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An Update of Information Pertaining to Northern Shrimp (*Pandalus borealis*, Krøyer) and Groundfish in NAFO Divisions 3LNO

by

D. C. Orr, P. J. Veitch and D. J. Sullivan

Abstract

This paper describes the 2005 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 August 2005) and biomass estimates (autumn 1995-spring 2005) are updated within this report. Preliminary data indicate that 12 620 and 13 219 tons of shrimp were taken against annual TACs of 13 000 tons in 2004 and 2005, respectively. The autumn 2004 biomass index could not be estimated because the Canadian autumn 2004 research survey did not cover all strata within NAFO Div. 3L. Historically 90-99% of the biomass had been attributed to NAFO Div. 3L and an analysis of the 3L data indicated that between 25 and 61% of the 3L biomass are normally found in the missing strata. As a corollary, strata that had been consistently fished in 3L had been analysed. The autumn 2004 biomass index, within consistently fished 3L strata, was 97 000 tons (95% C.I. = ±22 000 tons), the second highest value in the time series. The spring 2004 biomass index was 156 00 tons (95% C.I. = ±67 000 tons), the third highest in the time series. However, 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 catch rates by Canadian small vessel and international shrimp fishing fleets have increased or remained stable since the fishery began in 2000. The Canadian large vessel catch rates have decreased significantly, but this could be explained by noting that this fleet was searching for large shrimp.

Due to the increase in biomass over recent years, exploitation has remained relatively low (~7% catch/previous year's fishable biomass estimate) even though catches have increased from 6 000 tons (2000-002) to 13 000 tons (2003-2005).

Recruitment indices (age 2 abundance) is used to predict fishable biomass two years later. The spring and autumn recruitment indices are lower than they were during peak years; therefore fishable biomass is expected to decrease 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).

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 1996 TAC for shrimp in Div. 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 2004 shrimp assessment, SC decided that this advice should extend through 2006, and that the advice would be reviewed in September 2005 (NAFO, 2004).

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

Poor condition is usually associated with poor feeding and/ or environmental conditions. Ultimately poor condition may result in reduced reproductive capacity or increased mortality (Morgan, 2004). Therefore, weight/length relationships are presented in this document and it is hoped that over time, a series of weight/length relationships can be created, and that changes in slope can be used to infer changes in shrimp condition.

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, in prep; Wieland, 2004), within the optima of 1-6^{o}C (Shumway *et al.*, 1985). Koeller and Etter (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, higher natural mortality and shorter life span. Therefore it is important that 3LNO shrimp stock assessments include change in maturation schedule.

Full assessments of this stock are completed during the annual November shrimp assessment meetings. Results from these assessments provide necessary input for quota decisions made during Fishery Commission meetings, held during September. Autumn and spring Canadian multi-species 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 2005.

The present document was produced for the November 2005 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 because we wanted to present results that account 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:

$$Ln(CPUE_{ijkml}) = ln(u) + ln(S_j) + ln(V_k) + ln(T_m) + ln(Y_l) + e_{ijkml}$$

where: $CPUE_{ijkml}$ 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 $N(0,\sigma^2/n)$ where n is the number of observations in a cell and σ^2 is the variance.

The 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 2004 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. Iceland, Greenland and Norway provided catch and effort data; therefore it was possible to derive unstandardized single and double trawl catch rates for the NRA.

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 2). Therefore this paper focuses upon the 3NO indices and the impact of strata missed within 3L. Strata that were missed in 3L (autumn 2004) are highlighted in Table 2 and Fig. 2.

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.

Since spring 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 was 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 were plotted against fishable biomass 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 from the previous autumn survey.

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 model:

$$Wt(g) = 0.00088*lt(mm)^{2.857} \text{ (Table 3).}$$

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 and female spawning stock length frequencies from both the research and observer datasets. 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

Distributional maps of juvenile Atlantic cod (*Gadus morhua*), American plaice (*Hippoglossoides platessoides*), Greenland halibut (*Rheinhardtius hippoglossoides*) and redfish (*Sebastes mentella*) were overlain with plots of survey shrimp catches to determine the degree of overlap. The term juvenile refers to the modal length of a species (LC_{50}) passing through a 22 mm Nordmore Grate. The respective LC_{50} values for Atlantic cod, Greenland halibut, redfish and American plaice were: 19 cm (Orr *et al*., 2000 and Hickey *et al*., 1993), 24 cm (Nicolajsen, 1997), 14-18 cm (Hickey *et al*., 1993; Kulka and Power, 1996; Kulka, 1998; Nicolajsen, 1997 and Skűladóttir, 1997) and 23 cm (Orr *et al*., 2000). Potential for impact was assessed through observations of these plots and previously discussed by-catch analyses using observer datasets.

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 from the previous autumn survey), 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 Div. 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 12 620 tons, respectively (Table 1; Fig. 3). The 13 000 tON quota was exceeded during 2005 as preliminary data indicate that 13,219 tons of shrimp had been caught by October 19, 2005.

As per NAFO agreements, Canadian vessels took most of the catch during each year. Canadian catches increased from 4 250 tons in 2000 to 11 150 tons in 2005. Fishing vessels from contracting nations took 619, 5 437, 1 563, 1 939, 2 007, 2 069 tons of shrimp during each respective year.

Canadian Fleet

Since 2000, large (>500 tons) and small (<=500 tons) shrimp fishing vessels catches have been taken from a broad area (Fig. 4-6) from the northern border with 3K south east along the 200-500 m contours to the NRA border. In general, the amount of area accounting for 95% of small vessel logbook catches has tracked the amount of area accounting for 95% of the survey catches, with a one year lag. (Fig. 4). Small vessel catches were taken over a broad area along the slope edge; however, a large concentration of effort is taken near the 200 Nmi limit (Fig. 5). On the other hand, the amount of area accounting for 95% of the large vessel catches has remained stable over the time period (Fig. 4 and 6) with most of the catch taken near the 200 Nmi limit.

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 87% of the variance in the data and indicated that the annual, standardized catch rates for 2000, 2001 and 2004 were similar to the 2005 CPUE estimate (1 522 kg/hr; Tables 4 and 5; Fig.7). The 2002 and 2003 catch rates were significantly higher than the 2005 catch rate. The drop in catch rate during 2005 can be explained by the fact that the large vessels were searching for large shrimp (B. McNamara, pers. comm. Newfound Resources Ltd.). There were no trends in the residuals around parameter estimates (Fig. 8). Preliminary data exploration indicated that there was no relationship between length of small vessel (<=500 t) and tonnage or horse power. Therefore small vessel CPUE was modeled using month and year as explanatory variables. The final model explained 89% 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 2005 estimate (760 kg/hr; Tables 6 and 7; Fig. 7). There were no trends in the residuals around parameter estimates (Fig. 9).

International fleet

Catch rate data were obtained from Greenland, Iceland and Norway. Unstandardized data from Greenland, Iceland, and Norway were plotted against time (Fig. 10). In all cases, each fleet began using single trawls but over time switched to double trawls. In general, catch rates have been increasing over time. Average Icelandic single (500 kg/hr) and double trawl catch rates (700 kg/hr) were much lower than the respective average Greenlandic and Norwegian catch rates (single trawl = 1 800 kg/hr.; double trawl = 3 312 kg/hr.). Figure 11 makes use of expanding symbols to indicate catches taken by Norwegian vessels since 2000. Please note that the dataset captured approximately 50% of the total catches. The does not mean that observations were not taken of almost all catches; however, I was given only data that captured length frequencies. Normally length frequencies are randomly taken once or twice a day.

Size Composition

Several length frequency observations were taken from large vessel catches (Fig. 12). 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 modes overlapped considerably therefore there was no attempt to use Mix in ageing the shrimp. The male and female length frequency distributions are broad indicating that the catch probably consists of more than one age group within each sex. Catch rates had been maintained at over 200 000 animals per hour and the frequency weighted average carapace length for females ranged between 22.88 mm and 23.62 mm. There were no trends in the average size of females.

Figures 13 and 14 present the length frequencies from the Icelandic and Norwegian catches. As noted in the figures, the samples sizes were very small (1-7), therefore comparisons could not be made between the Canadian and foreign length frequencies.

Probit analyses indicate that the size at transition, as determined from large vessel commercial samples, decreased from 21.50-20.44 mm between 2003 and 2004 (Fig 15).

RESEARCH SURVEY DATA

Stock Size

Analyses of the autumn 1995-2003 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 2). Figures 16 and 17 confirm the importance of these strata and that catches, within these strata, vary both seasonally and annually. For these reasons, it was not appropriate to use a multiplicative model to estimate 3L biomass and abundance indices for the missing strata from the autumn 2004 survey. However, analyses conducted on strata that had been consistently fished each autumn since 1995 produced an estimate of 96 926 tons (95% C.I. = ±21 744 tons) of northern shrimp, the second highest value, for this partial index, within this time series (Table 8). It should be noted that the confidence intervals of the biomass estimates from strata completed in the autumn 2004 are relatively tight, indicating relatively low variances between catches. Further, the lower confidence limit of the partial autumn 2004 survey is above the lower confidence limits from the previous four autumn surveys (i.e. from the total 3L indices). The inclusion of additional strata in the overall biomass index would result in the index increasing or staying the same. Therefore one may conclude that the biomass index from the autumn of 2004 was at least as high as it was in the previous four years. Table 9 and Fig. 18 present the biomass and abundance indices produced from the 1995-2003 autumn Canadian multi-species research bottom trawl surveys.

Analyses from the spring 2005 survey indicated that the Div. 3LNO trawlable biomass was 155 627 tons (95% C.I. = ±12 534 tons), the third highest value in the time series. 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 (Tables 10 and 11; Fig. 19), although this was not the case in 2005.

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

Between 90.5 and 99.8% 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 11.9 and 29.2% of the total 3LNO biomass estimates (Tables 12 and 13; Fig. 16 and 17). Three year running averages were estimated in order to smooth the peaks and troughs within the data. They indicate that 16.0-27.6% of the total 3LNO autumn biomass is within the NRA. Over the period 2000-2003 the overall average autumn percent biomass within the NRA was 21.1%. However, during the spring, the percent biomass within the NRA ranged between 12.5 and 32.0%. Over the period 1999-2004 the average spring percent biomass with the NRA was 24.26%.

In all surveys, Div. 3N accounted for .05-9% of the total 3LNO biomass. More than 80% of the 3N biomass was found outside the 200 Nmi limit. Division 3O accounted for less than 1% of the 3LNO biomass. Less than 25% of the Div. 3O biomass was found outside the 200 Nmi limit.

Stock Composition

Length frequency distributions from the spring 1999 – spring 2005 surveys are presented within Fig. 20. Length distributions representing abundance – at – length from the autumn 1995 to autumn 2003 surveys are compared in Fig. 21. Tables 14-19 provide the detailed length frequency data obtained from each spring and autumn survey. Modes increase in height as one moves from ages 1-3 indicating that catchability of the research trawl improves as the shrimp increase in size. Tables 20 and 21 provide the modal analysis and the estimated demographics from spring and autumn surveys, respectively.

This 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; prior to 2000 the abundances at age are much lower than in the post 1999 time period. 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 one 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 age 1 and 2 modes 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 the autumn modal identification as noted by the vertical lines in Table 21 and Fig. 21. The spring survey length frequencies and biomass/ abundance estimates were more variable (Tables 10 and 20 as well as Fig. 20).

Abundances within the autumn 2003 survey data were dominated by males with a modal length of 19.83-mm CL, believed to have been the 1999 year-class (age 4). The 2000 year-class was evident near 17.6 mm while the 2001 year-class had a mode at 15.05 mm while the 2002 year-class had a mode at 9.84 mm. The largest males (>19 mm) and smallest females (<22 mm) are thought to belong to the 1999 year-class (Table 21). The broad female distribution suggests that it consists of more than one year-class. The relative strength of the 1999 year-class and the breath of the female distributions are consistent with the observations pertaining to the commercial large vessel length frequencies. It is predicted that the 1999-2002 year-classes will be able to sustain the fishery for the next few years.

Recruitment Index

Figure 22 presents a series of relationships between fishable biomass ('000 tons) lagged by 2, 3 and 4 years and regressed against age two abundance (billion animals). It should be noted that relatively strong relationships should be expected because both biomass and recruitment at age 2 have been increasing for some time and then stabilized at a high level.

In general, the autumn index increased from 1993 to 2001, decreased in 2002, and increased again in 2003. The last five points (1997-2001 year-classes) in this index have been above average. The spring index also showed that the 1997-1999 year-classes were the most abundant, while the 2002 and 2003 year-classes are lower (Fig. 23).

The linear relationship created from the 2 year lag was used to predict future fishable biomass (Fig. 24). Using the 2002 and 2003 recruitment indices, we are predicting that the 2004 and 2005 fishable biomasses will decrease to 143 000 and 151 000 tons, respectively.

Annual Change in Size at Sex Transition

The size at sex transition (L_{50}) increased from 17.24 mm during 1995 to 22.9 mm the next year then remained without trend since (Table 22 and Fig. 15). Size at transition during 1999, 2001 and 2002 were statistically similar to the size at transition during 2003 (Table 22). Between 1999 and 2003 autumn commercial L_{50} indices were near 21 mm while the L_{50} was 20.44 mm during 2004.

Exploitation Rates

Exploitation levels using ratios of catch/lower 95% confidence interval below the biomass estimate, catch/spawning stock biomass (SSB) and catch/fishable biomass follow similar trajectories (Table 23). Overall, exploitation has been low. TAC for this stock was set in 1999 and again during 2002 by applying a 15% exploitation rate to the lower 95% confidence interval below recent biomass estimates, therefore, it is useful to discuss exploitation in terms of catch/ lower 95% confidence intervals below the biomass indices. This index was below 5% during the mid-late 1990s, increased to 13.4% during 2000 reflecting the start of the fishery under TAC regulation, and then decreased as biomass indices increased. The ratio has never exceeded 15% of the minimum trawlable biomass and is presently 12%. It is important to note that these ratios are believed to over estimate the exploitation rate because the catchability of the research trawl is thought to be less than 1.

By-catch

Tables 24 and 25 indicate that low numbers and weights of Atlantic cod (*Gadus morhua*), American plaice (*Hippoglossoides platessoides*) and redfish (*Sebastes* spp.) had been taken by Canadian shrimp fishing fleets. The 2004 total estimated by-catch of Atlantic cod, American plaice and redfish was approximately 0.2, 3 and 7 tons respectively. The 2005 observer data had not been completely keypunched in time to provide accurate estimates of by-catch; however, preliminary estimates indicate that by-catch remains low.

Relative to other species, high levels of Greenland halibut (*Rheinhardtius hippoglossoides*) are taken in the shrimp fishery. The 2004 total estimated by-catch of Greenland halibut was 13 tons compared to a NAFO Div. 3L autumn 2003 biomass index of 26 123 tons (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 24 and 25 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 2002-2004. As noted above, the 2005 data was not available in its entirety; however, the data are probably representative of fleet by-catch.

Small vessel observer coverage ranged between 3.7% (correction factor = 26 in 2003) and 5.9% (correction factor = 17 in 2002). 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.

Distribution of Shrimp in Relation to Various Commercially Important Groundfish Species

Atlantic cod

Relatively few juvenile cod (<=19 cm total length) have been caught during recent years, although, young cod were often found within Conception, Trinity and Bonavista Bays where their distribution overlapped with shrimp (Fig. 25). Concentrations appeared within Div. 3NO and the southern portion of 3L. Few shrimp were found in these areas. It is important to note that the fishery is restricted to 3L in an effort to preserve juvenile groundfish.

American plaice

Figure 26 indicates that juvenile American plaice (<=23 cm total length) are dispersed throughout the Grand Banks and that there is overlap between American plaice and large shrimp catches. However, most American plaice were found in water shallower than 200 m with the largest concentrations in the southern Grand Banks.

Redfish

Both shrimp and juvenile redfish (<=16 cm total length) are commonly found along the edge of the Grand Banks in water between 200 and 500 m (Fig. 27). Areas of overlap occur where juvenile redfish have traditionally been found, particularly in the Sackville Spur and on the nose of the Grand Banks. These are areas of highest shrimp concentrations. However, the largest concentrations of redfish are found along the southern edge of Div. 3NO.

Greenland halibut

Figure 28 indicates that large concentrations of juvenile Greenland halibut (<=24 cm total length) are sympatric with large concentrations of shrimp.

Information provided by these plots is in agreement with by-catch levels provided in Tables 24 and 25. Levels of by-catch are generally in relation to abundances of juvenile groundfish and degrees of overlap between the species. There are relatively few Atlantic cod which for the most part are distributed away from the shrimp fishery; consequently by-catch of Atlantic cod has generally been less than a ton. Juvenile American plaice are more abundant, but highest concentrations are in shallow water south of the fishery, consequently by-catch levels are higher than they are for cod but were still less than 4 tons during 2004. There is more overlap between juvenile redfish, Greenland halibut and the shrimp fishery. By-catch is greatest for these species.

