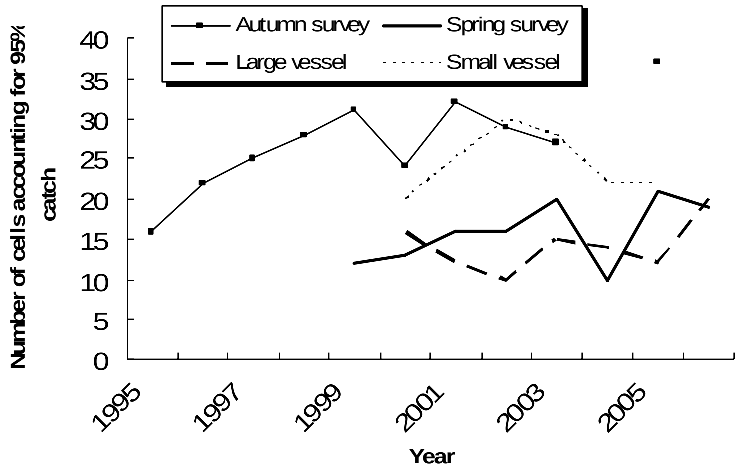


Fig. 8. The number of cells required to account for 95% of the Div. 3L autumn and spring Canadian research survey, and commercial shrimp catches over time.

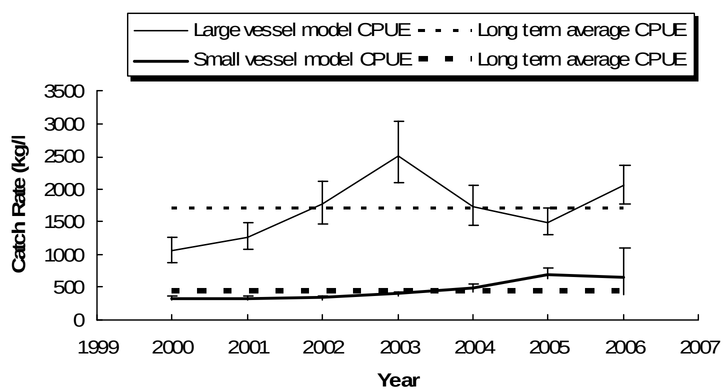


Fig. 9. Model catch rates for Canadian large (>500 t) and small (<=500 t; <65') vessels fishing for shrimp in NAFO Div. 3L, 2000-2006.

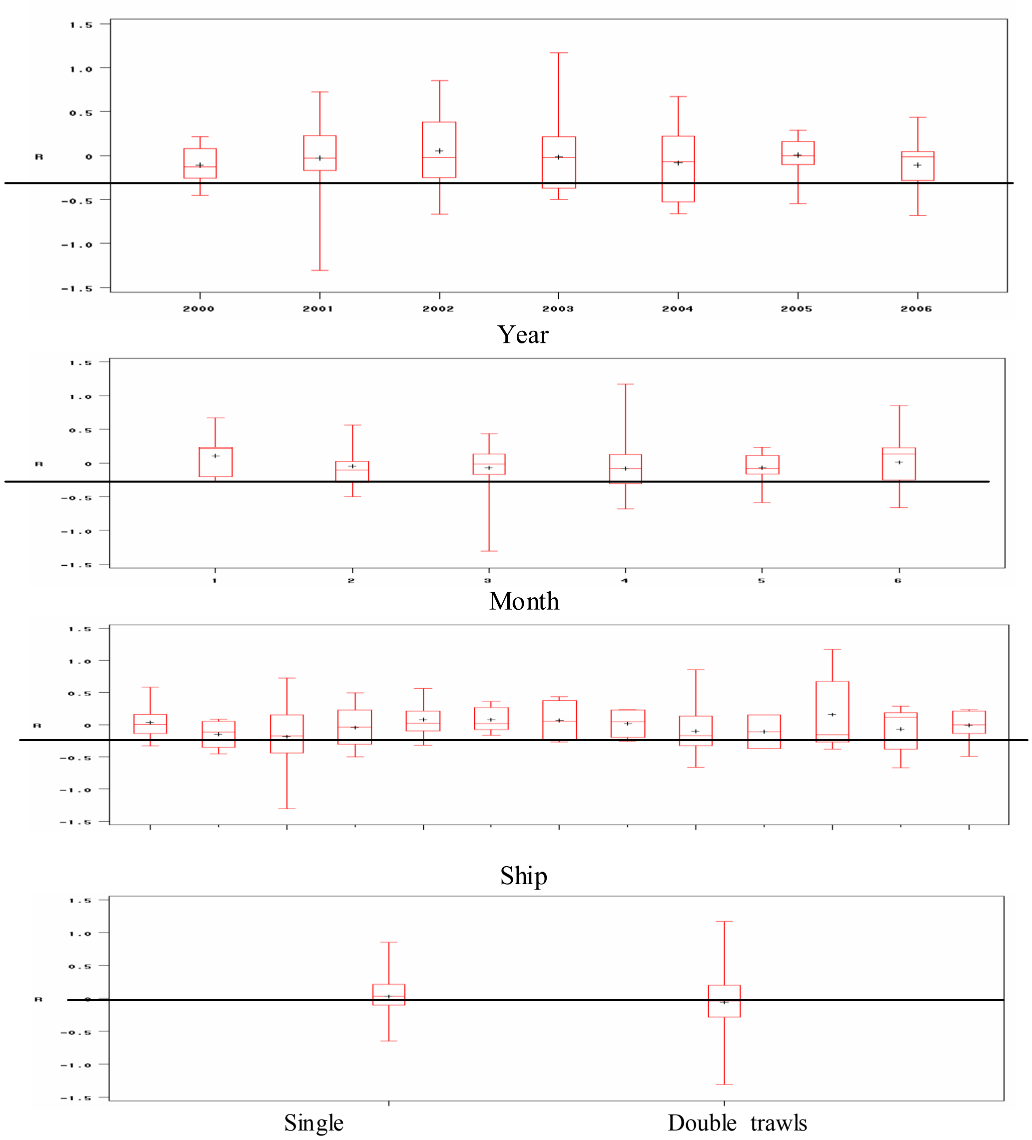


Fig. 10. The distribution of residuals around estimated values for parameters used to model Canadian large vessel Div. 3L shrimp catch rates, 2000-2006.

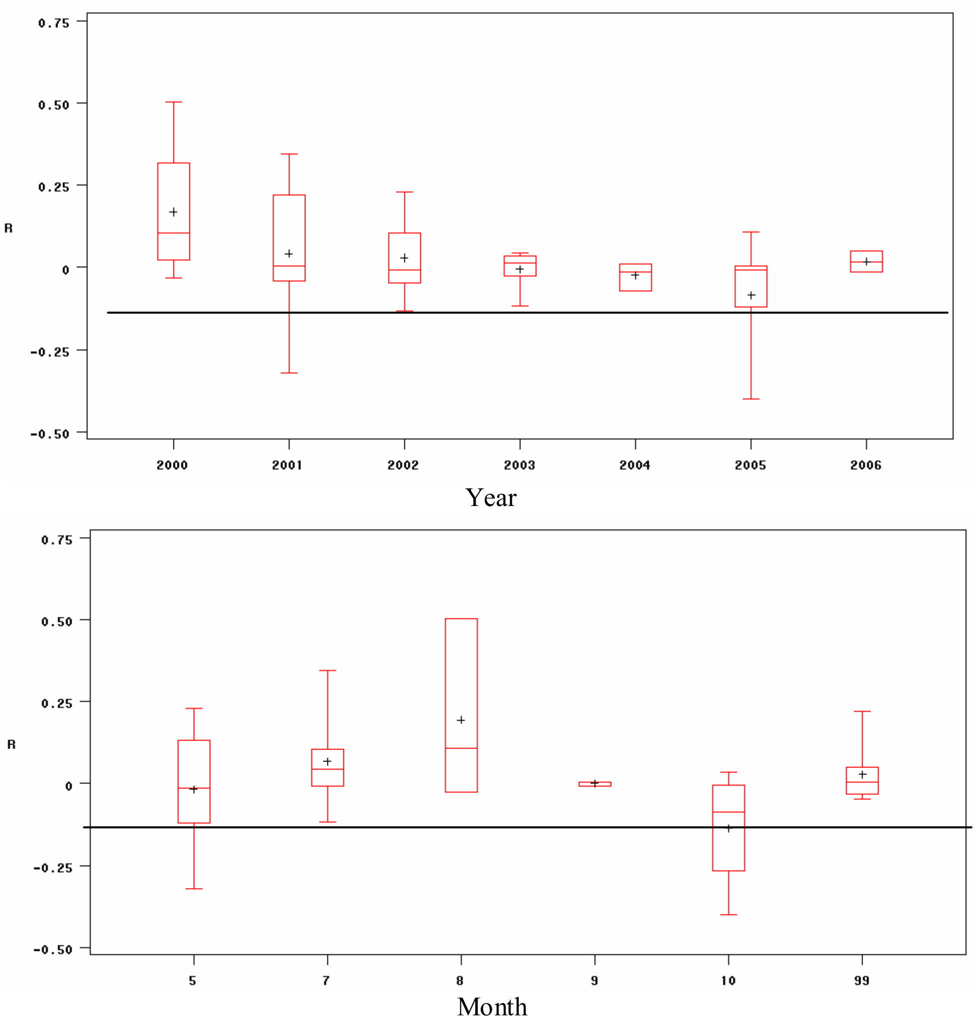


Fig. 11. The distribution of residuals around estimated values for parameters used to model Canadian small vessel Div. 3L shrimp catch rates, 2000-2006.

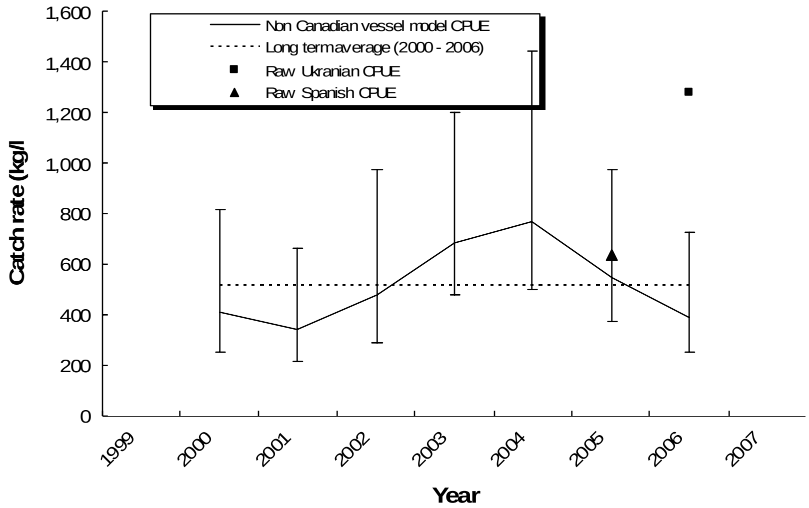


Fig. 12. Model and raw catch rates for non Canadian vessels fishing shrimp in the NAFO Div. 3L NRA, 200-2006. The modeled rate made use of data from Estonia, Greenland, Iceland, Norway and Russia.

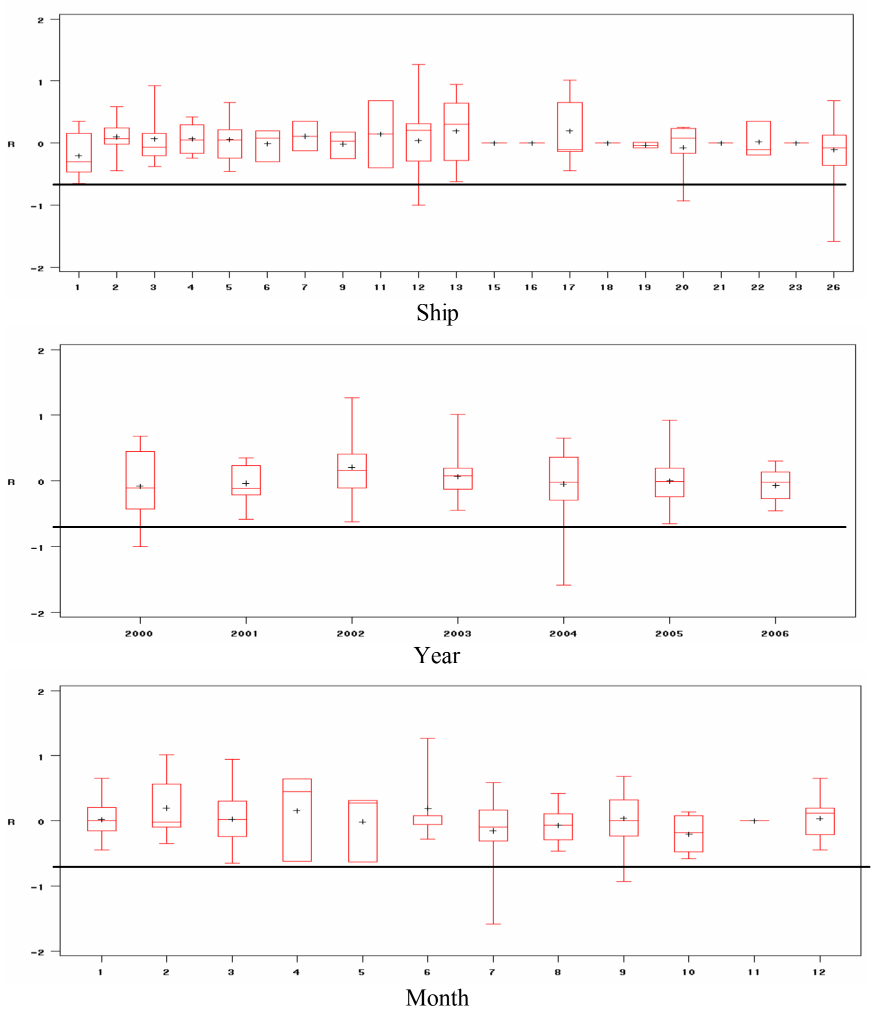


Fig. 13. The distribution of residuals around estimated values for parameters used to model non Canadian vessel Div. 3L shrimp catch rates, 2000-2006.