Resource Status

Canadian large (>500 tons) catch rates decreased significantly since 2003 while the area fished has remained stable throughout the fishery. Personal communication with the fishing industry indicated that large vessel catch rates are confounded by searching for large shrimp. Conversely both small (<=500 tons) vessel catch rates have increased since 2003. Both biomass and abundance indices increased over the period 1995 to 2001 and have since stabilized at a high level. The international fleets were able to maintain or increase catch rates over time. Thus the catch rate information appears positive.

The average fishable biomass from the last four autumn surveys was 173 000 tons (37 billion animals). As a result of increases in biomass/abundance indices, exploitation in terms of catch/fishable biomass remained 13.7% during 2004 even though the TAC more than doubled.

Analyses from research survey data indicate that the size at transition increased from 17 mm in 1995 to 21 mm in 2001 and has remained stable near 21 mm. Increased female size usually implies an increase in individual fecundity. Increased size also implies that the environmental conditions have improved.

The present autumn survey female length distribution is broad suggesting that it consists of more than one year-class. The relative strength of the 1997-2003 year-classes and the breath of the female distributions were consistent with the observations pertaining to the commercial large vessel length frequencies. It is predicted that these year-classes will be able to sustain the fishery for the next few years.

Additionally there is a strong relationship between the fishable biomass lagged by two years and the age two recruitment index. The recruitment index in recent surveys (autumn 2002-spring 2005) is lower than it had been during peak years (spring 2000-autumn 2001); therefore, we should expect a decrease in autumn fishable biomass to decrease over the next few years.

Since present biomass/ abundance indices are stable at a high level, there is a two year lag between recruitment indices and fishable biomass, exploitation has remained low, there is no detectable impact from the fishery and residual female biomass is still strong the stock can probably sustain harvest levels of 22 000 tons. However, the stock should continue to be monitored closely.

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 Annual nominal catches by country of northern shrimp (*Pandalus borealis*) caught in NAFO Div. 3L.

Country	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Canada	2[1]					82[1]	78[1]	4,250[2]	5,129[2]	5,414[2]	10,008[2]	10,613[2]	11,150[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]	505[1]	
Faroe Islands	1,789[1]	1,865[1]		171[1]	485[1]	544[1]	706[1]	42[1]	2,052[4]	620[5]		614[1]	767[1]	
France (SPM)								67[1]		36[3]			78[1]	
Greenland								34[1]			672[8]	294[1]	302[1]	
Iceland								97[1]	55[7]	55[7]	133[7]	105[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]				
Spain							11[1]		699[4]					
Ukraine									57[1]		144[1]	144[1]	137[1]	
USA										69[3]	144[1]			
GRAND TOTAL	1,791	1,865	0	171	485	567	795	4,869	10,566	6,977	11,947	12,620	13,219	
TAC (tons)								6,000	6,000	6,000	13,000	13,000	13,000	22,000

Sources:

1 NAFO STATLANT 21A
2 Canadian 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.

Table 2. Biomass estimates (tons) of northern shrimp (*Pandalus borealis*) from Canadian fall surveys in Div. 3L using a Campelen trawl during 1995-2004. Light shading indicates strata not fished in 2004. The inshore strata were not consistently sampled over the years therefore this table includes only offshore strata. (stand. 15 min. tows)

Depth Range (m)	Area	Stratum	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
57 - 92	2071	350	0	0	1	3	1	1	2	31	38	4
	1780	363	0	1	1	2	0	7	19	18	622	1
	1121	371	0	0	1	0	0	7	5	10	23	0
	2460	372	0	3	12	6	1	7	7	106	166	8
	1120	384	0	2	1	1	2	12	5	489	38	6
	465	785	.	.	.	.	.	.	.	.	.	.
93 - 183	1519	328	32	57	92	15	41	12	14	28	73	38
	1574	341	0	81	41	4	18	27	21	52	58	37
	585	342	0	1	0	25	4	444	4	35	48	1
	525	343	0	1	1	5	1	5	4	5	4	19
	2120	348	4	18	20	56	291	361	435	675	195	5,309
	2114	349	0	3	6	16	12	30	40	466	298	37
	2817	364	1	3	44	14	5	120	190	316	92	26
	1041	365	1	3	105	179	63	.	3,385	3,405	99	.
	1320	370	2	1	57	712	134	84	3,011	129	103	.
	2356	385	1	9	1,471	205	1,274	2,078	4,307	3,629	7,381	5,367
	1481	390	0	0	10	6	12	152	2,498	3,520	7,928	1,330
184 - 274	1582	344	8	29	104	2,858	5,068	3,192	1,971	7,549	2,084	14,774
	983	347	21	45	25	4,850	1,547	7,372	10,450	8,516	1,743	21,775
	1394	366	674	560	11,878	5,425	7,673	24,193	25,316	27,047	22,959	.
	961	369	23	182	1,843	6,319	3,939	3,353	10,842	6,694	21,994	.
	983	386	18	304	9,299	5,981	7,884	6,161	15,245	25,131	22,962	.
	821	389	42	2,007	1,630	6,917	10,065	25,088	32,443	34,321	17,502	11,248
	282	391	0	391	236	166	246	3,643	353	106	7,838	2,312
	164	795	.	.	.	.	.	.	.	.	.	.
	72	789	.	.	.	.	.	.	.	.	.	.
	227	791	.	.	.	.	.	.	.	.	.	.
	100	798	.	.	.	.	.	.	.	.	.	.
275 - 366	1432	345	723	2,030	5,976	9,954	4,361	18,288	17,904	31,885	16,945	20,045
	865	346	1,802	7,069	5,608	3,510	5,328	6,251	18,983	35,886	29,796	11,056
	334	368	77	1,232	483	358	101	27	16,985	457	10,162	.
	718	387	1,199	2,393	4,258	7,197	3,908	12,013	43,798	11,890	44,725	.
	361	388	363	1,599	2,117	1,485	570	4,326	13,612	7,204	3,747	.
	145	392	210	324	73	187	123	387	320	44	881	906
	175	796	.	.	.	.	.	.	.	.	.	.
	81	800	.	.	.	.	.	.	.	.	.	.
367 - 549	186	729	0	3	2	0	51	1	603	0	15	1
	216	731	0	.	16	11	14	112	92	772	0	1,496
	468	733	8	212	170	12	66	0	243	4	0	262
	272	735	134	2	166	2	57	119	8	12	147	.
	50	792	.	.	.	.	.	.	.	.	.	.
550 - 731	170	730	0	1	0	0	0	0	1	0	0	0
	231	732	12	0	0	0	1	0	2	9	0	866
	228	734	0	0	1	0	0	0	1	9	0	.
	175	736	1	0	8	2	2	27	13	0	18	.
732 - 914	227	737	0	0	0	0	0	1	0	0	0	.
	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			5,358	18,566	45,758	56,485	52,864	117,902	223,149	210,453	220,713	96,926
Upper 95% CL.			7,397	28,893	66,426	76,064	69,804	142,948	369,574	299,083	337,873	118,670
Lower 95% CL.			3,318	8,238	25,090	36,905	35,923	92,855	76,725	121,821	103,549	75,182
% of 3L autumn biomass index within the missing strata			**39.74%**	**25.19%**	**61.39%**	**46.34%**	**44.95%**	**39%**	**53.15%**	**35.53%**	**55.81%**	**???**

Table 3. Length weight relationships derived from live *Pandalus borealis* collected during spring and autumn Canadian multi-species bottom trawl surveys.

May-June 2004 Northern shrimp length weight relationships

<u>Converting length to weight</u>

NAFO Division	Maturity	Length range (mm)	Sample size	Adj. r^2	Model	P value
3LN	Males	16.4 – 22.4	105	0.945	$Wt(g) = 0.000966*lt(mm)^{2.842}$	<.0001
3LN	Non ovigerous females females	19.9 – 27.4	228	0.932	$Wt(g) = 0.001347*lt(mm)^{2.750}$	<.0001

May-June 2004 Northern shrimp length weight relationships

<u>Converting weight to length</u>

NAFO Division	Maturity	Weight range (g)	Sample size	Adj. r^2	Model	P value
3LN	Males	2.71 – 6.54	105	0.945	$Lt(mm) =(wt(g)/.000966)^{.93155}$	<.0001
3LN	Non ovigerous females	4.87 – 13.28	228	0.932	$Lt(mm) = (wt(g)/.001347)^{.36363}$	<.0001

Oct. 2004-Feb. 2005 Northern shrimp length weight relationships.

By NAFO Division

<u>Converting length to weight</u>

NAFO Division	Maturity	Length range (mm)	Sample size	Adj. r^2	Model	P value
2H	Males	14.7 – 22.6	39	0.9438	$Wt(g) = 0.000434*lt(mm)^{3.098}$	<.0001
2H	FE2 – no hr	21.0 – 25.4	14	0.8909	$Wt(g) = 0.000343*lt(mm)^{3.163}$	<.0001
2H	Ovigerous females	20.6 – 28.0	498	0.9046	$Wt(g) = 0.000489*lt(mm)^{3.090}$	<.0001
2J	Males	11.7 – 22.5	50	0.8796	$Wt(g) = 0.00046*lt(mm)^{3.061}$	<.0001
2J	Ovigerous females	19.5 – 26.9	184	0.7019	$Wt(g) = 0.00232*lt(mm)^{2.580}$	<.0001
3K	Males	13.7 – 22.2	86	0.9665	$Wt(g) = 0.000676*lt(mm)^{2.955}$	<.0001
3K	Transitional no hr	20.5 – 23.8	30	0.899	$Wt(g) = 0.000649*lt(mm)^{2.976}$	<.0001
3K	Ovigerous females	21.1 – 27.4	59	0.8766	$Wt(g) = 0.000901*lt(mm)^{2.881}$	<.0001
3L	Males	14.5 – 22.7	94	0.9722	$Wt(g) = 0.00088*lt(mm)^{2.857}$	<.0001
3L	Transitional no hr	20.3 – 23.9	46	0.8442	$Wt(g) = 0.00186*lt(mm)^{2.625}$	<.0001
3L	Ovigerous females	21.1 – 26.6	18	0.916	$Wt(g) = 0.00193*lt(mm)^{2.663}$	<.0001

Oct. 2004-Feb. 2005 Northern shrimp length weight relationships.

Live animals taken from the research surveys.

NAFO Divisions combined

<u>Converting length to weight</u>

Maturity	Length range (mm)	Sample size	Adj. r^2	Model	P value
Males	11.7 – 22.7	269	0.934	$0.000544*lt(mm)^{3.020}$	<.0001
Transitionals no hr	20.3 – 23.9	77	0.854	$0.001216*lt(mm)^{2.766}$	<.0001
Ovigerous females	19.5 – 28.0	759	0.844	$0.000708*lt(mm)^{2.968}$	<.0001

Oct. 2004-Feb. 2005 Northern shrimp length weight relationships

Live animals taken from the research surveys.

<u>Converting weight to length</u>

Maturity	Length range (mm)	Sample size	Adj. r^2	Model	P value
Males	11.7 – 22.7	269	0.934	$Lt(mm) = (wt(g)/.000544)^{.331126}$	<.001
Transitionals no hr	20.3 – 23.9	77	0.854	$Lt(mm) = (wt(g)/.001216)^{.361533}$	<.001
Ovigerous females	19.5 – 28.0	759	0.844	$Lt(mm) = (wt(g)/.000708)^{.33693}$	<.001

Table 4. Multiplicative, year, month, vessel model for Canadian large (>500 t) vessels fishing northern shrimp in NAFO Div. 3L over the period 2000-2005. (Weighting by effort, single & double trawls, no windows, observer dataset)

The GLM Procedure
Class Level Information

Class	Levels	Values
year	6	2000 2001 2002 2003 2004 2005
month	6	1 2 3 4 5 6
CFV	11	
gear	2	66 99

Number of observations 96

Dependent Variable: lncpue
Weight: wfactor

Source	DF	Sum of Squares	Mean Square	F Value	Pr >
Model	21	1873.073017	89.193953	24.12	<.00
Error	74	273.695151	3.698583		
Corrected Total	95	2146.768169			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.872508	26.35871	1.923170	7.296145

Source	DF	Type I SS	Mean Square	F Value	Pr >
year	5	908.1338829	181.6267766	49.11	<.00
month	5	472.4187273	94.4837455	25.55	<.00
CFV	10	460.2508988	46.0250899	12.44	<.00
gear	1	32.2695084	32.2695084	8.72	0.00

Source	DF	Type III SS	Mean Square	F Value	Pr >
year	5	114.8943768	22.9788754	6.21	<.00
month	5	334.0082431	66.8016486	18.06	<.00
CFV	10	334.1317245	33.4131725	9.03	<.00
gear	1	32.2695084	32.2695084	8.72	0.00

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		7.042292735 B	0.15088168	46.67	<.0001
year	2000	-0.222629057 B	0.13367026	-1.67	0.1000
year	2001	0.040782859 B	0.12337913	0.33	0.7419
year	2002	0.307103436 B	0.12555929	2.45	0.0168
year	2003	0.410863233 B	0.12821824	3.20	0.0020
year	2004	0.136432464 B	0.12144757	1.12	0.2649
year	2005	0.000000000 B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
2000	7.105210	6.923899	7.286521
2001	7.368622	7.201046	7.536199
2002	7.634943	7.462076	7.807810
2003	7.738703	7.572143	7.905262
2004	7.464272	7.313484	7.615060
2005	7.327839	7.128879	7.526800

Table 5. Large vessel (>500 t) shrimp fishing fleet fishery data for NAFO Div. 3L, 2000-2005.

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	79	844	0.597	1,163	0.800	1,218	806
2001	2,500	2,394	83	1,267	0.896	1,889	1.042	1,585	1,510
2002	2,500	2,455	98	1,918	1.355	1,280	1.360	2,069	1,186
2003	4,267	3,956	69	3,569	2.522	1,109	1.508	2,295	1,723
2004	4,267	4,037	51	2,119	1.497	1,905	1.146	1,745	2,314
2005	4,267	4,037	21	1,415	1.000	2,853	1.000	1,522	2,652

[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.

Table 6. Multiplicative, year and month model for Canadian small (<=500 t) vessels fishing northern shrimp in NAFO Div. 3LNO over the period 2000-2005. (Weighting by effort, single trawl, no windows, logbook data, history of at least 2 years for each vessel).

The GLM Procedure
Class Level Information

Class	Levels	Values
year	6	2000 2001 2002 2003 2004 2005
month	7	4 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	2500.416736	227.310612	13.47	<.0001
Error	18	303.702121	16.872340		
Corrected Total	29	2804.118857			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.891694	68.75422	4.107595	5.974318

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	5	2166.562968	433.312594	25.68	<.0001
month	6	333.853768	55.642295	3.30	0.0228
Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	5	986.1695111	197.2339022	11.69	<.0001
month	6	333.8537676	55.6422946	3.30	0.0228

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		6.760897674	B	0.12532824	53.95	<.0001
year	2000	-0.828601711	B	0.13447950	-6.16	<.0001
year	2001	-0.840690897	B	0.13912600	-6.04	<.0001
year	2002	-0.775554328	B	0.13794495	-5.62	<.0001
year	2003	-0.623682096	B	0.13493307	-4.62	0.0002
year	2004	-0.455266023	B	0.13082387	-3.48	0.0027
year	2005	0.000000000	B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
2000	5.805242	5.674825	5.935659
2001	5.793153	5.682707	5.903598
2002	5.858289	5.741457	5.975122
2003	6.010161	5.925256	6.095067
2004	6.178577	6.041495	6.315660
2005	6.633843	6.367132	6.900555

Table 7. Small vessel (<=500 t; <65') shrimp fishing fleet fishery data for NAFO Div. 3L, 2000-2005.

				UNSTANDARDIZED			STANDARDIZED		
YEAR	TAC (t)	CATCH[1] (t)	PERCENT OF[2] CATCH IN STANDARD DATASET	CPUE (KG/HR)	CPUE INDEX	EFFORT[3] (HR)	RELATIVE CPUE	MODELLED CPUE	EFFORT (HRS)
1999		17							
2000	2,500	3,247	76.9	368	0.434	8,822	0.437	332	9,779
2001	2,500	2,482	91.7	314	0.370	7,895	0.431	328	7,565
2002	2,500	2,861	88.7	340	0.400	8,419	0.460	350	8,173
2003	6,566	6,457	79.1	391	0.461	16,496	0.536	408	15,844
2004	6,566	6,576	70.2	538	0.634	12,212	0.634	482	13,635
2005	6,566	7,147	13.6	849	1.000	8,415	1.000	760	9,399

[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 8. Biomass estimates (tons) of northern shrimp (*Pandalus borealis*) from Canadian fall surveys in Div. 3L using a Campelen trawl during 1995 - 2004. The analyses below are for strata sampled in all years. (stand. 15 min. tows).