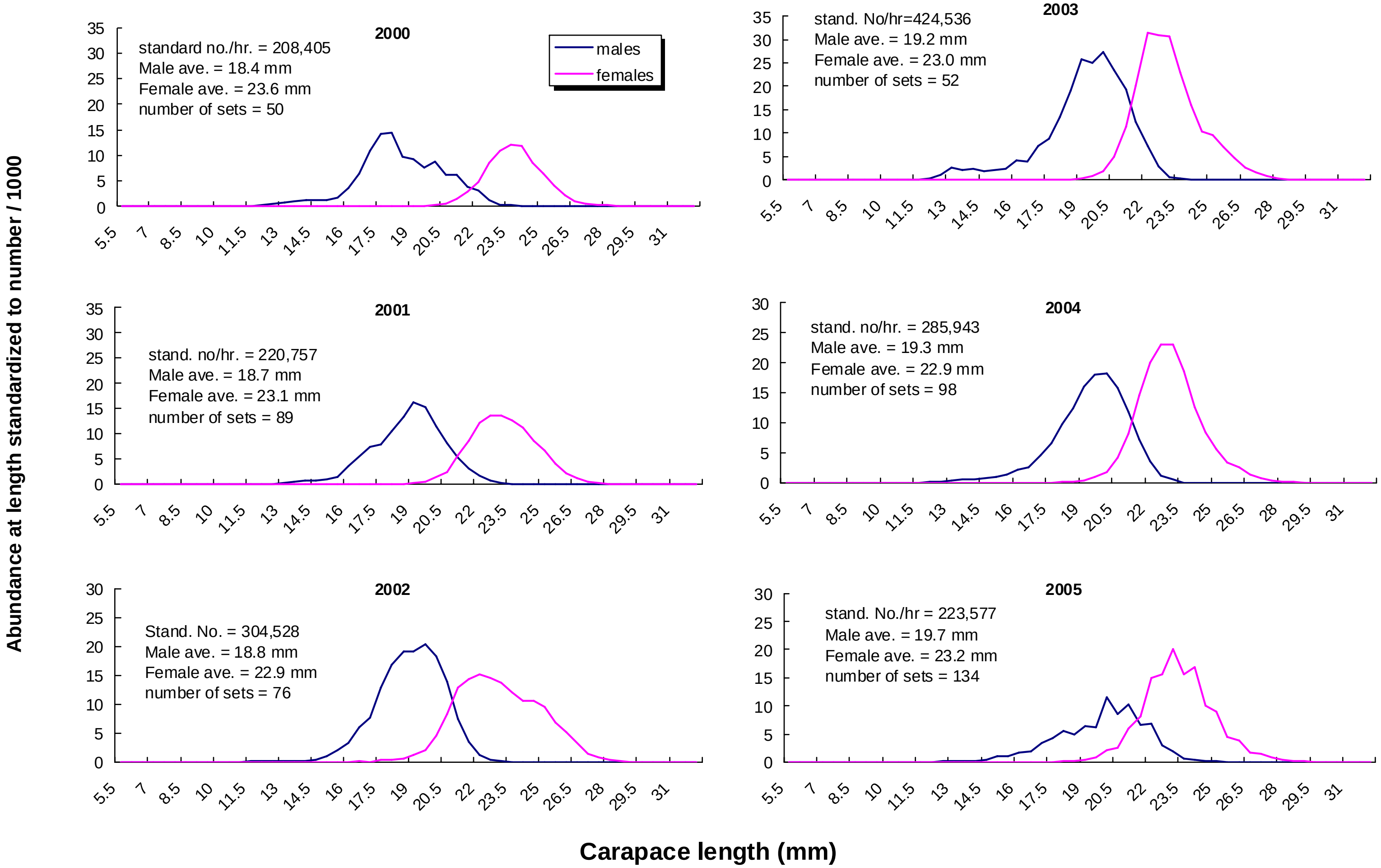


Fig. 14. Observed northern shrimp length frequencies from the Canadian large vessel (>500 t) fleet fishing shrimp in NAFO Div. 3L over the period 2000-2006.

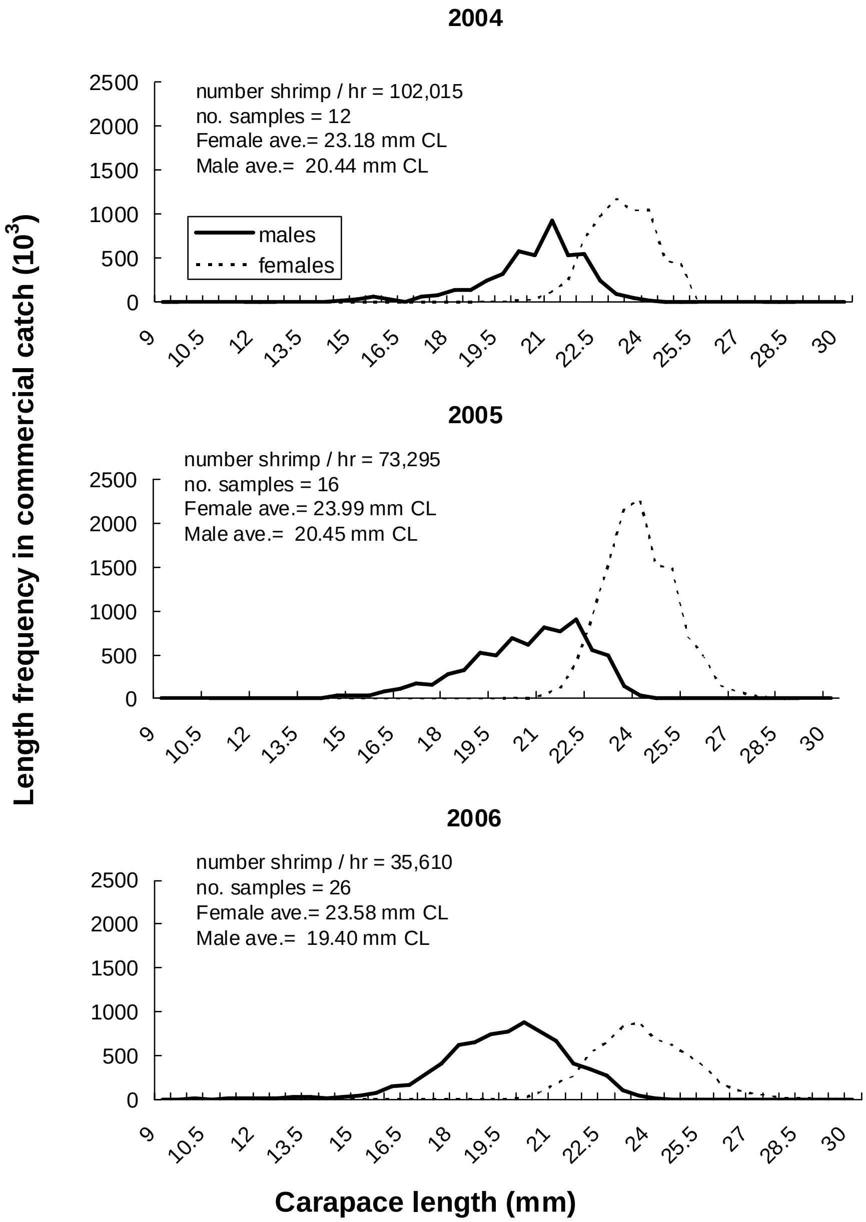


Fig. 15. Observed northern shrimp length frequencies from Icelandic vessels fishing shrimp in NAFO Div. 3L over the period 2004-2006.

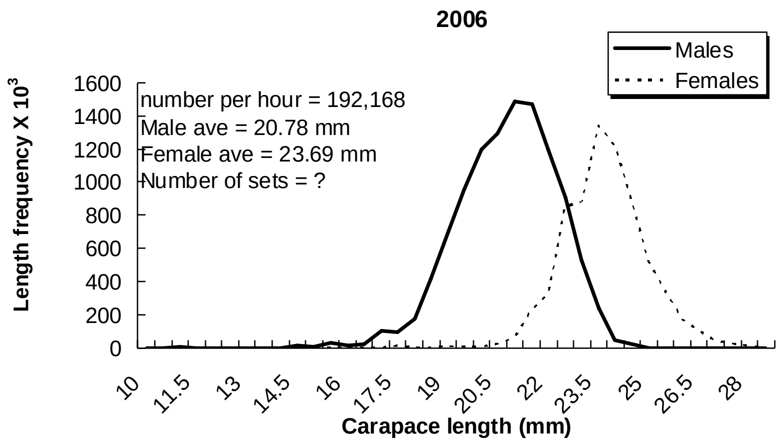


Fig. 16. Observed northern shrimp length frequencies from a Ukranian vessel fishing shrimp in NAFO Div. 3L during May-July, 2006.

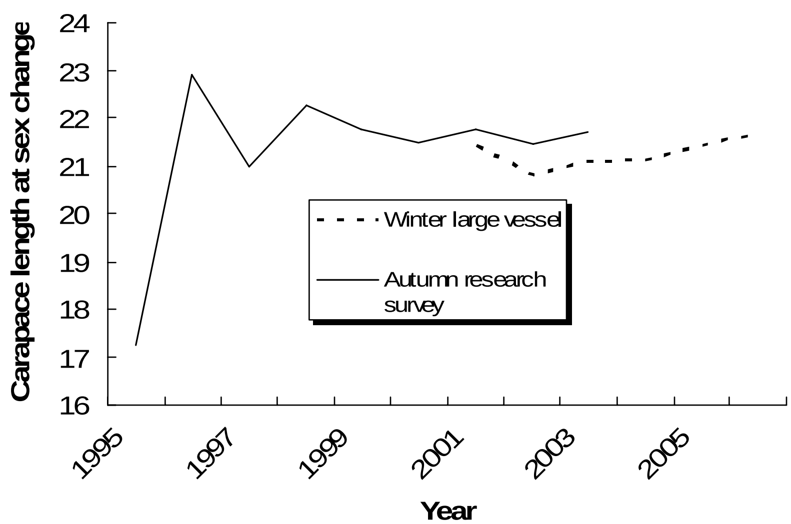


Fig. 17. A comparison between L_{50} values derived from the Canadian autumn research bottom trawl surveys and those from the winter (January-March) observed large vessel (>500 t) commercial length frequencies. L_{50} refers to the size at which 50% of the shrimp population changes from male to female.

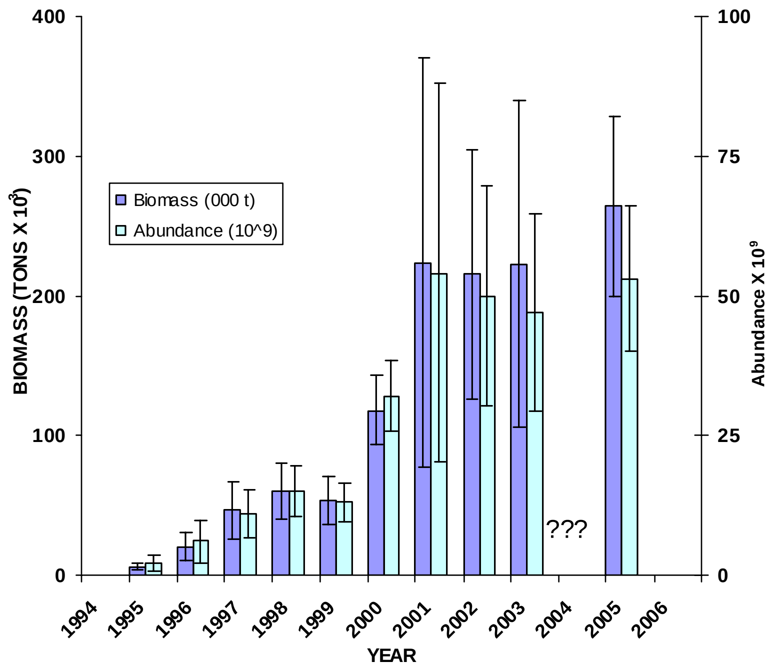


Fig. 18. Autumn northern shrimp (*Pandalus borealis*) biomass and abundance indices within NAFO Div. 3LNO, as determined using stratified area expansion calculations. Data were from annual Canadian multi-species bottom trawl surveys using a Campelen 1800 shrimp trawl. Due to an incomplete survey there are no estimates for 2004. (Standard 15 min. tows).

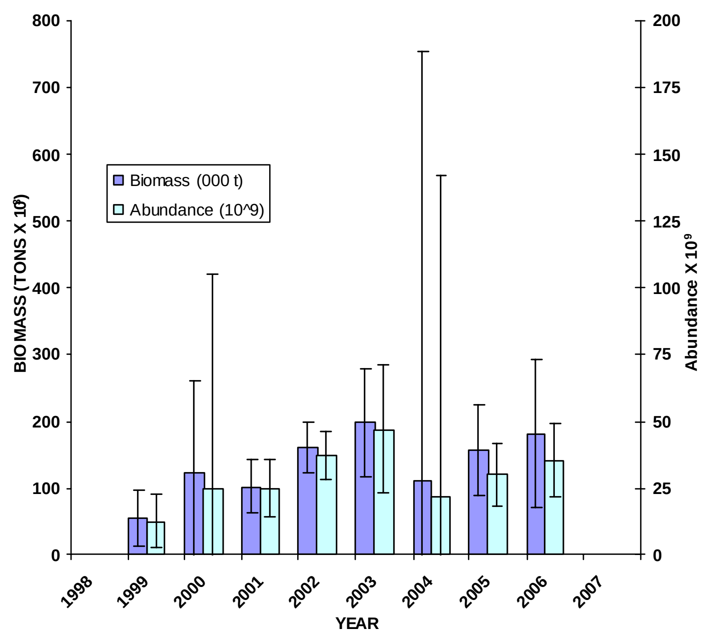


Fig. 19. Spring northern shrimp (*Pandalus borealis*) biomass and abundance indices within NAFO Div. 3LNO, as determined using stratified area expansion calculations. Data were from annual Canadian multi-species bottom trawl surveys using a Campelen 1800 shrimp trawl. Not all strata were surveyed in 3NO, however, at least 97% of the biomass/abundance has been attributed to 3L therefore the 2006 values are for 3L only. (Standard 15 min. tows).