Depth Range (m)	Area	Stratum	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
57 - 92	2071	350	0	0	1	3	1	1	2	31	38	4
	1780	363	0	1	1	2	0	7	19	18	622	1
	1121	371	0	0	1	0	0	7	5	10	23	0
	2460	372	0	3	12	6	1	7	7	106	166	8
	1120	384	0	2	1	1	2	12	5	489	38	6
93 - 183	1519	328	32	57	92	15	41	12	14	28	73	38
	1574	341	0	81	41	4	18	27	21	52	58	37
	585	342	0	1	0	25	4	444	4	35	48	1
	525	343	0	1	1	5	1	5	4	5	4	19
	2120	348	4	18	20	56	291	361	435	675	195	5,309
	2114	349	0	3	6	16	12	30	40	466	298	37
	2817	364	1	3	44	14	5	120	190	316	92	26
	2356	385	1	9	1,471	205	1,274	2,078	4,307	3,629	7,381	5,367
	1481	390	0	0	10	6	12	152	2,498	3,520	7,928	1,330
184 - 274	1582	344	9	29	104	2,858	5,068	3,192	1,971	7,549	2,084	14,774
	983	347	21	45	25	4,850	1,547	7,372	10,450	8,516	1,743	21,775
	821	389	42	2,007	1,630	6,917	10,065	25,088	32,443	34,321	17,502	11,248
	282	391	0	391	236	166	246	3,643	353	106	7,838	2,312
275 - 366	1432	345	723	2,030	5,976	9,954	4,361	18,288	17,904	31,885	16,945	20,045
	865	346	1,802	7,069	5,608	3,510	5,328	6,251	18,983	35,886	29,796	11,056
	145	392	210	324	73	187	123	387	320	44	881	906
367 - 549	186	729	0	3	2	0	51	1	603	0	15	1
	216	731	0 .		16	11	14	112	92	772	0	1,496
	468	733	8	212	170	12	66	0	243	4	0	262
550 - 731	170	730	0	1	0	0	0	0	1	0	0	0
	231	732	12	0	0	0	1	0	2	9	0	866
Biomass estimate (t)			2,866	12,290	15,543	28,824	28,534	67,597	90,917	128,472	93,767	96,926
Upper 95% CL			5,227	25,047	20,659	49,547	41,246	92,287	130,537	220,851	130,753	118,670
Lower 95% CL			506	-467	10,427	8,099	15,821	42,907	51,298	36,092	56,778	75,182

Table 9 Northern shrimp stock size estimates in NAFO divisions 3LNO from annual autumn Canadian multi-species bottom surveys, 1995 - 2003. Offshore strata only. (standard 15 min. tows) Please note autumn 2004 indices 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		???			???		

Table 10 Northern shrimp stock size estimates in NAFO divisions 3LNO from annual spring Canadian multi-species bottom surveys, 1999 - 2005. Offshore strata only. (standard 15 min. tows)

	Biomass (tons)			Abundance (numbers x 10^{-6})			Survey
Year	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1999	12,564	55,317	98,069	3,178	12,702	22,227	313
2000	-15,869	121,815	259,498	-54,743	25,012	104,768	298
2001	62,359	102,566	142,773	13,417	24,845	36,272	300
2002	121,067	159,491	197,916	28,311	37,512	46,714	300
2003	112,299	193,766	275,233	21,857	46,295	70,732	300
2004	-529,764	110,827	751,418	-97,747	21,696	141,395	296
2005	88,504	155,627	222,751	17,441	29,976	42,510	289

Table 11 NAFO divisions 3LNO *Pandalus borealis* biomass estimates for entire divisions. (Shrimp were collected during the Canadian spring and autumn multi-species surveys using a Campelen 1800 shrimp trawl. (standard 15 min. tows).

			Entire Division					Entire Division	
Season	Year	Division	Biomass estimate (Kg x 1000)	Percent by division	Season	Year	Division	Biomass estimate (Kg x 1000)	Percent by division
Autumn	1995	3L	5,357	90.48					
Autumn	1996	3L	18,566	92.42					
Autumn	1997	3L	45,758	99.04					
Autumn	1998	3L	56,485	94.28					
Autumn	1999	3L	52,863	99.47	Spring	1999	3L	53,934	97.50
Autumn	2000	3L	117,902	99.77	Spring	2000	3L	119,521	98.12
Autumn	2001	3L	223,149	99.62	Spring	2001	3L	102,493	99.93
Autumn	2002	3L	210,451	97.88	Spring	2002	3L	155,061	97.22
Autumn	2003	3L	220,711	98.72	Spring	2003	3L	195,121	98.46
Autumn	2004	3L	???	???	Spring	2004	3L	109,590	98.88
					Spring	2005	3L	154,970	99.58
Autumn	1995	3N	533	9.00					
Autumn	1996	3N	1,514	7.54					
Autumn	1997	3N	427	0.92					
Autumn	1998	3N	3,360	5.61					
Autumn	1999	3N	272	0.51	Spring	1999	3N	1,349	2.44
Autumn	2000	3N	270	0.23	Spring	2000	3N	2,248	1.85
Autumn	2001	3N	836	0.37	Spring	2001	3N	53	0.05
Autumn	2002	3N	4,444	2.07	Spring	2002	3N	4,395	2.76
Autumn	2003	3N	2,785	1.25	Spring	2003	3N	2,852	1.44
Autumn	2004	3N	1,422	???	Spring	2004	3N	1,099	0.99
					Spring	2005	3N	530	0.34
Autumn	1995	3O	31	0.52					
Autumn	1996	3O	9	0.04					
Autumn	1997	3O	17	0.04					
Autumn	1998	3O	69	0.12					
Autumn	1999	3O	9	0.02	Spring	1999	3O	34	0.06
Autumn	2000	3O	8	0.01	Spring	2000	3O	46	0.04
Autumn	2001	3O	10	0.00	Spring	2001	3O	20	0.02
Autumn	2002	3O	113	0.05	Spring	2002	3O	35	0.02
Autumn	2003	3O	72	0.03	Spring	2003	3O	196	0.10
Autumn	2004	3O	77	???	Spring	2004	3O	138	0.12
					Spring	2005	3O	127	0.08
	all divisions					all divisions			
Autumn	1995		5,921						
Autumn	1996		20,089						
Autumn	1997		46,202						
Autumn	1998		59,914						
Autumn	1999		53,144		Spring	1999		55,317	
Autumn	2000		118,180		Spring	2000		121,815	
Autumn	2001		223,995		Spring	2001		102,566	
Autumn	2002		215,008		Spring	2002		159,491	
Autumn	2003		223,568		Spring	2003		198,169	
Autumn	2004		???		Spring	2004		110,827	
					Spring	2005		155,627	

Table 12 NAFO divisions 3LNO *Pandalus borealis* biomass estimates for entire divisions and outside the 200 Nmi limit. Shrimp were collected during the autumn Canadian multi-species surveys using a Campelen 1800 shrimp trawl. (standard 15 min. tows).

Season	Year	Division	Entire Division Biomass estimate (Kg x 1000)	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	220,711	98.72	43,986	94.76		19.93	20.11
Autumn	2004	3L	???	???	13,687	90.70		???	???
			Overall average	**96.85**			Overall average	**19.03**	
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	5.22		86.93	85.95
Autumn	2004	3N	1,422	???	1,393	9.23		97.96	86.35
			Overall average	**3.06**			Overall average	**88.74**	
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	0.08		15.58	18.34
			Overall average	**0.09**			Overall average	**18.60**	
	all divisions								
Autumn	1995		5,921		1,537			25.96	25.96
Autumn	1996		20,088		5,862			29.18	27.57
Autumn	1997		46,202		5,509			11.92	22.36
Autumn	1998		59,914		11,508			19.21	20.11
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		223,568		46,416			20.76	20.87
Autumn	2004		???		15,091			???	???
							Overall average 1995 - 2003	**21.12**	

Table 13 NAFO divisions 3LNO *Pandalus borealis* biomass estimates for entire divisions and outside the 200 Nmi limit.
Shrimp were collected during the spring Canadian multi-species surveys using a Campelen 1800 shrimp trawl.
(standard 15 min. tows)

Season	Year	Division	Entire Biomass estimate (Kg x 1000)	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	190,718	98.43	38,473	93.13		20.17	22.87
Spring	2004	3L	109,590	98.88	27,262	96.37		24.88	25.18
Spring	2005	3L	154,970	99.58	18,982	97.27		12.25	19.10
			Overall average	**98.52**			Overall average	**23.33**	
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	2,853	1.47	2,834	6.86		99.33	89.25
Spring	2004	3N	1,099	0.99	1,019	3.60		92.72	91.85
Spring	2005	3N	530	0.34	516	2.64		97.36	96.47
			Overall average	**1.41**			Overall average	**93.30**	
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	0.01		1.02	7.48
Spring	2004	3O	138	0.12	8	0.02		5.80	6.08
Spring	2005	3O	127	0.08	17	0.06		13.39	6.73
			Overall average	**0.06**			Overall average	**7.81**	
	all divisions								
Spring	1999		55,317		16,057			29.03	29.03
Spring	2000		121,815		38,310			31.45	30.24
Spring	2001		102,566		18,444			17.98	26.15
Spring	2002		159,491		50,962			31.95	27.13
Spring	2003		193,766		41,310			21.32	23.75
Spring	2004		110,827		28,289			25.53	26.27
Spring	2005		155,627		19,515			12.54	19.79
							Overall average	**24.26**	

Table 14 Abundance (000's) of male northern shrimp (*Pandalus borealis*) collected in NAFO Div. 3LNO during spring Canadian research surveys during 1999 - 2005. The data were taken from strata <784 so that all years would be comparable.

Length in mm	Spring 99 WT 238 - 241 1999	Spring 00 WT 316 - 318 2000	Spring 01 WT 365 - 370 2001	Spring 02 WT 419 - 424 2002	Spring 03 WT 479 - 482 2003	Spring 04 WT 546 - 549 2004	Spring 05 WT 618 - 621 2005
0.5	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
5.5	0	0	0	0	0	0	0
6	0	0	0	0	44	0	1,701
6.5	629	0	2,909	3,092	12,101	543	6,733
7	10,950	14,387	7,218	28,159	21,826	10,900	5,088
7.5	4,505	46,869	36,791	159,756	100,993	16,006	28,727
8	21,825	95,301	36,831	136,376	214,975	14,853	49,402
8.5	26,815	135,840	11,852	93,359	63,134	3,425	73,764
9	15,785	74,180	137	27,860	7,757	3,823	52,407
9.5	28,176	39,831	9,711	10,798	4,984	22,441	26,383
10	14,367	34,300	20,829	17,085	47,769	16,791	13,992
10.5	15,123	60,587	36,128	129,491	93,127	38,451	16,520
11	24,841	50,993	184,768	122,222	219,930	56,113	40,178
11.5	29,581	169,630	201,256	367,118	195,113	115,739	58,767
12	49,207	274,247	312,945	399,854	528,599	163,139	162,138
12.5	135,597	455,568	614,303	579,093	930,029	262,772	227,976
13	267,629	891,854	689,768	432,246	777,992	293,275	324,149
13.5	704,706	994,659	744,396	405,781	709,577	385,717	521,556
14	804,028	1,028,440	681,121	298,773	493,491	265,564	533,802
14.5	840,930	716,927	508,801	362,284	526,902	215,298	571,136
15	741,258	742,644	484,341	760,694	528,161	225,580	529,506
15.5	435,207	614,294	795,068	1,304,791	618,014	267,551	777,501
16	192,745	613,210	879,612	1,608,691	998,814	326,881	1,019,912
16.5	121,670	771,835	1,351,224	1,945,095	945,943	534,401	1,248,683
17	283,562	1,358,786	1,288,397	2,329,591	795,140	657,320	1,522,027
17.5	339,923	1,647,536	1,540,283	2,616,479	962,097	755,938	1,587,094
18	518,383	1,633,388	1,575,429	2,497,661	890,169	1,387,142	1,410,253
18.5	479,302	1,241,221	1,787,205	2,354,153	895,744	1,371,513	1,268,921
19	490,357	617,208	1,901,729	2,220,763	1,356,242	1,750,306	1,407,813
19.5	593,703	687,161	1,647,032	2,046,579	831,747	1,729,213	1,046,010
20	742,174	435,102	1,007,472	1,767,802	622,445	1,565,154	810,115
20.5	690,630	547,918	452,165	1,083,680	263,898	1,414,838	836,808
21	484,495	409,895	232,646	467,015	170,087	582,640	590,338
21.5	413,102	247,461	87,887	150,834	79,386	388,419	319,060
22	115,645	179,686	52,072	41,214	25,850	185,549	214,061
22.5	54,782	116,076	13,845	10,202	7,506	15,137	101,397
23	23,786	13,182	8,716	5	716	3,144	18,426
23.5	6,794	8,366	15,237	0	25	649	8,431
24	1,089	189	20	0	0	53	0
24.5	0	0	0	0	2,237	0	85
25	0	0	0	0	0	0	0
25.5	0	0	4,183	0	0	416	0
26	0	0	0	0	0	0	0
26.5	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0
28.5	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0
29.5	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
30.5	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0
31.5	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0
Total (000's)	9,723,302	16,968,771	19,224,326	26,778,595	14,964,698	15,046,693	17,430,857
Upper 95% limit	18,079,360	36,240,923	29,374,530	34,873,186	35,816,078	105,290,000	25,193,470
Lower 95% limit	1,367,243	-2,303,381	9,074,122	18,684,004	-5,886,682	-75,200,000	9,668,244

Table 15 Abundance (000's) of transitional northern shrimp (*Pandalus borealis*) collected in NAFO Div. 3LNO during spring Canadian research surveys during 1999 - 2005. The data were taken from strata <784 so that all years would be comparable.

Length in mm	Spring 99 WT 238 - 241	Spring 00 WT 316 - 318	Spring 01 WT 365 - 370	Spring 02 WT 419 - 424	Spring 03 WT 479 - 482	Spring 04 WT 546 - 549	Spring 05 WT 618 - 621
0.5	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
5.5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
9.5	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
10.5	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
11.5	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
13.5	0	0	0	0	0	0	209
14	0	0	0	0	0	48	104
14.5	0	0	0	0	0	97	209
15	0	0	24	0	0	49	104
15.5	0	0	48	0	0	49	209
16	0	0	18,876	1,506	0	147	209
16.5	0	0	72	37	0	2,465	209
17	156	3,153	11,856	0	40	13,269	122
17.5	2,752	5,615	7,865	0	5,140	241	7,110
18	4	13,755	72	6,328	748	1,060	5,574
18.5	6,041	11	9,508	16,462	4,034	7,780	120
19	2,314	15,948	27,507	14,549	13,311	21,423	23,161
19.5	21,171	60,712	127,445	190,044	23,629	44,023	10,415
20	13,436	117,600	240,083	785,681	150,812	126,447	80,044
20.5	48,071	254,028	430,125	1,290,489	449,986	209,426	238,047
21	96,358	328,120	440,732	1,703,644	596,555	416,668	439,807
21.5	182,755	601,082	428,310	1,625,473	713,250	830,222	887,981
22	390,113	636,319	376,987	1,249,021	610,800	652,032	1,292,645
22.5	498,405	811,106	353,202	607,802	364,622	459,839	1,408,621
23	403,913	861,544	300,325	230,005	255,053	362,595	942,233
23.5	349,581	843,773	136,802	55,564	55,207	148,438	680,345
24	186,312	376,890	106,178	29,508	14,289	38,235	300,193
24.5	89,024	246,273	42,713	9,749	44,741	74,104	110,422
25	39,463	147,609	34,772	9,347	747	8,363	26,684
25.5	7,782	44,764	1,090	50	2,265	5,957	22,694
26	1,582	19,820	855	152	51	1,273	1,695
26.5	46	1,121	233	0	101	58	2,127
27	0	230	166	0	0	0	46
27.5	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0
28.5	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0
29.5	0	0	0	0	0	0	0
30	0	0	0	0	0	0	0
30.5	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0
31.5	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0
Total (000's)	2,339,278	5,389,472	3,095,845	7,825,407	3,305,380	3,424,308	6,481,337
Upper 95% limit	4,226,450	11,814,756	4,679,470	9,566,813	5,189,468	21,609,413	10,604,954
Lower 95% limit	452,105	-1,035,812	1,512,221	6,084,002	1,421,291	-14,760,000	2,357,721

Table 16 Abundance (000's) of multiparous & ovigerous northern shrimp (*Pandalus borealis*) collected in NAFO Div. 3LNO during spring Canadian research surveys during 1999 - 2005. The data were taken from strata <784 so that all years would be comparable.

Length in mm	Spring 99 WT 238 - 241	Spring 00 WT 316 - 318	Spring 01 WT 365 - 370	Spring 02 WT 419 - 424	Spring 03 WT 479 - 482	Spring 04 WT 546 - 549	Spring 05 WT 618 - 621
0.5	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0
3.5	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0
4.5	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
5.5	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
9.5	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
10.5	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0
11.5	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0
13.5	0	0	7,841	0	0	0	0
14	0	0	0	0	0	48	0
14.5	0	0	0	0	0	0	209
15	0	3,153	0	0	0	143	862
15.5	0	0	0	0	0	48	417
16	0	0	0	1,979	13,807	143	522
16.5	0	0	2,651	32	0	8,707	730
17	257	0	14,678	19,046	40	50	246
17.5	4,309	22	12,677	26,020	8,739	2,377	20,881
18	6,357	24,194	2,789	3,049	11,889	3,075	12,646
18.5	6,452	19,307	15,383	42,140	38,599	7,298	1,319
19	10,509	18,883	18,738	20,218	8,325	9,276	15,561
19.5	2,204	14,316	24,397	12,510	9,452	9,373	30,061
20	2,723	22,939	36,410	27,532	16,459	12,885	42,867
20.5	2,296	36,349	13,971	98,216	25,001	23,208	901
21	10,165	36,223	33,871	100,823	71,521	84,068	173,892
21.5	6,067	152,084	76,698	195,630	187,826	177,575	270,052
22	33,072	217,812	198,823	255,134	234,253	210,374	476,754
22.5	42,180	288,943	208,713	355,844	216,017	445,736	583,030
23	61,102	315,931	355,834	367,421	231,170	460,679	889,592
23.5	87,701	384,238	394,172	368,020	90,291	503,592	971,337
24	110,767	407,007	385,297	412,853	141,419	490,563	775,312
24.5	78,498	317,258	317,707	203,134	57,424	377,109	711,895
25	60,844	160,754	205,918	182,827	37,718	165,002	396,088
25.5	60,492	94,156	155,971	78,257	31,533	88,998	361,007
26	23,344	58,375	91,262	61,327	35,650	35,387	112,553
26.5	11,183	48,109	57,068	54,885	3,535	35,629	104,174
27	4,979	19,528	21,669	18,430	7,671	14,471	58,064
27.5	8,045	5,589	4,161	578	13,646	822	24,049
28	2,968	3,358	13,606	70	163	4,755	20,289
28.5	3,230	3,077	1,304	0	314	2,845	184
29	1,148	2,604	1,022	71	90	113	585
29.5	581	254	437	0	0	77	232
30	327	363	0	16	0	38	5,022
30.5	52	36	0	0	32	0	0
31	212	57	0	0	0	0	0
31.5	0	62	0	0	0	37	0
32	0	36	0	0	0	0	0
Total (000's)	642,062	2,655,014	2,673,069	2,906,060	1,492,583	3,174,502	6,061,331
Upper 95% limit	894,893	9,122,670	3,516,292	4,421,781	2,228,704	14,584,787	8,964,035
Lower 95% limit	389,231	-3,812,642	1,829,846	1,390,339	756,462	-8,235,783	3,158,626

Table 17 Abundance (000's) of male northern shrimp (*Pandalus borealis)* collected in NAFO Div. 3LNO during autumn Canadian research surveys during 1995 - 2002. The data were taken from strata <784 so that all years would be comparable. Length frequencies determined by stratified areal expansion methods.

Length in mm	Autumn 95 WT 176 - 179 WT 181, Tel 22 & Tel 23	Autumn 96 WT 196 - 198, Tel 41	Autumn 97 WT 213-217 Tel 57 & 58	Autumn 98 WT 230 - 233 Tel 75 & 76	Autumn 99 WT 246 - 248	Autumn 2000 WT 321 - 323 Tel 339, 342 & 343	Autumn 2001 WT 373 - 376 AN 399, Tel 357, 358 & 361	Autumn 2002 WT 428 - 431 Tel 412, 413 & 415	Autumn 2003 WT 485 - 489, 511, 515 Tel 469, 509, 510, 513 Tel 514
3.0									
3.5									0
4.0									8
4.5									813
5.0									0
5.5	0	0	855	0	0	0	0	0	10,150
6.0	0	0	0	0	0	0	0	0	0
6.5	0	111	0	0	0	0	0	0	0
7.0	382	55	0	47	1,276	0	0	0	20,300
7.5	4,492	548	3,341	71	4,290	18,215	14,074	0	12,514
8.0	270	2,178	1,542	804	5,582	5,696	4,993	13,271	81,705
8.5	4,848	6,509	6,875	60,601	20,487	91,357	34,666	47,774	161,193
9.0	27,395	9,910	21,185	162,470	15,644	150,098	111,553	162,999	189,001
9.5	62,014	31,303	62,256	329,427	30,214	229,876	199,461	217,316	237,052
10.0	134,066	36,438	68,030	640,705	65,922	421,556	119,091	430,628	321,830
10.5	165,074	27,124	104,909	803,347	78,823	432,442	92,017	318,584	384,298
11.0	204,882	28,566	97,314	688,029	76,732	304,061	45,002	142,390	264,996
11.5	125,333	47,621	71,023	467,599	75,651	176,027	39,355	81,501	115,318
12.0	75,757	76,101	40,746	172,256	34,346	93,780	70,499	171,780	96,170
12.5	33,682	86,904	34,673	121,814	48,364	128,345	156,348	244,495	113,147
13.0	22,484	99,708	27,764	63,981	71,854	343,253	365,679	474,890	311,908
13.5	24,914	127,367	38,460	92,604	134,311	788,552	656,012	896,804	274,265
14.0	20,856	235,167	77,113	135,430	242,200	1,201,742	1,054,379	1,100,277	441,893
14.5	16,247	368,703	191,153	270,428	396,076	1,705,726	1,843,186	1,371,170	762,060
15.0	23,272	619,513	403,670	443,520	780,197	1,754,548	2,366,129	958,101	1,113,723
15.5	32,890	727,877	633,475	471,543	1,222,507	1,688,485	2,094,576	1,021,447	1,317,216
16.0	44,575	652,349	743,964	459,915	1,326,686	1,327,051	1,990,297	1,404,120	1,205,483
16.5	38,401	445,760	496,225	415,527	966,914	1,398,609	3,019,319	2,690,245	1,151,647
17.0	41,682	280,750	472,840	436,950	492,181	1,908,443	3,205,491	3,877,847	1,266,191
17.5	29,305	184,004	476,973	579,364	306,399	2,901,654	3,432,891	3,356,620	1,712,095
18.0	16,164	210,944	576,167	842,287	346,026	3,400,956	3,480,415	3,476,615	2,083,435
18.5	12,839	212,870	790,144	997,213	468,133	2,259,814	4,221,574	3,745,035	2,416,476
19.0	21,104	256,541	720,103	1,061,021	485,986	1,617,071	4,714,143	2,986,152	3,004,615
19.5	16,056	251,255	656,060	975,338	490,523	1,031,449	4,700,334	3,035,047	3,525,506
20.0	16,756	150,181	380,955	875,327	519,131	694,549	3,740,211	2,903,310	3,525,366
20.5	13,294	80,541	255,787	733,217	512,787	555,935	2,168,914	2,275,945	3,489,030
21.0	10,476	77,822	116,219	500,967	493,872	398,602	1,128,505	1,340,849	2,501,256
21.5	8,238	38,332	62,912	345,670	331,419	404,183	490,010	684,487	1,667,334
22.0	4,862	33,114	15,121	130,505	193,324	211,379	142,675	287,333	828,173
22.5	2,547	26,946	8,466	27,672	120,117	101,683	48,402	32,933	422,669
23.0	1,248	17,019	592	15,252	34,878	56,800	48,110	5,542	161,747
23.5	248	10,842	416	1,236	25,468	12,853	14,026	32	51,557
24.0	104	3,428	69	23	3,528	4,857	54	0	1,733
24.5	54	1,427	0	0	1,820	20	15	0	53
25.0	54	0	0	0	0	0	0	32	0
Total (000's)	1,256,864	5,465,828	7,657,395	13,322,160	10,423,664	27,819,667	45,812,405	39,755,566	35,198,556
Upper 95% limit	2,386,779	9,122,011	10,393,910	17,507,324	13,237,807	33,599,699	68,184,931	54,588,882	45,832,224
Lower 95% limit	126,949	1,809,644	4,920,880	9,136,997	7,609,522	22,039,635	23,439,879	24,922,251	24,564,888

Table 18 Abundance (000's) of transitional northern shrimp (*Pandalus borealis)* collected in NAFO Div. 3LNO during autumn Canadian research surveys during 1995 - 2002. The data were taken from strata <784 so that all years would be comparable.

Length in mm	Autumn 95 WT 176 - 179 WT 181, Tel 22 & Tel 23	Autumn 96 WT 196 - 198, Tel 41	Autumn 97 WT 213-217 Tel 57 & 58	Autumn 98 WT 230 - 233 Tel 75 & 76	Autumn 99 WT 246 - 248	Autumn 2000 WT 321 - 323 Tel 339, 342 & 343	Autumn 2001 WT 373 - 376 AN 399, Tel 357, 358 & 361	Autumn 2002 WT 428 - 431 Tel 412, 413 & 415	Autumn 2003 WT 485 - 489, 511, 515 Tel 469, 509, 510, 513 Tel 514
9.5	0	0	0	0	0	0	0	0	0
10.0	0	0	0	0	0	0	0	0	0
10.5	0	0	0	0	0	0	0	0	0
11.0	0	0	0	0	0	0	0	0	0
11.5	0	0	0	0	0	0	0	0	0
12.0	0	0	0	0	638	0	0	0	0
12.5	959	0	0	0	0	0	0	0	0
13.0	0	0	0	0	0	0	0	0	0
13.5	3,989	0	0	0	0	0	0	0	0
14.0	15,348	0	0	0	0	0	0	0	0
14.5	9,708	0	0	0	0	0	0	0	0
15.0	48,864	0	0	0	0	0	0	0	0
15.5	126,767	0	0	0	0	0	0	0	954
16.0	116,811	0	245	0	0	0	0	0	0
16.5	92,772	2,574	71	0	0	0	0	0	0
17.0	63,648	58	4,611	0	0	0	0	0	0
17.5	43,865	5,883	593	47	0	26	0	25,879	0
18.0	16,738	3,738	13,738	0	184	35,572	3,223	0	0
18.5	13,954	7,247	32,009	9,680	3,945	62,928	4,445	7,301	10,150
19.0	16,792	13,926	68,940	9,390	16,718	96,459	54,568	13,719	20,408
19.5	18,622	22,211	193,204	47,758	35,375	94,795	136,497	183,043	26,858
20.0	19,354	30,842	221,376	55,099	70,631	248,462	273,335	279,563	57,878
20.5	17,089	26,876	382,406	86,637	139,780	220,411	289,877	208,057	111,563
21.0	16,499	9,931	407,291	104,502	267,540	326,132	250,074	282,056	180,652
21.5	20,577	19,652	360,800	79,428	374,626	275,908	160,120	141,035	162,488
22.0	22,242	6,808	201,701	45,695	317,088	172,006	86,509	153,467	117,937
22.5	17,315	8,842	107,364	20,662	211,040	178,600	12,625	14,583	64,646
23.0	13,263	430	55,497	4,126	87,859	111,377	4,240	11	43,446
23.5	8,503	41	25,610	0	46,931	26,702	9,245	0	41,242
24.0	2,988	42	6,821	0	44,066	9,989	0	22	15,309
24.5	3,041	16	4,102	11	3,151	6,221	0	0	3,982
25.0	432	7	40	0	0	1,707	0	0	2,797
25.5	129	0	23	0	0	0	0	0	0
26.0	10	0	0	0	0	0	0	0	14
26.5	0	0	0	0	0	0	0	0	0
27.0	10	0	0	0	0	0	0	0	0
27.5	60	0	0	0	0	0	0	0	0
28.0	0	0	0	0	0	0	0	0	9
Total (000's)	730,345	159,123	2,086,440	463,035	1,619,572	1,867,295	1,284,757	1,308,734	860,331
Upper 95% limit	1,088,041	434,880	3,539,739	651,862	2,170,017	3,039,382	1,837,752	2,490,132	1,327,001
Lower 95% limit	372,650	-116,634	633,141	274,208	1,069,127	695,208	731,762	127,336	393,661

Table 19 Abundance (000's) of multiparous + ovigerous northern shrimp (*Pandalus borealis)* collected in NAFO Div. 3LNO during autumn Canadian research surveys during 1995 - 2002. The data were taken from strata <784 so that all years would be comparable.

Length in mm	Autumn 95 WT 176 - 179 WT 181, Tel 22 & Tel 23	Autumn 96 WT 196 - 198, Tel 41	Autumn 97 WT 213-217 Tel 57 & 58	Autumn 98 WT 230 - 233 Tel 75 & 76	Autumn 99 WT 246 - 248	Autumn 2000 WT 321 - 323 Tel 339, 342 & 343	Autumn 2001 WT 373 - 376 AN 399, Tel 357, 358 & 361	Autumn 2002 WT 428 - 431 Tel 412, 413 & 415	Autumn 2003 85 - 489, 511, 515 469, 509, 510, 513 Tel 514
12.0	0	0	0	0	0	0	3,421	0	0
12.5	0	58	0	0	0	0	0	0	0
13.0	0	0	0	0	0	0	0	0	0
13.5	0	0	0	0	1,792	0	0	0	10,150
14.0	0	0	523	0	0	0	0	0	16,517
14.5	0	289	0	0	0	0	0	0	0
15.0	755	457	0	0	0	0	0	0	11,644
15.5	0	58	0	406	0	0	0	0	786
16.0	0	231	3,135	4,834	0	0	2,616	0	0
16.5	0	231	1,305	4,760	3,918	9,912	19,479	6,342	4,278
17.0	0	0	1,317	7,548	8,841	56	38,682	7,167	10,298
17.5	0	1,662	2,673	6,860	7,583	3,125	30,676	24,254	24,099
18.0	298	284	1,370	9,586	7,744	17,122	13,825	26,845	98,469
18.5	0	1,023	3,401	1,833	6,374	7,538	39,320	1,728	127,251
19.0	724	6,087	3,195	1,069	14,008	9,610	27,101	35,774	163,768
19.5	506	6	4,004	5,013	4,277	11,738	61,304	96,264	140,033
20.0	438	391	7,986	9,164	10,157	5,495	75,227	316,121	160,471
20.5	60	847	8,832	24,229	7,455	27,118	120,651	676,823	426,913
21.0	746	1,190	21,861	55,240	17,745	58,720	431,617	1,369,431	769,918
21.5	2,290	4,362	48,246	115,863	39,186	118,559	524,140	1,475,710	1,289,165
22.0	2,766	4,119	66,829	186,364	79,099	153,368	807,568	1,230,444	1,466,122
22.5	4,067	14,577	83,857	251,298	103,443	293,286	957,566	887,953	1,774,866
23.0	6,211	24,802	95,627	248,676	150,063	290,711	909,836	761,183	1,391,935
23.5	6,281	25,728	99,927	188,663	149,734	395,290	777,056	632,914	1,088,439
24.0	8,159	20,280	78,887	161,696	153,122	406,877	717,568	595,282	663,734
24.5	12,241	30,367	82,838	98,121	84,113	285,001	559,677	415,733	458,201
25.0	8,434	30,943	72,359	66,753	75,424	186,106	455,051	210,292	424,877
25.5	9,094	23,848	40,667	42,105	43,163	91,892	192,569	171,418	225,504
26.0	7,674	17,710	23,821	20,125	23,975	41,133	107,162	106,152	76,553
26.5	6,583	11,484	5,331	10,911	11,335	37,121	43,124	83,363	113,581
27.0	4,562	6,745	5,910	10,571	7,471	5,231	37,794	27,720	20,742
27.5	2,347	3,847	10,963	3,796	4,668	5,885	17,942	24,808	11,302
28.0	2,569	2,376	2,270	5,916	3,070	1,994	5,520	3,488	17,261
28.5	827	2,815	1,759	1,823	674	226	878	450	25
29.0	374	2,198	1,650	309	1,300	79	229	3,555	2,181
29.5	670	1,635	356	0	197	2,262	54	100	8
30.0	79	1,227	238	17	67	0	54	18	5,903
30.5	50	1,138	110	20	79	0	0	0	0
31.0	0	110	106	0	0	869	0	0	0
31.5	0	135	0	20	14	0	0	0	0
32.0	0	0	0	0	0	0	0	0	
Total (000's)	88,805	243,314	781,349	1,543,586	1,020,090	2,466,323	6,977,708	9,191,329	10,994,993
Upper 95% limit	437,945	538,855	1,558,469	2,196,382	1,526,132	3,772,757	11,770,822	13,820,674	21,026,176
Lower 95% limit	-260,335	-52,227	4,230	890,789	514,049	1,159,889	2,184,595	4,561,984	963,811

Table 20. Modal analysis using Mix 3.01 (MacDonald and Pitcher, 1993) of *P. borealis* in Div. 3LNO, from spring Canadian multi-species bottom trawl surveys.