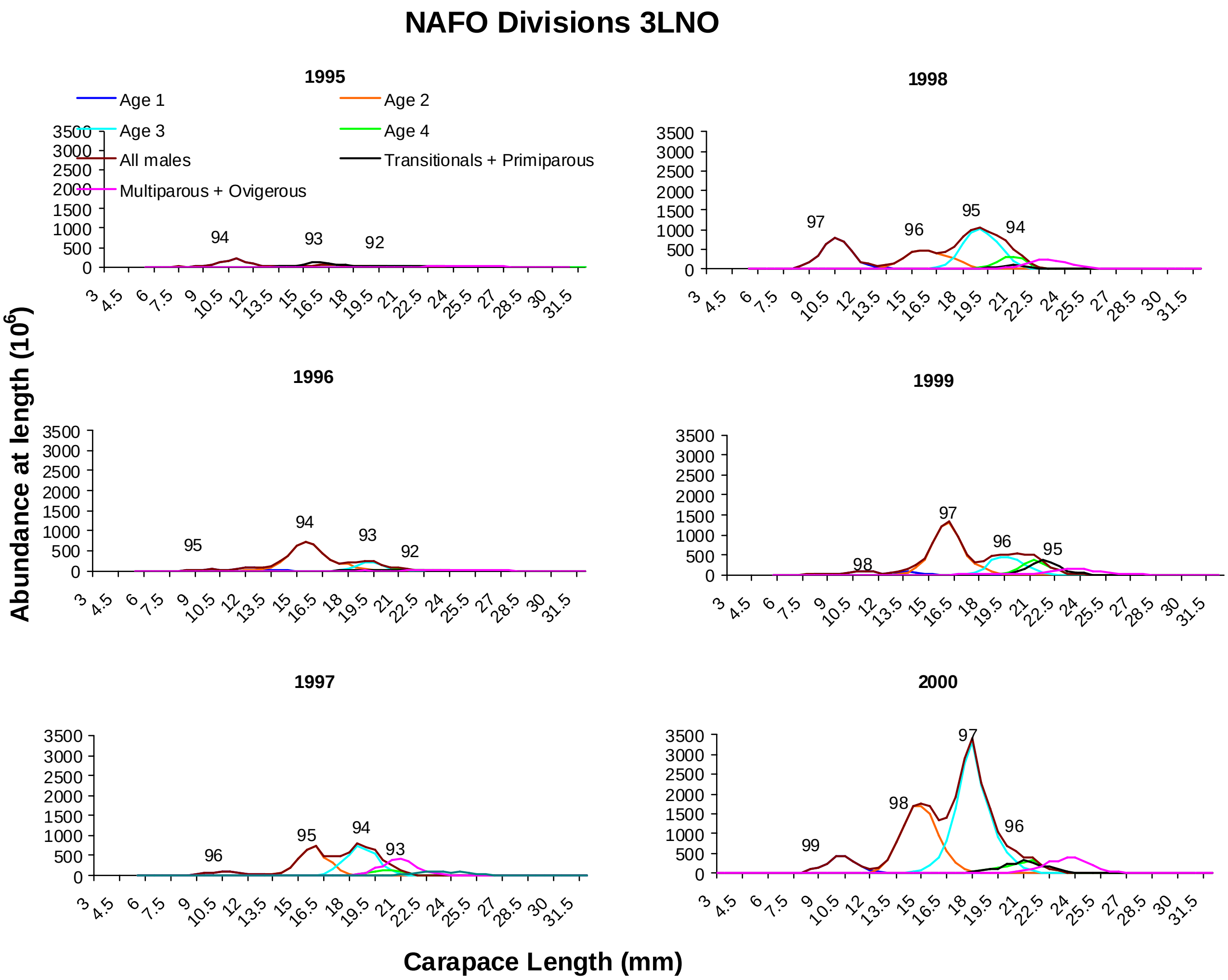


Fig. 20. Abundance at length for NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) estimated by stratified areal expansion analysis of Canadian autumn multi-species bottom trawl survey data 1995-2005.

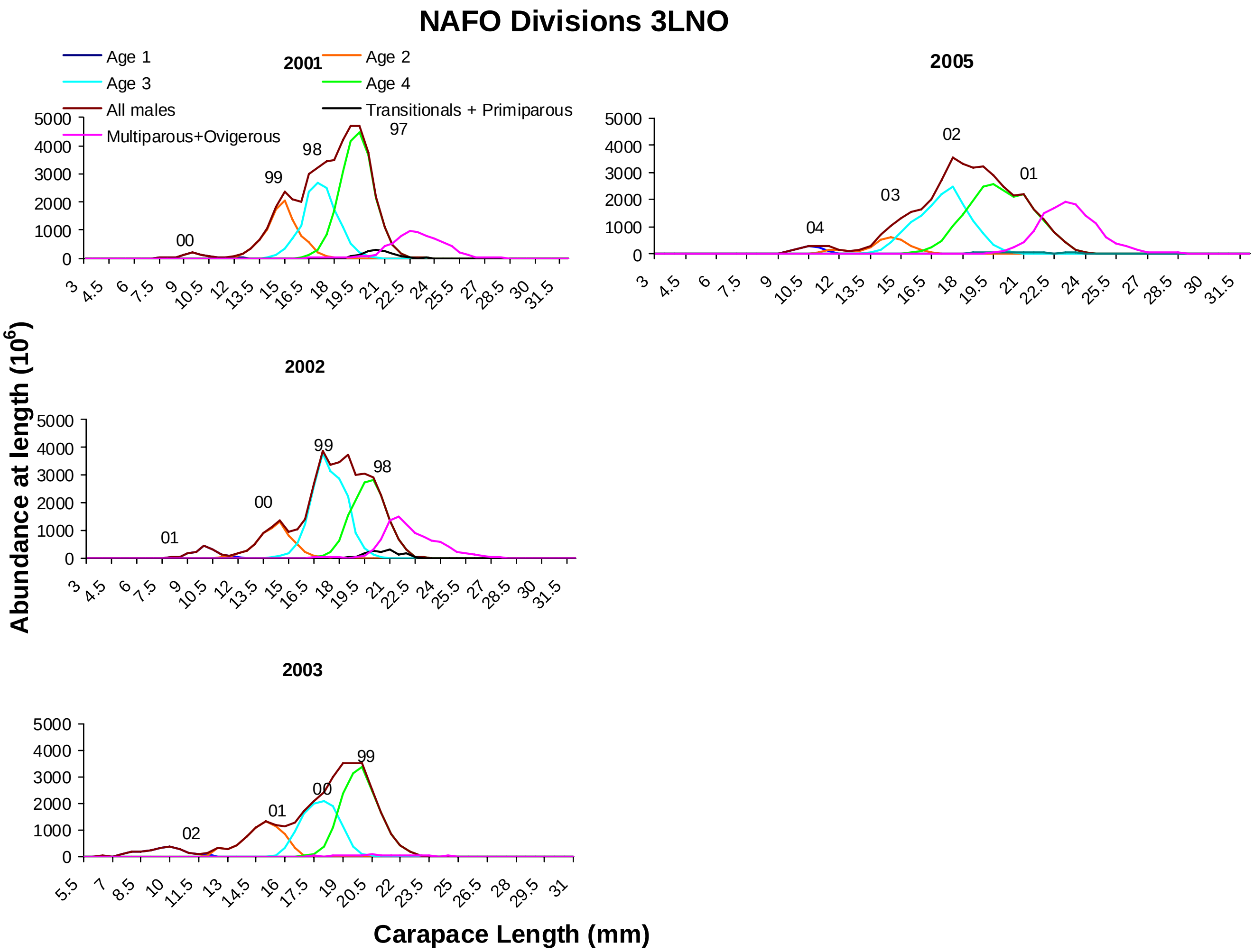


Fig. 20. Abundance at length for NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) estimated by stratified areal expansion analysis of Canadian autumn multi-species bottom trawl survey data 1995-2005. (Continued)