Mean Carapace Length (Standard Error)

	Age				
Year	1	2	3	4	5
1999		14.57 (.0006)	18.13 (.0016)	20.44 (.0014)	
2000	8.74 (0.001)	14.20 (0.009)	17.91(.007)	20.61(.0024)	
2001		13.42 (.0008)	16.83 (.0014)	19.10 (.0008)	
2002		12.65 (.0007)	16.62 (.0009)	18.97 (.0007)	
2003	Not determined - problem with length frequency file				
2004		13.52 (.0022)	18.07 (.0220)	19.92 (.0038)	
2005		13.83 (.0012)	17.15 (.0014)	19.58 (.0014)	

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

	Age					
Year	1	2	3	4	5	Total
1999		.45 (.0006)	.15 (.0004)	.40 (.0004)		1.000
2000	.02(.0000)	.38 (.0001)	.43 (.0003)	.16 (.0003)		0.990
2001		.21 (.0001)	.29 (.0003)	.50 (0.0003)		1.000
2002		.10 (.0001)	.32 (.0002)	.58 (.0003)		1.000
2003	Not determined - problem with length frequency file					
2004		.12 (.0002)	.36 (.0057)	.52 (.0055)		1.000
2005		.14 (.0001)	.44 (.0004)	.42 (.0004)		1.000

Distributional Sigmas (Standard Error and constraints)

	Age				
Year	1	2	3	4	5
1999		1.03 (.0005)	0.68 (.001)	1.03 (.0009)	
2000	0.72(.001)	1.30(.0007)	.87(.0007)	1.10(.0013)	
2001		1.12 (0.0004) (EQ sigmas)	1.12 (0.0004) (EQ sigmas)	1.12 (0.0004) (EQ sigmas)	
2002		.85 (.0002) (CV = .067)	1.12 (.0002) (CV = .067)	1.28 (.0002) (CV = .067)	
2003	Not determined - problem with length frequency file				
2004		1.11 (.0013)	1.44 (.0100)	1.04 (.0021)	
2005		1.03 (.0005) (CV =.075)	1.28 (.0005) (CV = .075)	1.47 (.0005) (CV = .075)	

Population at Age Estimates (10^6)

	Male Ages					Transitionals	Female	Total
Year	0	1	2	3	4			
1999		123	4,349	1,473	3,779	2,339	642	12,705
2000		429	6,451	7,319	2,770	5,389	2,655	25,013
2001		96	4,013	5,538	9,577	3,096	2,673	24,993
2002		459	2,502	8,509	15,309	7,825	2,906	37,510
2003	Not determined - problem with length frequency file							
2004		78	1,907	5,309	7,753	3,424	3,175	21,646
2005		145	2,464	7,639	7,182	1,285	6,978	25,693

Table 21. Modal analysis using Mix 3.01 (MacDonald and Pitcher, 1993) of *P. borealis* in Div. 3LNO, from autumn Canadian multi-species bottom trawl surveys.

Mean Carapace Length (Standard Error)

	Age				
Year	1	2	3	4	5
1995	11.15 (.001)	16.39 (.003)	20.22 (.004)		
1996	11.16 (.002)	15.26 (.000)	18.80 (.002)	21.71 (.006)	
1997	11.03 (.001)	16.16 (.001)	19.03 (.002)	20.51 (.007)	
1998	10.87 (.001)	15.72 (.001)	18.69 (.001)	20.52 (.001)	
1999	11.03 (.001)	16.01 (.000)	19.39 (.002)	21.18 (.002)	
2000	10.51 (.001)	15.19 (.001)	18.12 (.001)	20.35 (.004)	
2001	10.08 (.001)	15.12 (.001)	17.40 (.001)	19.60 (.000)	
2002	10.39 (.001)	14.50 (.001)	17.67 (.000)	20.05 (.000)	
2003	9.84 (.001)	15.05 (.001)	17.69 (.003)	19.83 (.001)	

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

	Age					
Year	1	2	3	4	5	Total
1995	.705 (.000)	.210 (.000)	.085 (.000)			1.000
1996	.068 (.000)	.670 (.000)	.236 (.000)	.026 (.000)		1.000
1997	.068 (.000)	.408 (.000)	.464 (.001)	.059 (.001)		0.999
1998	.262 (.000)	.177 (.000)	.319 (.080)	.242 (.000)		1.000
1999	.045 (.000)	.569 (.000)	.208 (.000)	.178 (.000)		1.000
2000	.069 (.000)	.348 (.000)	.444 (.000)	.139 (.000)		1.000
2001	.015 (.000)	.198 (.000)	.294 (.000)	.493 (.000)		1.000
2002	.037 (.000)	.145 (.000)	.462 (.000)	.355 (.000)		0.999
2003	.055 (.000)	.175 (.000)	.203 (.000)	.567 (.000)		1.000

Distributional Sigmas (Standard Error and constraints)

	Age				
Year	1	2	3	4	5
1995	1.09 (.001 Eq)	1.09 (.001 Eq)	1.09 (.001 Eq)		
1996	1.09 (.001 Eq)	1.09 (.001 Eq)	1.09 (.001 Eq)	1.09 (.001 Eq)	
1997	0.95 (.001 Eq)	0.95 (.001 Eq)	0.95 (.001 Eq)	0.95 (.001 Eq)	
1998	0.93 (.000 Eq)	0.93 (.000 Eq)	0.93 (.000 Eq)	0.93 (.000 Eq)	
1999	1.01 (.000 Eq)	1.01 (.000 Eq)	1.01 (.000 Eq)	1.01 (.000 Eq)	
2000	0.92 (.001)	1.04 (.000)	0.81 (.001)	1.28 (.002)	
2001	1.02 (.000 Eq)	1.02 (.000 Eq)	1.02 (.000 Eq)	1.02 (.000 Eq)	
2002	0.96 (.000 Eq)	0.96 (.000 Eq)	0.96 (.000 Eq)	0.96 (.000 Eq)	
2003	1.17 (.000 Eq)	1.17 (.000 Eq)	1.17 (.000 Eq)	1.17 (.000 Eq)	

Population at Age Estimates (10^6)

	Male Ages					Transitionals	Female	Total
Year	0	1	2	3	4			
1995	0	886	264	107	0	730	89	2,076
1996	0	753	2,953	1,507	253	159	243	5,868
1997	1	495	2,647	3,772	742	2,086	781	10,525
1998	0	3,497	2,353	4,249	3,224	463	1,544	15,329
1999	0	465	5,931	2,168	1,860	1,620	1,020	13,063
2000	0	1,934	8,897	14,691	2,297	1,867	2,466	32,153
2001	0	679	9,082	13,489	22,563	1,285	6,978	54,075
2002	0	1,482	5,774	18,365	14,134	1,309	9,191	50,256
2003	11	1,933	6,149	7,137	19,968	860	10,995	47,054

Table 22. The Proc Genmod analysis to determine whether there were significant annual changes in size at sex transition of *Pandalus borealis* collected during Canadian autumn multi-species surveys over the period 1995-2003.

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	433
Number Of Events	33309.9575
Number Of Trials	123049.0000

Class Level Information

Class	Levels	Values
year	9	1995 1996 1997 1998 1999 2000 2001 2002 2003

Criteria for Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	423	9300.3430	21.9866
Scaled Deviance	423	423.0000	1.0000
Pearson Chi-Square	423	426523.4411	1008.3296
Scaled Pearson X2	423	19399.2217	45.8610
Log Likelihood		-1305.6105	

Algorithm converged. Analysis of Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > Ch
Intercept		1	-25.3378	0.7766	-26.8599	-23.8157	1064.51	<.0
length		1	1.1622	0.0357	1.0922	1.2322	1058.69	<.0
year	1995	1	5.5615	0.2999	4.9737	6.1493	343.92	<.0
year	1996	1	-0.8512	0.2951	-1.4296	-0.2728	8.32	0.0
year	1997	1	0.8871	0.1800	0.5342	1.2399	24.28	<.0
year	1998	1	-0.6662	0.2044	-1.0668	-0.2656	10.62	0.0
year	1999	1	0.0693	0.1977	-0.3182	0.4568	0.12	0.7
year	2000	1	0.3885	0.1973	0.0019	0.7751	3.88	0.0
year	2001	1	-0.2000	0.1859	-0.5643	0.1642	1.16	0.2
year	2002	1	0.2542	0.1686	-0.0762	0.5846	2.27	0.1
year	2003	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale		0	4.6890	0.0000	4.6890	4.6890		

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	95599.4488						
length	19906.3432	1	423	3442.69	<.0001	3442.69	<.0001
year	9300.3430	8	423	60.30	<.0001	482.38	<.0001

Least Squares Means

Effect	year	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq
year	1995	2.5499	0.2350	1	117.76	<.0001
year	1996	-3.8628	0.2848	1	183.98	<.0001
year	1997	-2.1245	0.1406	1	228.21	<.0001
year	1998	-3.6778	0.1916	1	368.33	<.0001
year	1999	-2.9423	0.1776	1	274.40	<.0001
year	2000	-2.6231	0.1687	1	241.85	<.0001
year	2001	-3.2116	0.1606	1	399.68	<.0001
year	2002	-2.7574	0.1370	1	405.17	<.0001
year	2003	-3.0116	0.1450	1	431.64	<.0001

Table 23. NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) exploitation rates based upon the ratios of commercial catch to the previous autumn Canadian multi-species bottom trawl survey indices.

Year	catch (t)	Lower 95% CL of biomass index (t)	spawning stock biomass (SSB) (t)	fishable biomass (t)
1995		3,639	3,805	4,632
1996	171	10,230	3,555	11,402
1997	485	25,530	19,566	38,415
1998	567	40,011	16,794	50,403
1999	795	36,202	22,262	44,891
2000	4,869	93,132	32,517	95,051
2001	10,566	77,563	64,077	197,816
2002	6,977	126,180	76,444	194,335
2003	11,947	106,338	91,967	205,229
2004	12,620			

Year	catch/lower CL biomass	catch/SSB	catch/fishable biomass
1995	0.047	0.045	0.045
1996	0.047	0.136	0.136
1997	0.022	0.029	0.029
1998	0.020	0.047	0.047
1999	0.134	0.219	0.219
2000	0.113	0.325	0.325
2001	0.090	0.109	0.109
2002	0.095	0.156	0.156
2003	0.119	0.137	0.137

Table 24. Estimated bycatch within the large vessel (>500 t) fleet fishing shrimp in 3L over the period 2002 - 2005.

	Atlantic cod				American plaice			
Year	2002	2003	2004	2005	2002	2003	2004	2005
Observed shrimp catch (t)	2,342	4,071	4,060	1,516	2,342	4,071	4,060	1,516
Logbook shrimp catch (t)	2,455	3,956	4,037	3,839	2,455	3,956	4,037	3,839
correction factor	1.0484	1.0000	1.0000	2.5321	1.0484	1.0000	1.0000	2.5321
estimated bycatch (kg)	137	61	85	35	312	605	852	995.0958
Bycatch (kg)/ (t) shrimp	0.06	0.02	0.02	0.01	0.13	0.15	0.21	0.26
Number of fish measured	0	37	25	12	0	251	383	87
	estimated number at age				estimated number at age			
age								
0	0	0	0	0	0	0	0	0
1	0	38	59	43	0	70	318	25
2	0	61	80	28	0	961	1,971	831
3	0	6	4	3	0	1,182	2,166	1,540
4	0	1	1	3	0	3,002	4,282	4,644
5	0	0	0	0	0	2,073	2,698	3,682
6	0	0	0	0	0	243	428	370
7	0	0	0	0	0	39	59	35
8	0	0	0	0	0	23	29	28
9	0	0	0	0	0	2	9	0
10	0	0	0	0	0	2	0	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
total	0	106	144	76	0	7,597	11,960	11,154

	redfish				Greenland halibut			
Year	2002	2003	2004	2005	2002	2003	2004	2005
Observed shrimp catch (t)	2,342	4,071	4,060	1,516	2,342	4,071	4,060	1,516
Logbook shrimp catch (t)	2,455	3,956	4,037	3,839	2,455	3,956	4,037	3,839
correction factor	1.0484	1.0000	1.0000	2.5321	1.0484	1.0000	1.0000	2.5321
estimated bycatch (kg)	993	2148	2321	1970	5818	6708	7353	3036
Bycatch (kg)/ (t) shrimp	0.40	0.54	0.57	0.51	2.43	1.65	1.82	0.79
Number of fish measured	0	217	312	383	2732	1995	4014	603
	estimated number at age				estimated number at age			
age								
0	0	0	0	0	3,793	2,561	2,014	1,223
1	0	0	0	0	4,256	13,698	32,607	15,717
2	0	914	538	2,221	23,689	27,036	34,473	26,071
3	0	7,420	3,398	9,718	12,638	13,274	8,406	6,039
4	0	27,107	19,651	25,453	7,051	5,639	4,205	1,517
5	0	15,211	16,128	8,913	830	1,327	242	314
6	0	4,808	10,482	6,510	140	73	2	8
7	0	1,217	2,443	4,776	12	21	0	0
8	0	777	368	2,241	0	2	0	0
9	0	247	18	511	0	0	0	0
10	0	26	0	41	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
total	0	57,727	53,026	60,383	52,410	63,631	81,949	50,888

Table 25 Estimated bycatch within the small vessel (<=500 t; LOA <100') fleet fishing shrimp in 3L over the period 2002 - 2005.

	Atlantic cod				American plaice			
Year	2002	2003	2004	2005	2002	2003	2004	2005
Observed shrimp catch (t)	175	248	318	56	175	248	318	56
Logbook shrimp catch (t)	2,959	6,549	6,576	7,147	2,959	6,549	6,576	7,147
correction factor	16.95	26.36	20.65	128.09	16.95	26.36	20.65	128.09
estimated bycatch (kg)	153	975	186	0	559	4,375	2,313	2,818
Bycatch (kg)/ (t) shrimp	0.05	0.15	0.03	0	0.19	0.67	0.35	0.39
Number of fish measured	0	48	2	0	0	0	35	0
	estimated number at age				estimated number at age			
age								
0	0	132	351	0	0	0	0	
1	0	1,845	41	0	0	0	21	
2	0	659	0	0	0	0	475	
3	0	26	0	0	0	0	2,974	
4	0	0	0	0	0	0	6,360	
5	0	0	0	0	0	0	4,832	
6	0	0	0	0	0	0	1,074	
7	0	0	0	0	0	0	496	
8	0	0	0	0	0	0	186	
9	0	0	0	0	0	0	41	
10	0	0	0	0	0	0	21	
11	0	0	0	0	0	0	0	
12	0	0	0	0	0	0	0	
13	0	0	0	0	0	0	0	
14	0	0	0	0	0	0	0	
15	0	0	0	0	0	0	0	
16	0	0	0	0	0	0	0	
total	0	2,662	392	0	0	0	16,479	

	redfish				Greenland halibut			
Year	2002	2003	2004	2005	2002	2003	2004	2005
Observed shrimp catch (t)	175	248	318	56	175	248	318	56
Logbook shrimp catch (t)	2,959	6,549	6,576	7,147	2,959	6,549	6,576	7,147
correction factor	16.95	26.36	20.65	128.09	16.95	26.36	20.65	128.09
estimated bycatch (kg)	1,305	10,570	5,183	4611.3809	2,898	18,793	5,575	3,459
Bycatch (kg)/ (t) shrimp	0.44	1.61	0.79	0.65	0.98	2.87	0.85	0.48
Number of fish measured	0	311	580	0	0	616	277	0
	estimated number at age				estimated number at age			
age								
0	0	0	0	0	0	9,569	3,283	0
1	0	14,129	2,024	0	0	60,654	38,512	0
2	0	50,532	32,214	0	0	78,447	11,358	0
3	0	78,948	46,339	0	0	36,719	8,818	0
4	0	174,820	52,947	0	0	10,597	4,626	0
5	0	32,818	10,697	0	0	343	620	0
6	0	12,073	5,204	0	0	0	21	0
7	0	1,924	909	0	0	0	0	0
8	0	158	62	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0
total	0	365,402	150,394	0	0	196,329	67,236	0