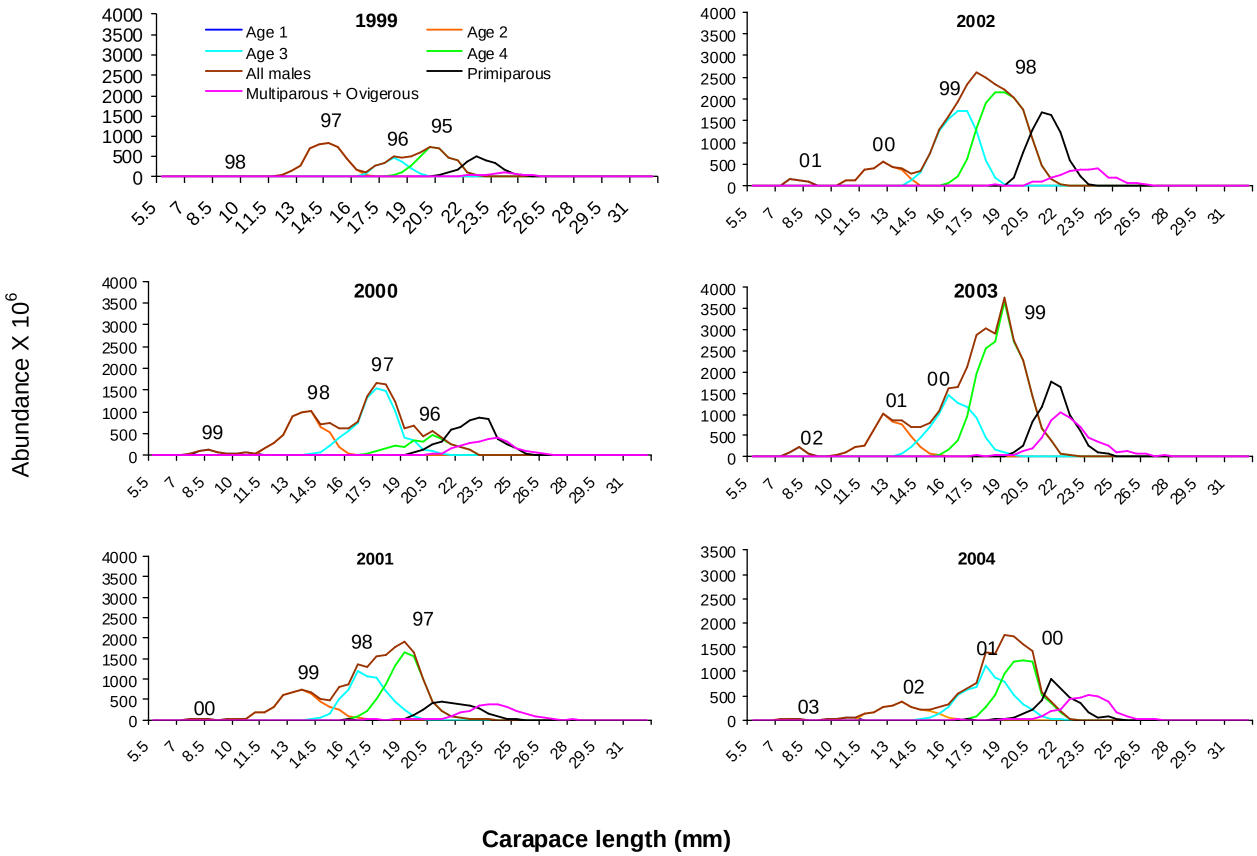


Fig. 21. Abundance at length for NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) estimated by stratified areal expansion analysis of Canadian spring multi-species bottom trawl survey data 1999-2006.

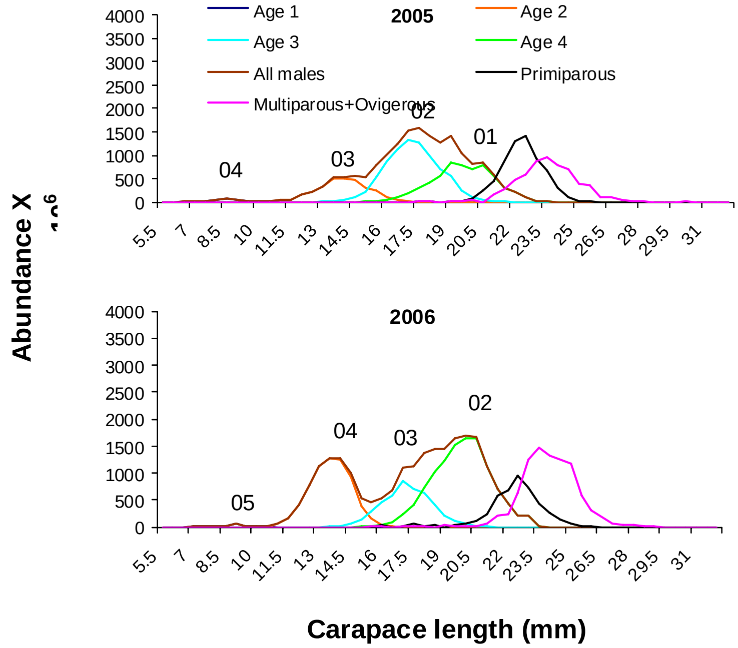


Fig. 21. Abundance at length for NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) estimated by stratified areal expansion analysis of Canadian spring multi-species bottom trawl survey data 1999-2006. (continued).

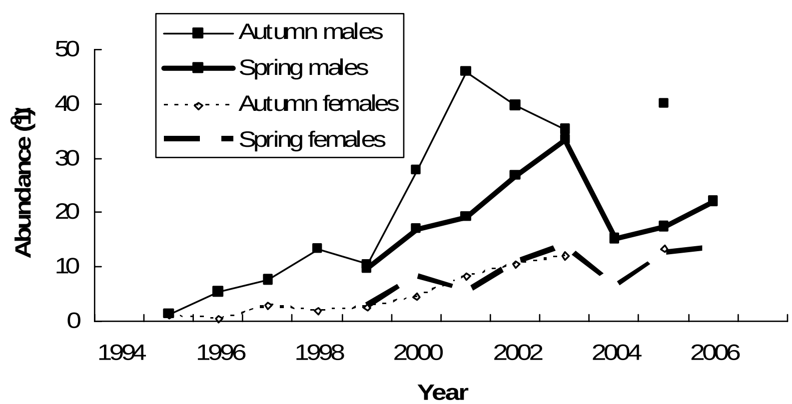


Fig. 22. Abundances of male and female shrimp within Div. 3LNO as estimated from Canadian multi-species survey data using areal expansion calculations.

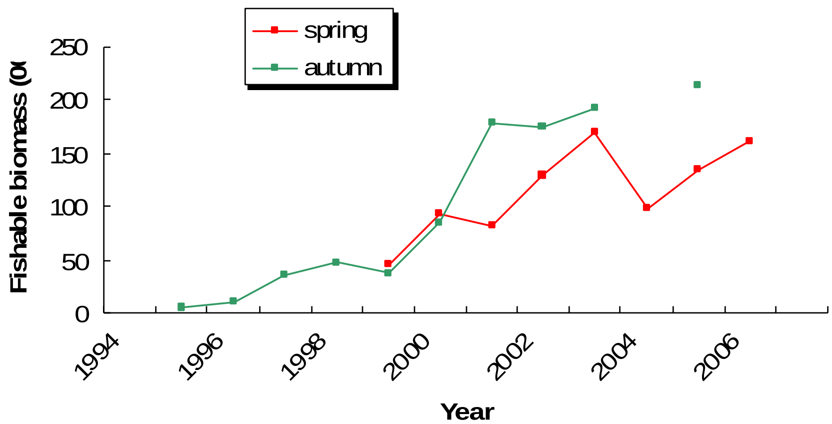


Fig. 23. Fishable biomass (000 t) defined as the weight of all females + the weight of all males with carapace lengths => 17.5 mm. The fishable biomass was determined using areal expansion calculations of data from the spring and autumn annual Canadian research bottom trawl data.

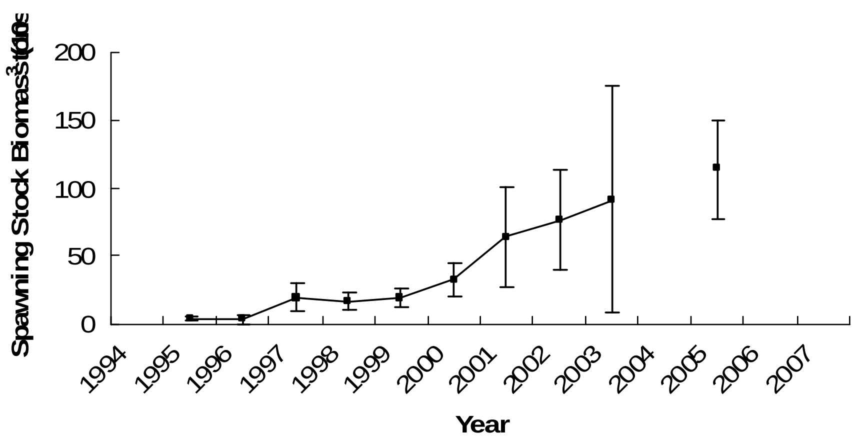


Fig. 24. NAFO Div. 3LNO spawning stock biomass as determined from annual Canadian autumn multi-species research bottom trawl survey data, 1995-2005.

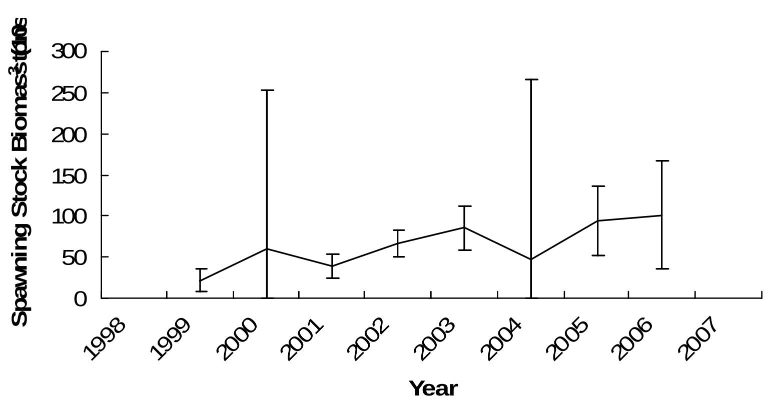
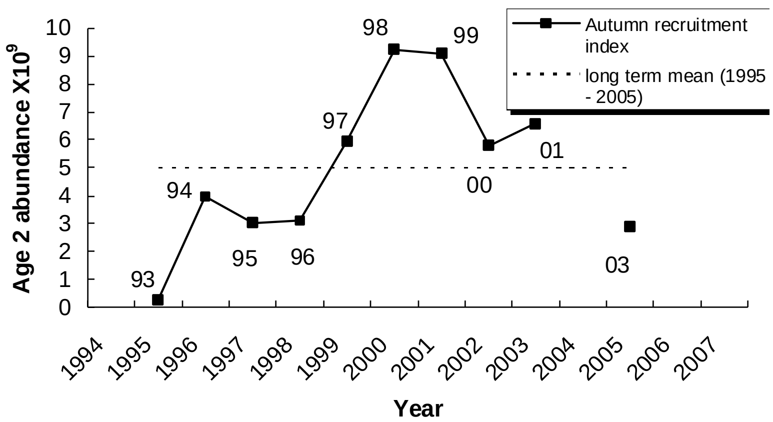


Fig. 25. NAFO Div. 3LNO spawning stock biomass as determined from annual Canadian spring multi-species research bottom trawl survey data, 1999-2006.



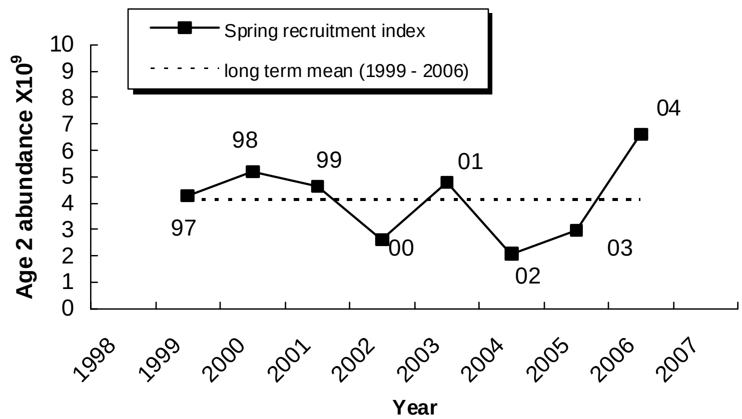


Fig. 26. The autumn and spring recruitment indices (age 2 abundance) as determined from Mix analysis of Canadian research bottom trawl data.