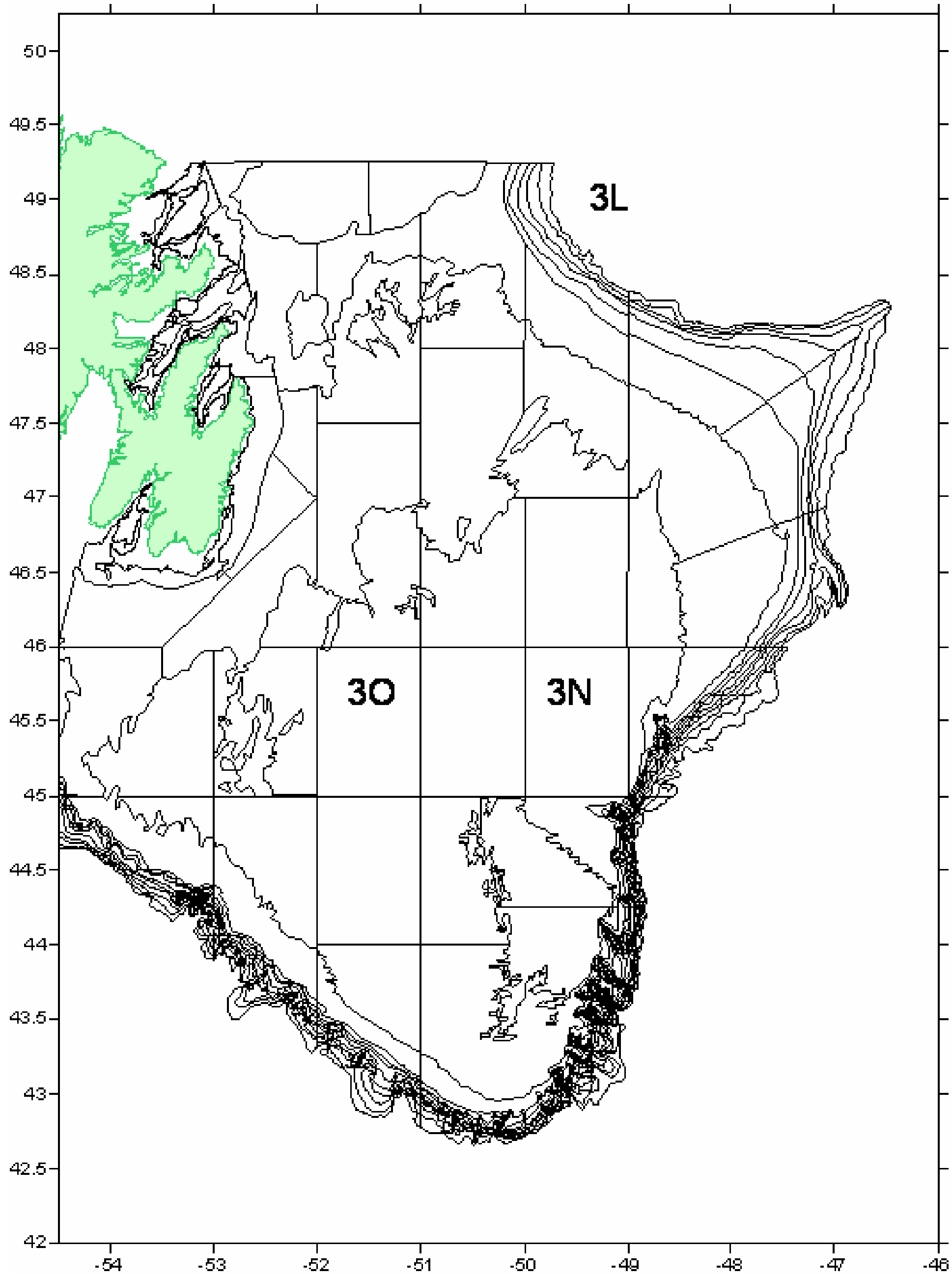

Fig. 1. The NAFO Div. 3LNO stratification scheme used in Canadian research bottom trawl survey set allocation.

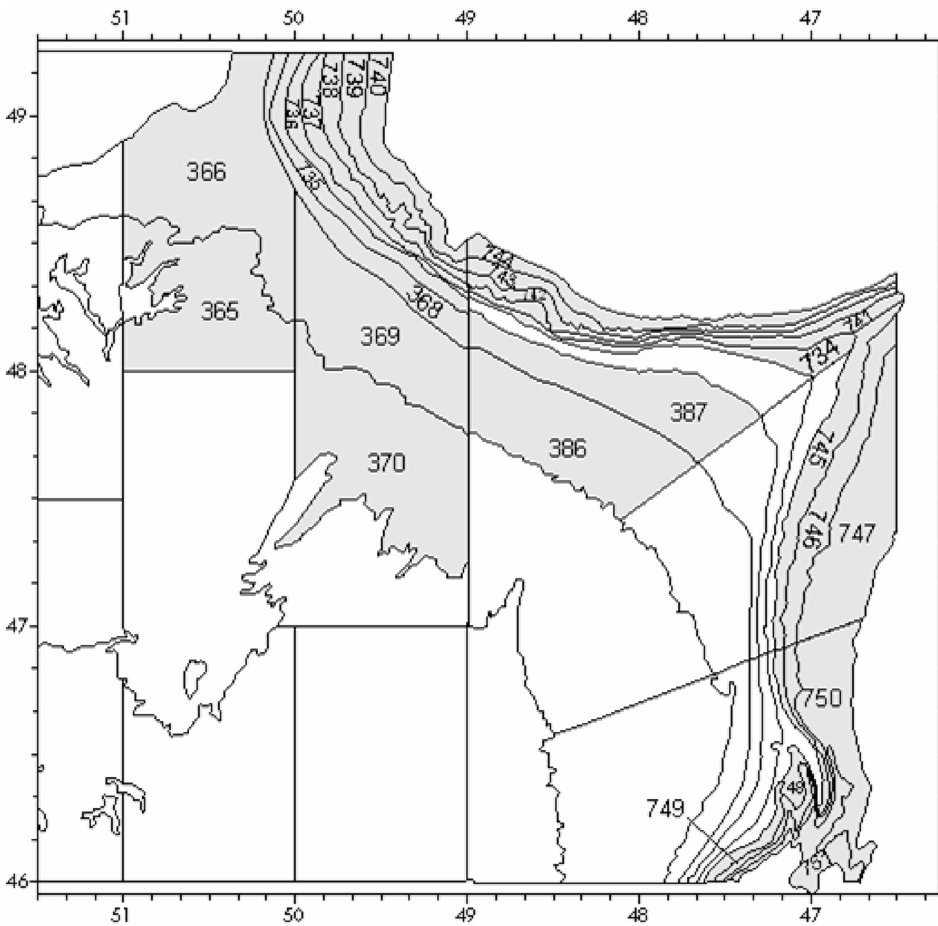

Fig. 2. Strata in Div. 3L that were not surveyed (numbered and shaded area) during autumn 0f 2004.

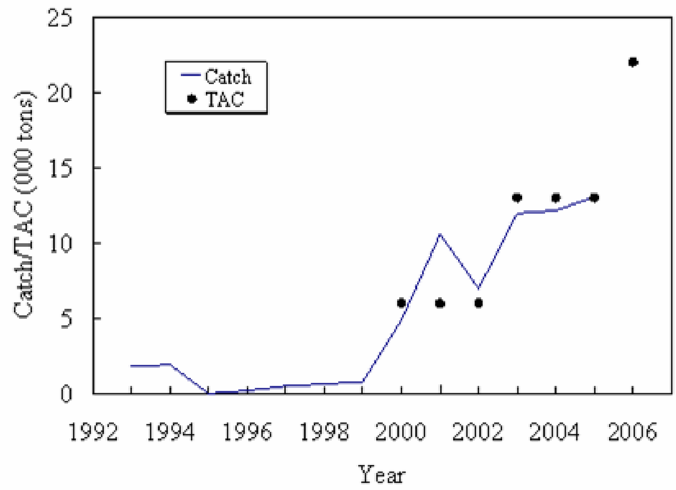

Fig. 3. Trends in the NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) catch and TAC over the period 1993-2005.

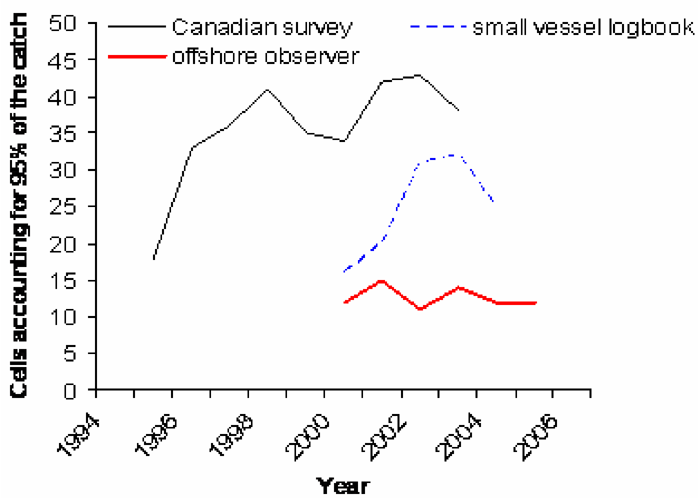

Fig. 4. The number of cells required to account for 95% of the Div. 3LNO autumn Canadian research survey and commercial shrimp catches over time

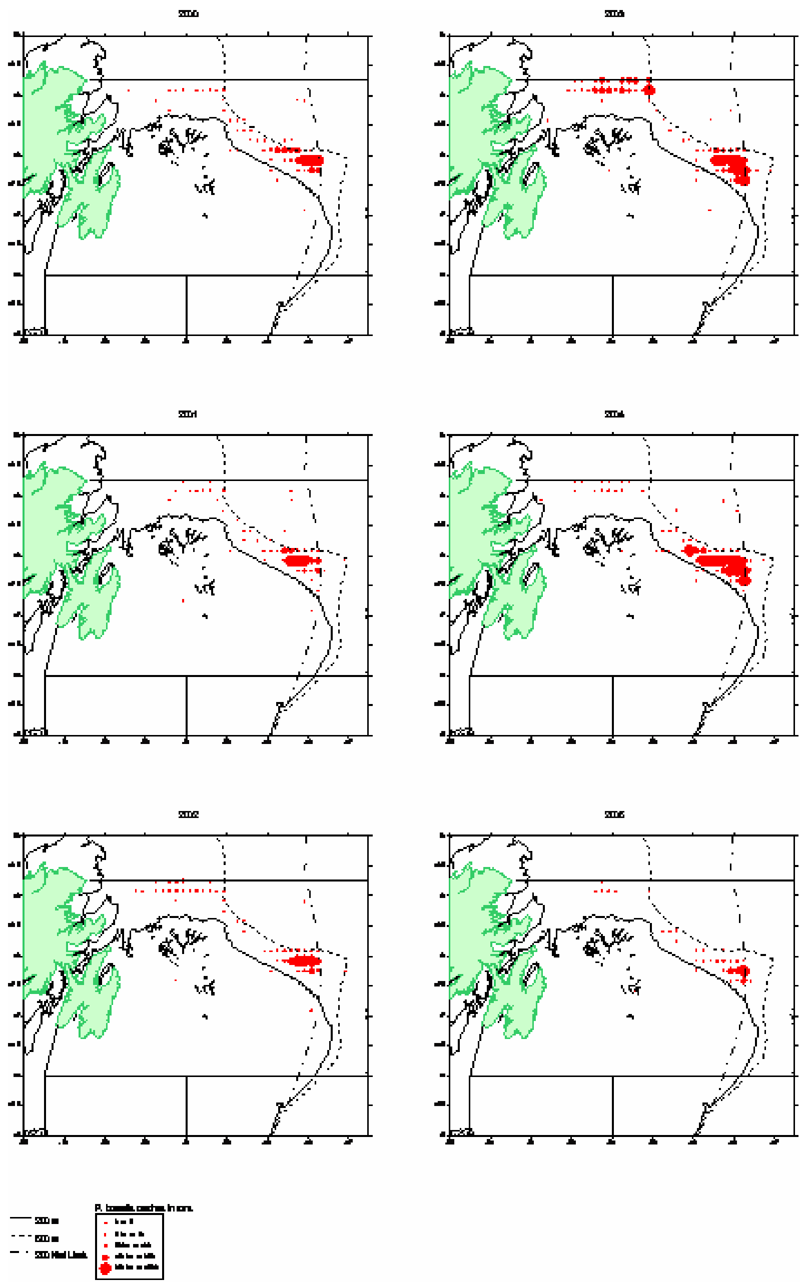

Fig. 5. Distribution of small vessel (<=500 t; <65') shrimp catches in NAFO Div. 3L, 2000-2005. (Logbook data aggregated into 10 min X 10 min cells).

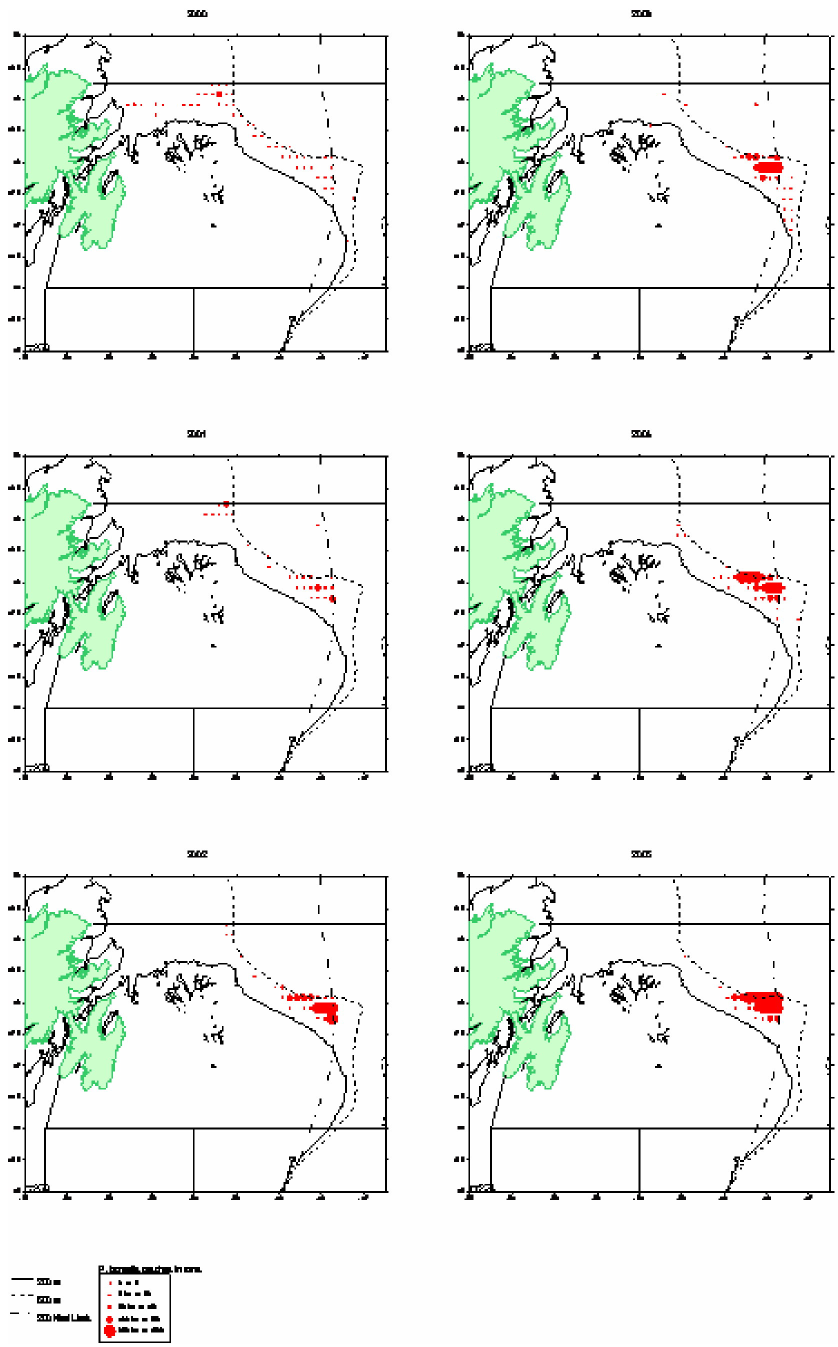

Fig. 6. Distribution of large vessel (>500 t) shrimp catches in NAFO Div. 3L, 2000-2005. (Observer data aggregated into 10 min X 10 min cells).