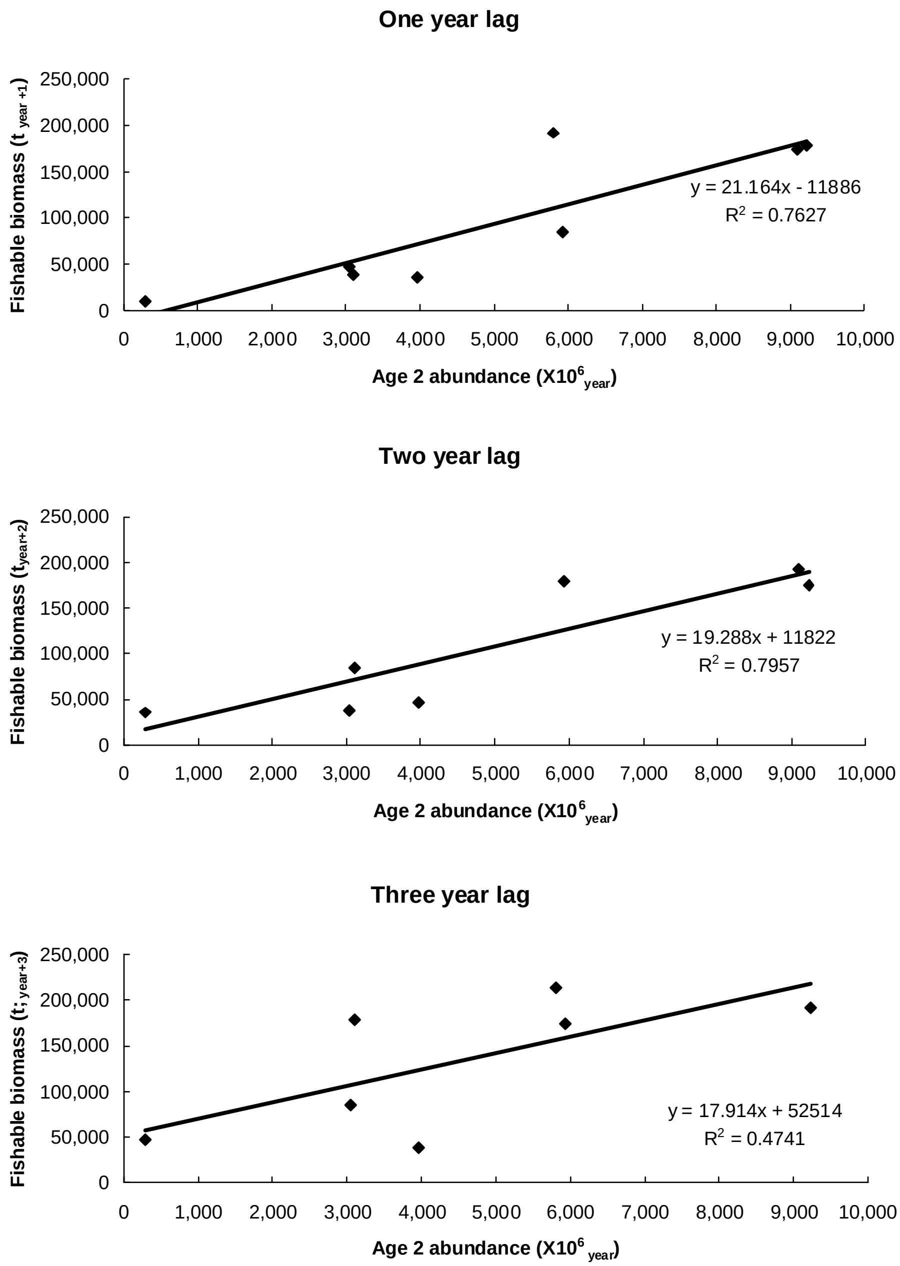


Fig. 27. The regression of fishable biomass with various lags against the recruitment indices (age 2 abundance) using Canadian autumn survey data.

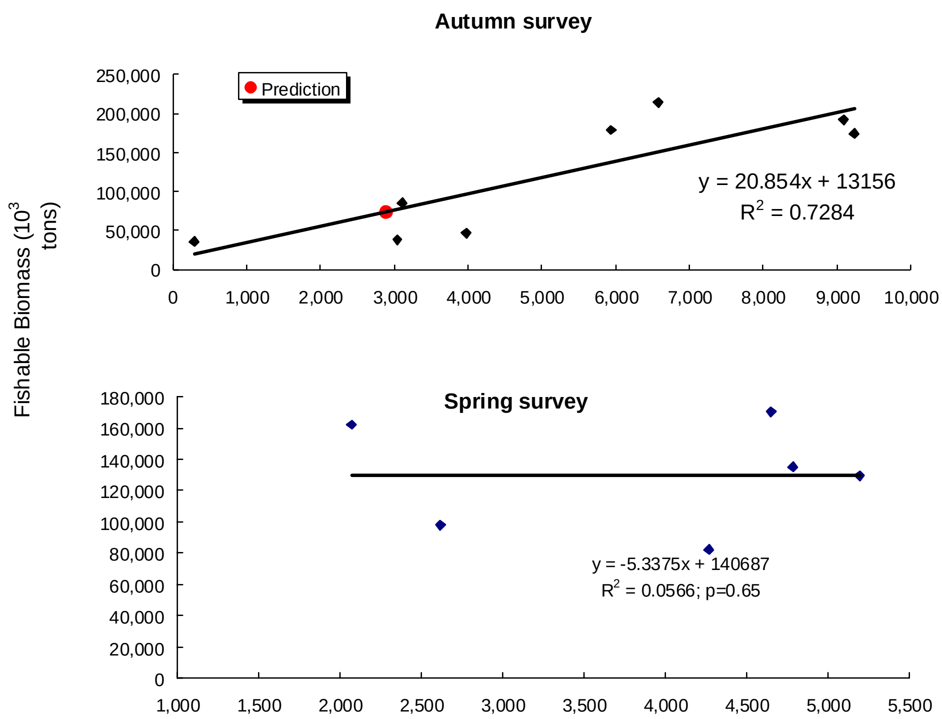


Fig. 28. Autumn and spring recruitment indices used to predict fishable biomass with a two year lag (data from the Canadian multi-species survey series). The red point presents a prediction for the 2007 autumn survey from autumn 2005 recruitment index (2.887 X10^9 age 2 males).

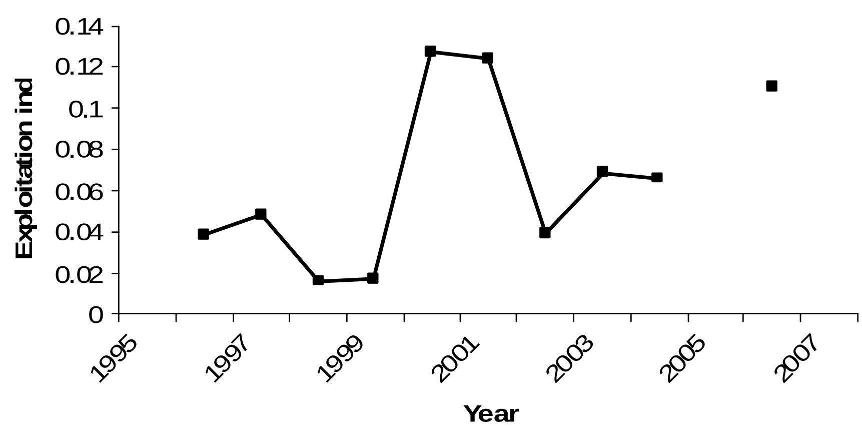


Fig. 29. Exploitation rate indices for NAFO Div. 3LNO determined by dividing total catch by the previous year's Canadian autumn survey fishable biomass.