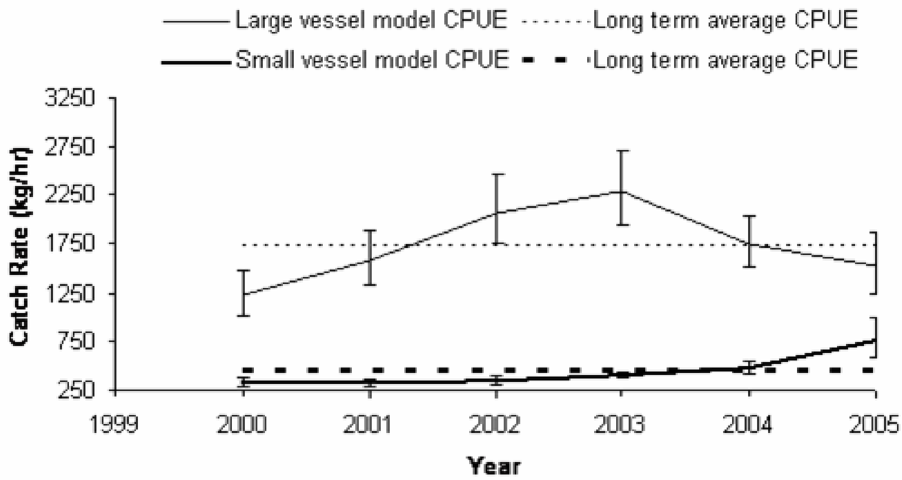

Fig. 7. Model catch rates for Canadian large (>500 t) and small (<= 500 t; <65') vessels fishing for shrimp in NAFO Div. 3L, 2000-2005).

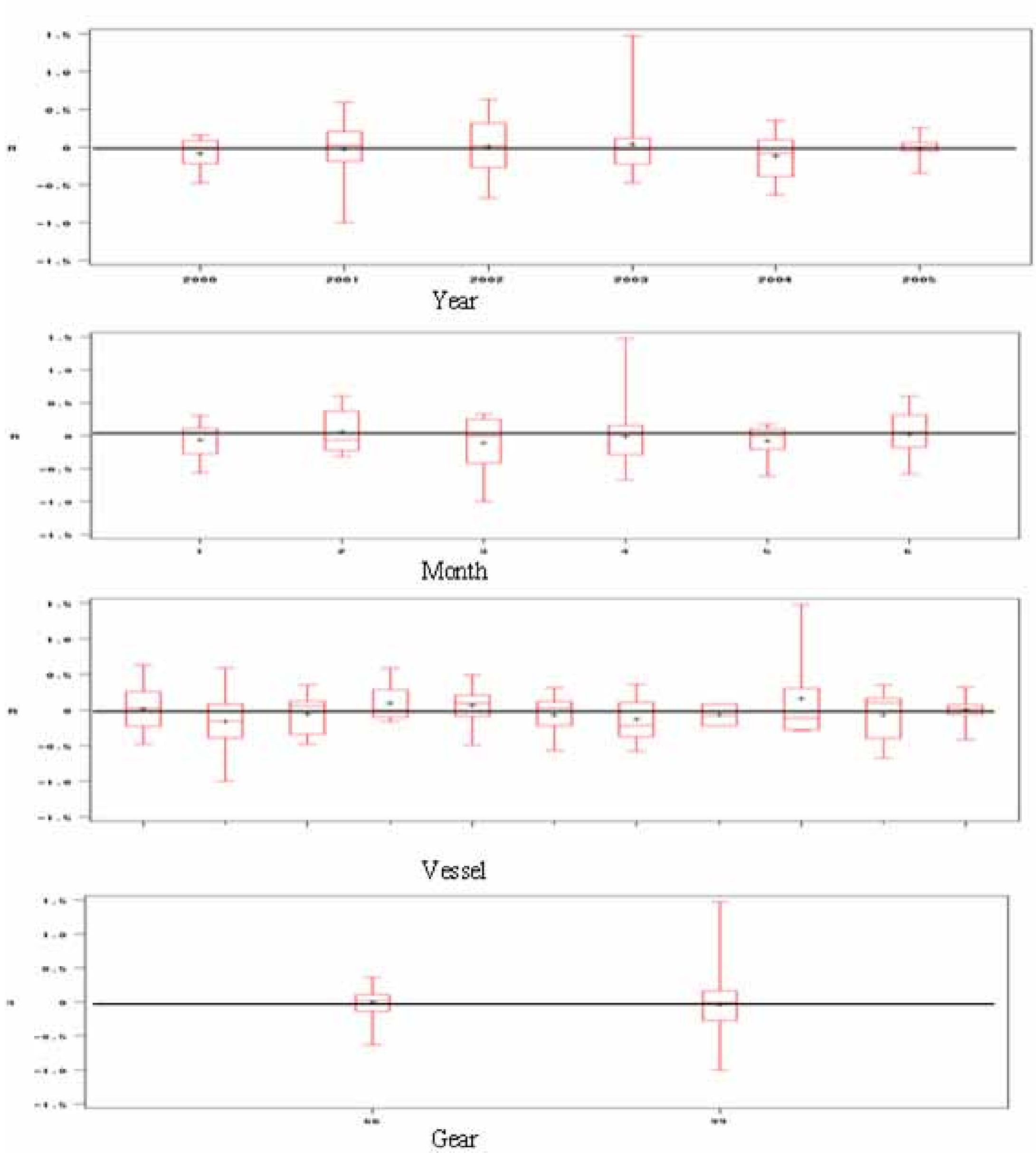

Fig. 8. The distribution of residuals around estimated values for various parameters used in the catch rate model for large Canadian (>500 t) vessels fishing shrimp in NAFO Div. 3L over the period 2000-2005.

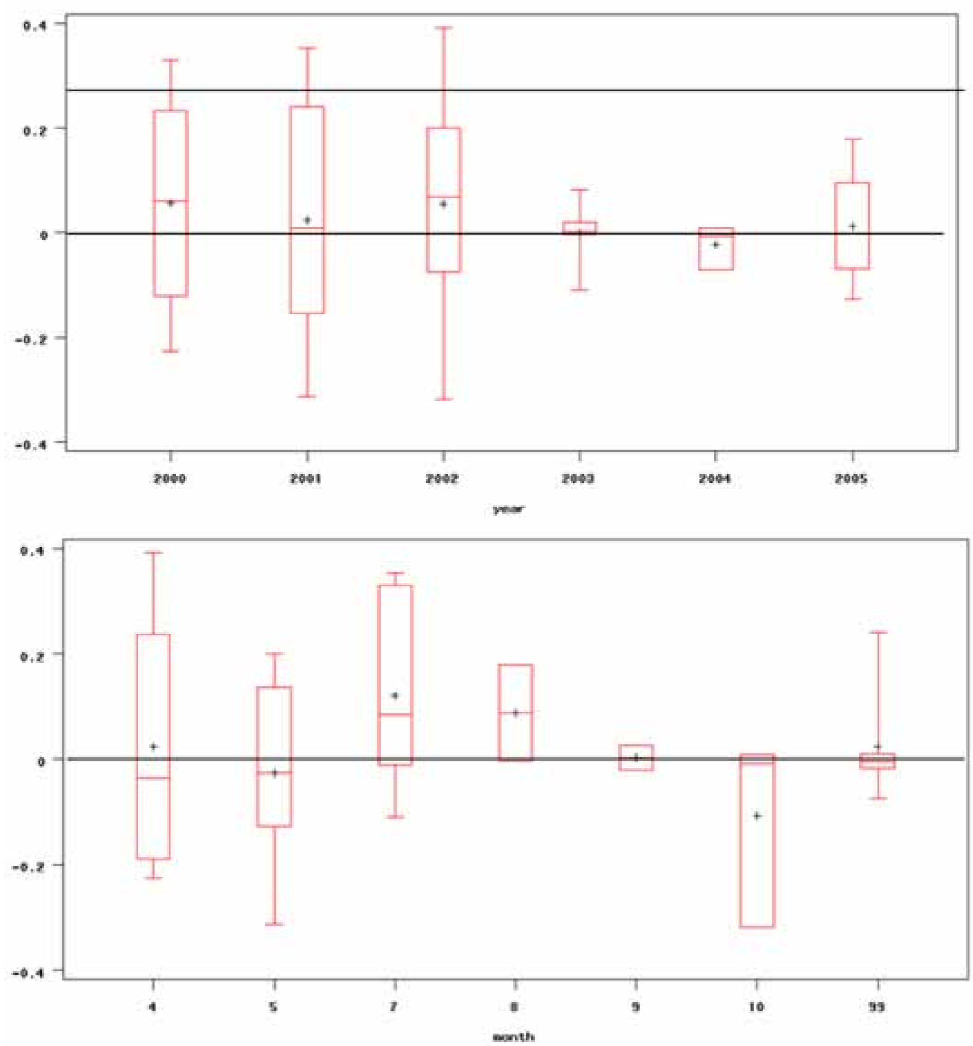

Fig. 9. The distribution of residuals around estimated values for various parameters used in the catch rate model for large Canadian (>500 t) vessels fishing shrimp in NAFO Div. 3L over the period 2000-2005.

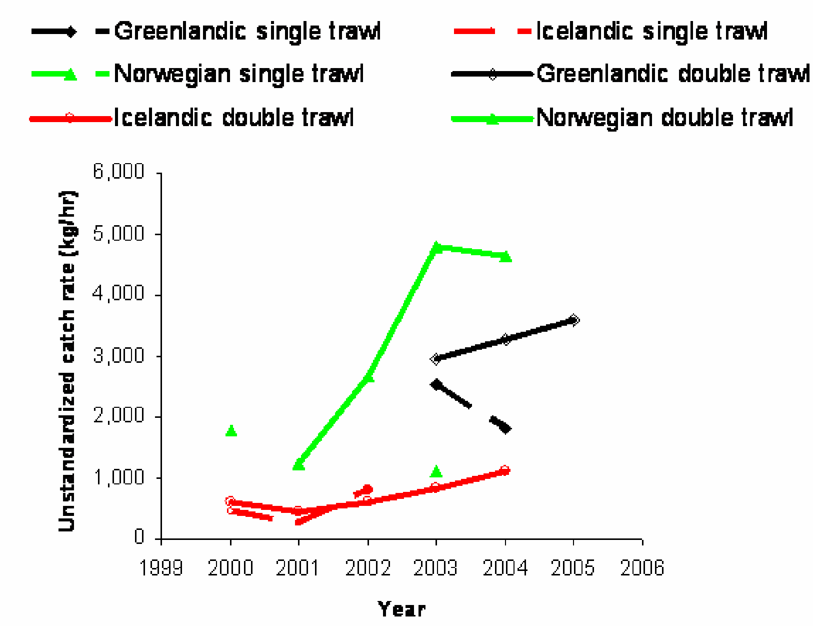

Fig. 10. Unstandardized catch rates by international fleets fishing northern shrimp in the NAFO Div. 3L NRA over the period 2000-2004.

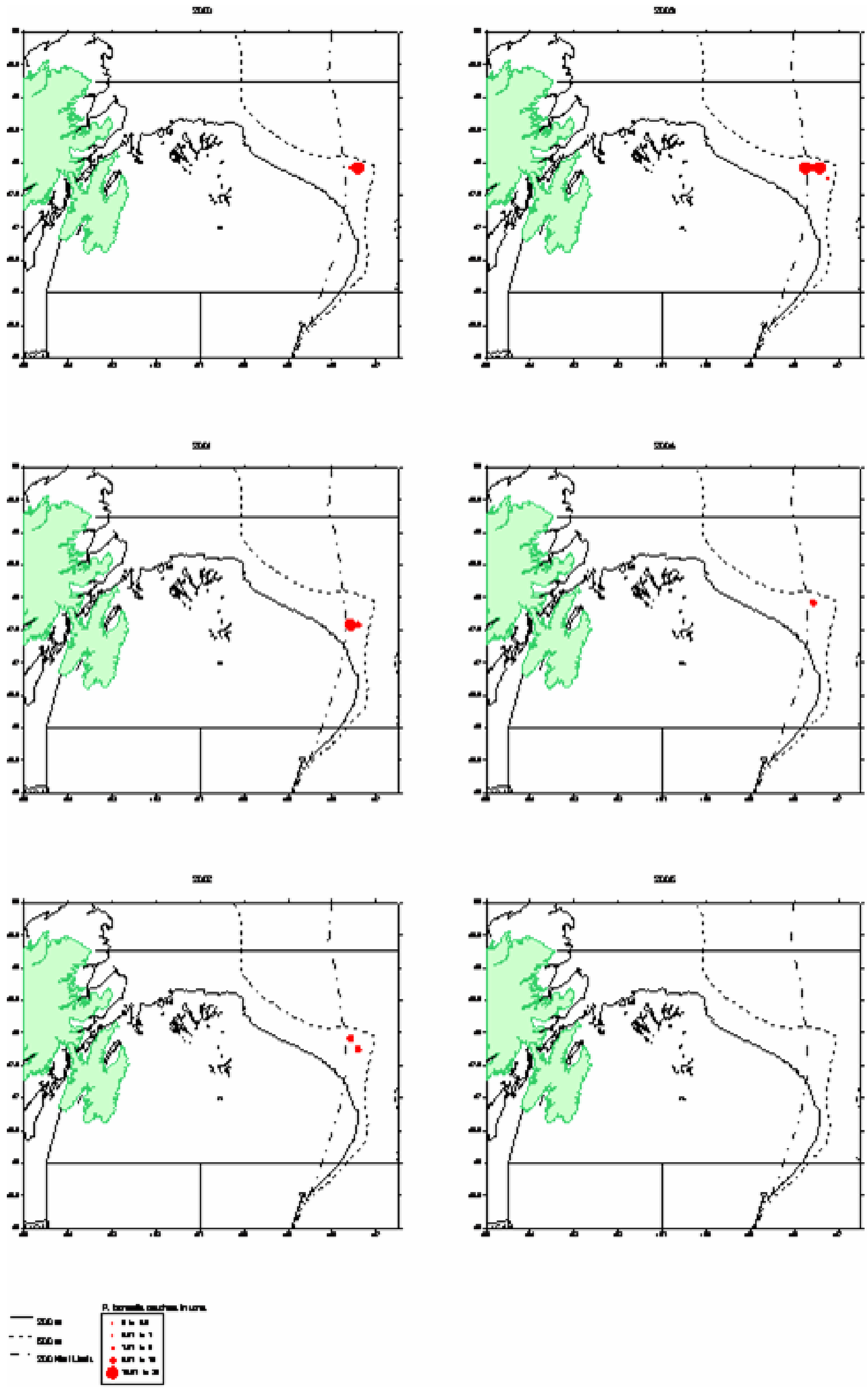

Fig. 11. Distribution of Norwegian NAFO Div. 3L shrimp catches, 2000-2005. (Observer data aggregated into 10 min. X 10 min. squares).

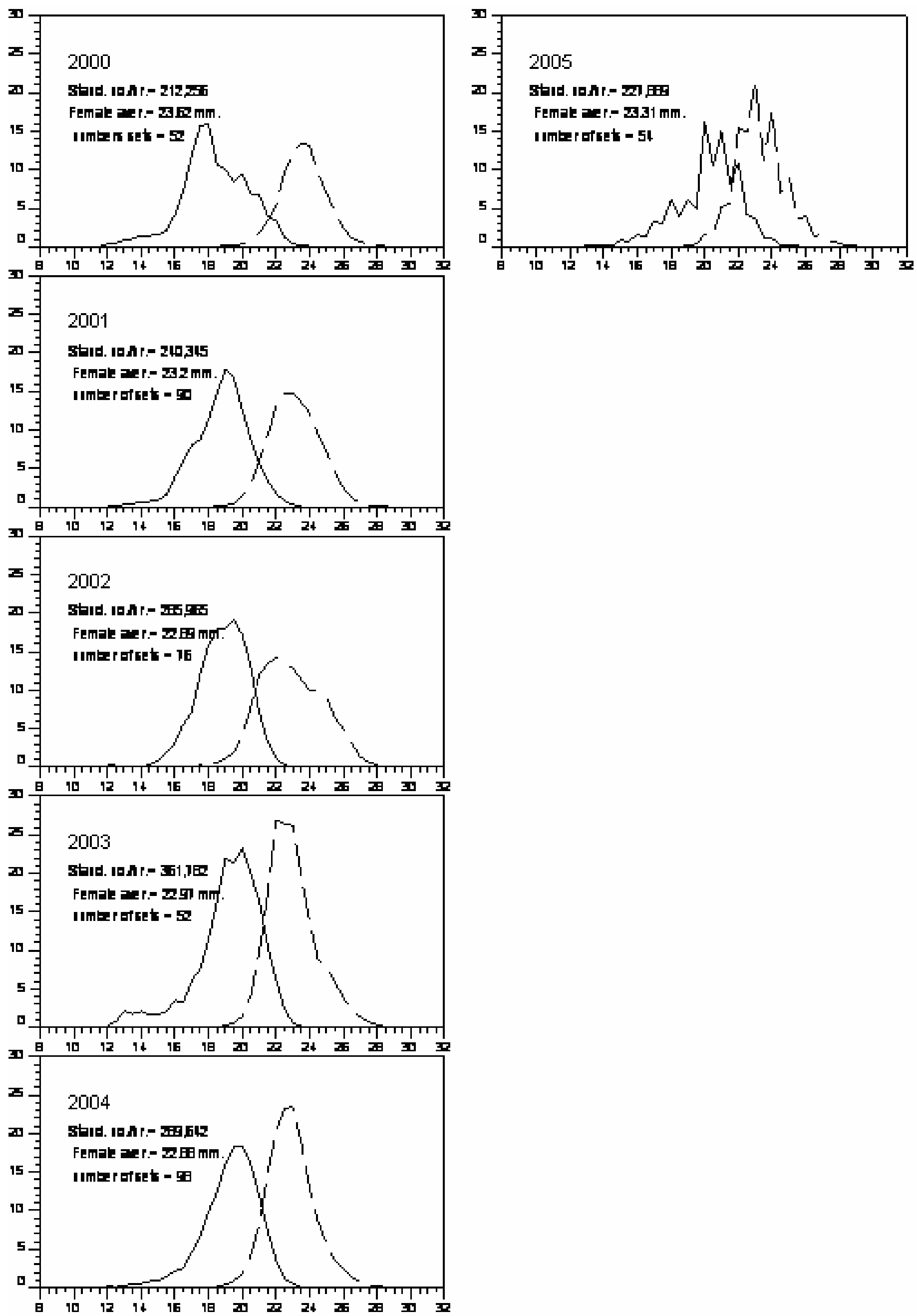

Fig. 12. Observed northern shrimp length frequencies from the large Canadian vessel (>500 t) fleet fishing shrimp in NAFO Division 3L over the period 2000-2005.

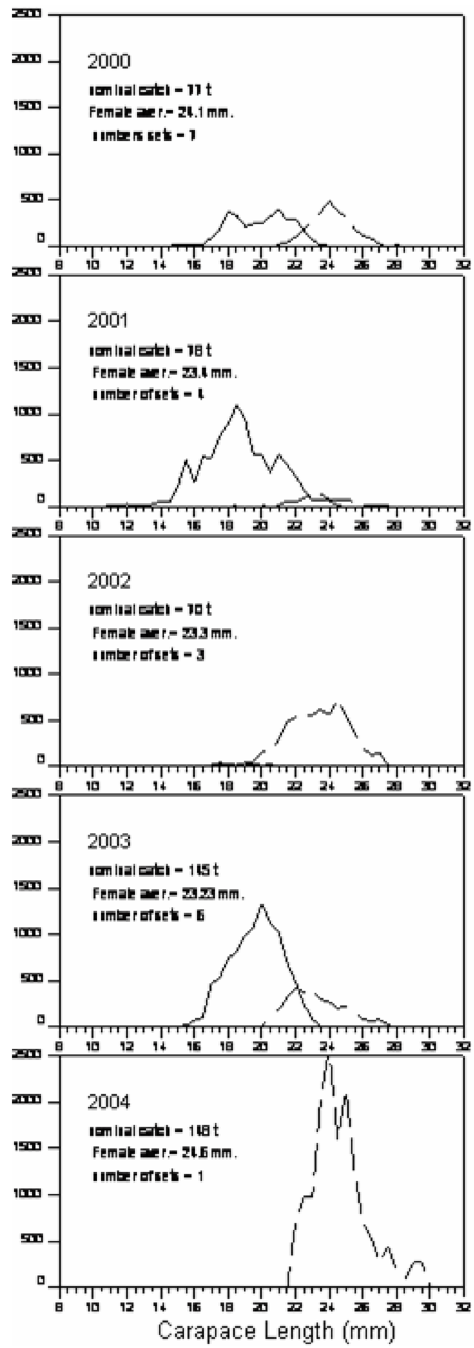

Fig. 13. Observed northern shrimp length frequencies from the Norwegian fleet fishing shrimp in NAFO Div. 3L over the period 2000-2004.

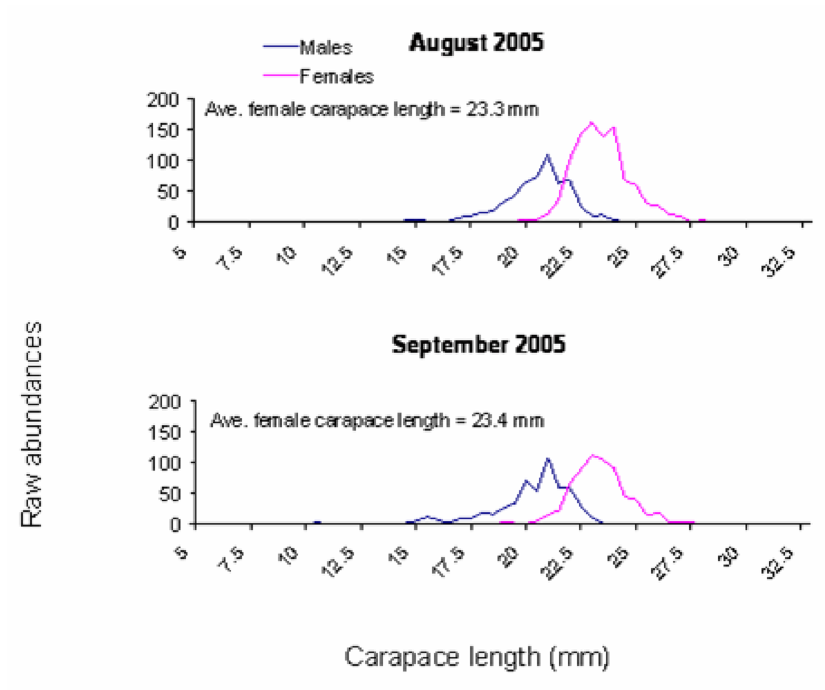

Fig. 14. Observed northern shrimp length frequencies from the Icelandic fleet fishing shrimp in NAFO Div. 3L over the period 2000-2004.

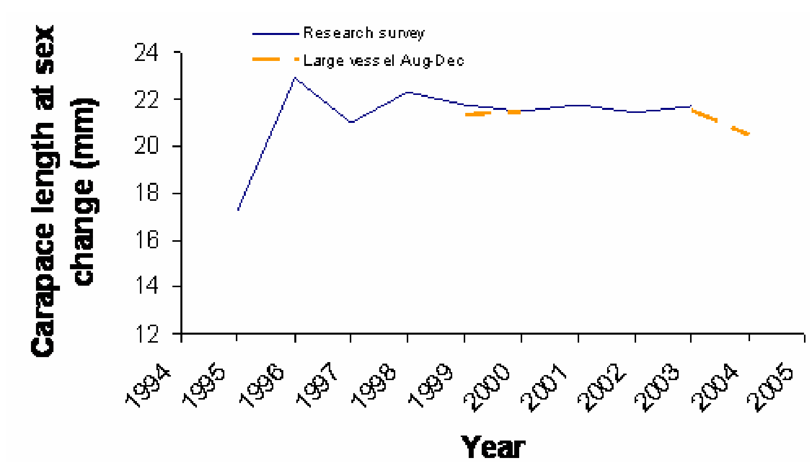

Fig. 15. A comparison between L_{50} values derived from Canadian autumn research bottom trawl surveys and those from large vessel (>500 t) commercial length frequencies. L_{50} refers to the size at which 50% of the shrimp population changes from male to female.

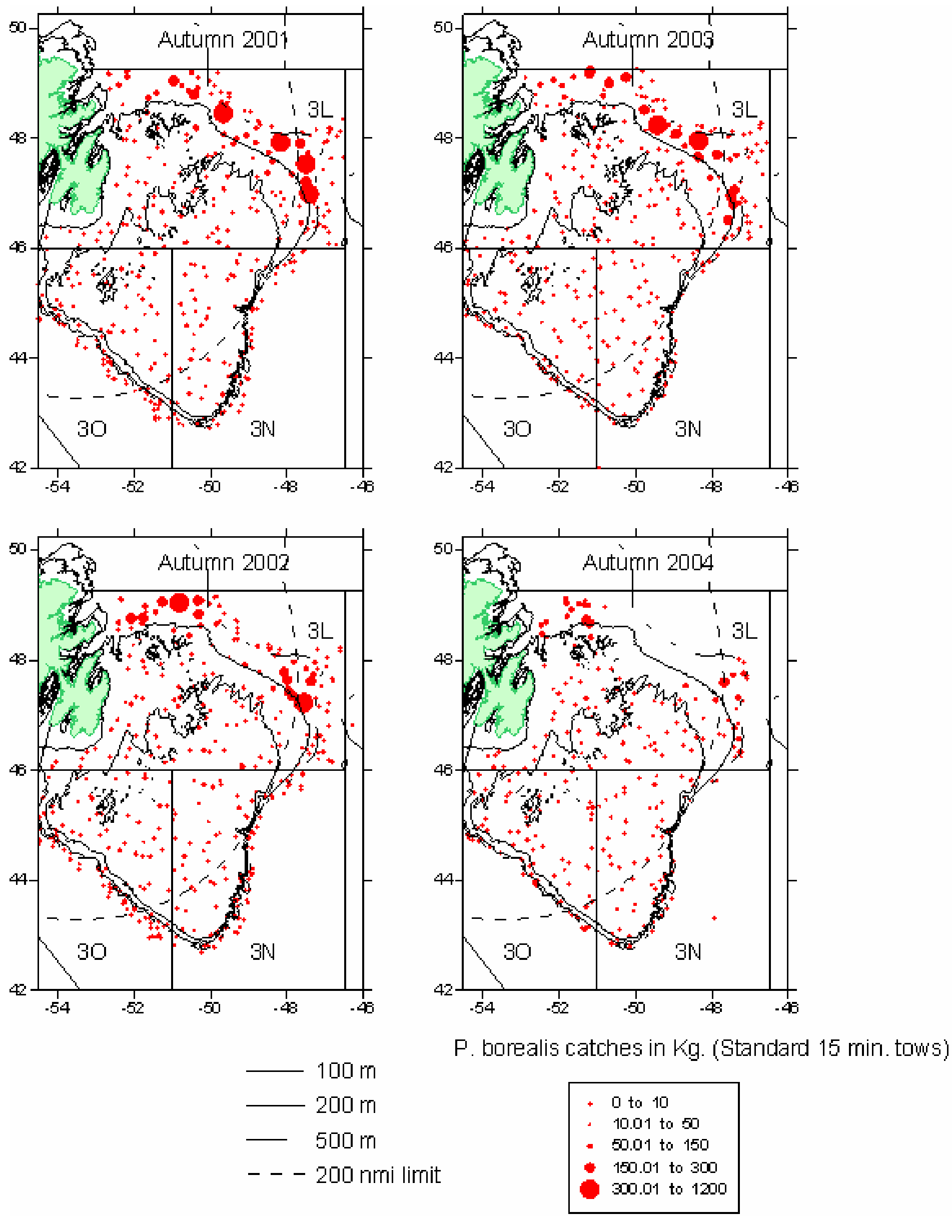

Fig. 16. Distribution of NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) catches kg/tow) as obtained from autumn research bottom trawl surveys conducted over the period 2001-2004.

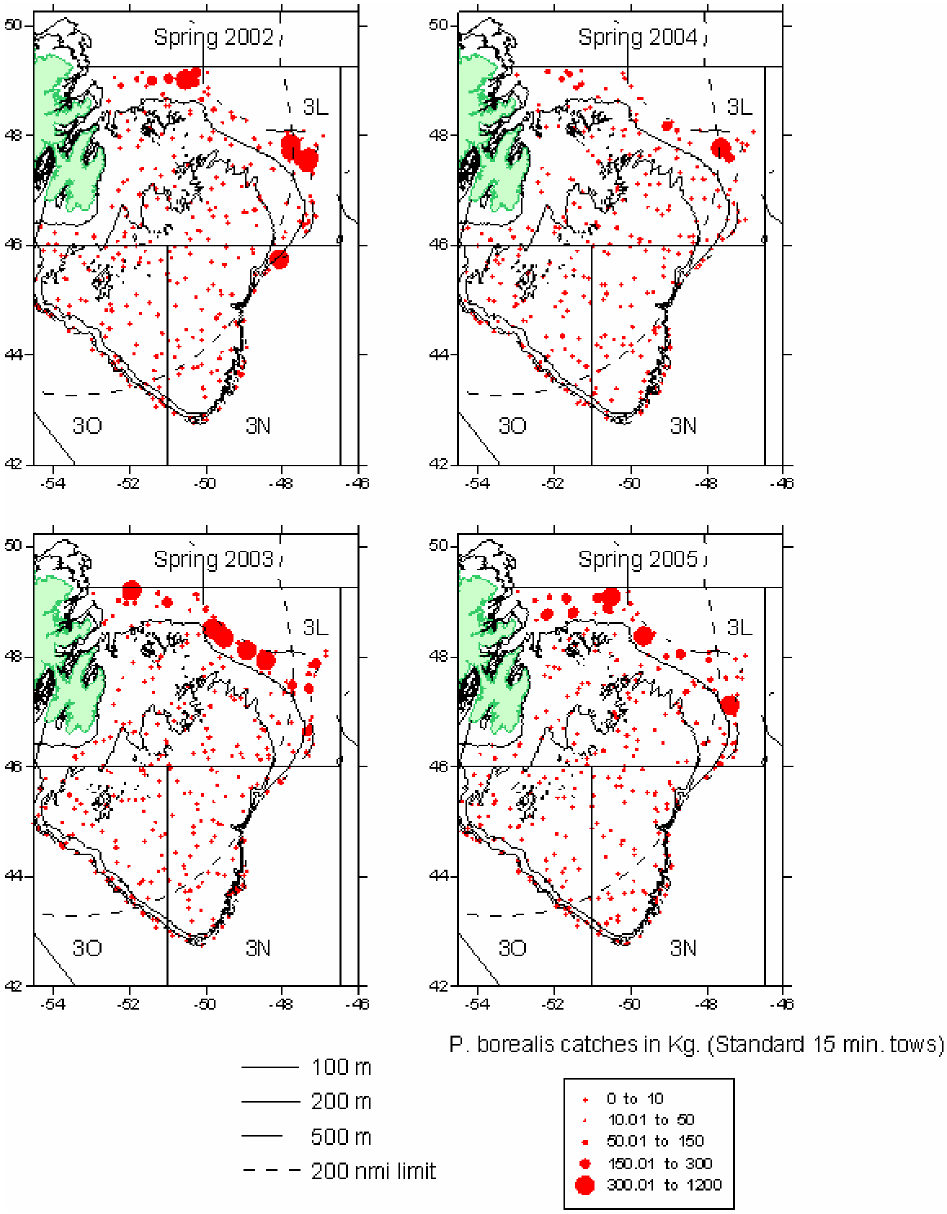

Fig. 17. Distribution of NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) catches kg/tow) as obtained form spring research bottom trawl surveys conducted over the period 2001-2004.

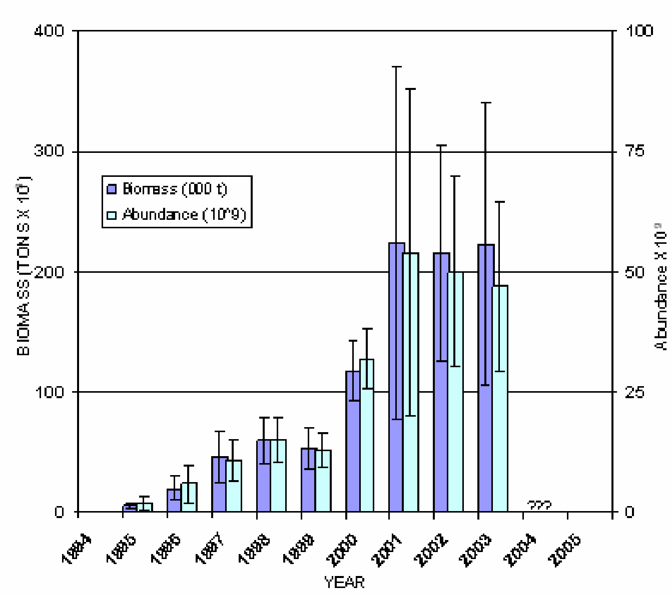

Fig. 18. Autumn northern shrimp (*Pandalus borealis*) biomass and abundance indices within NAFO Div. 3LNO, as determined using stratified areal expansion calculations. Data were form Canadian multi-species bottom trawl surveys using a Campelen 1800 shrimp trawl. (Standardized 15 min. tows).

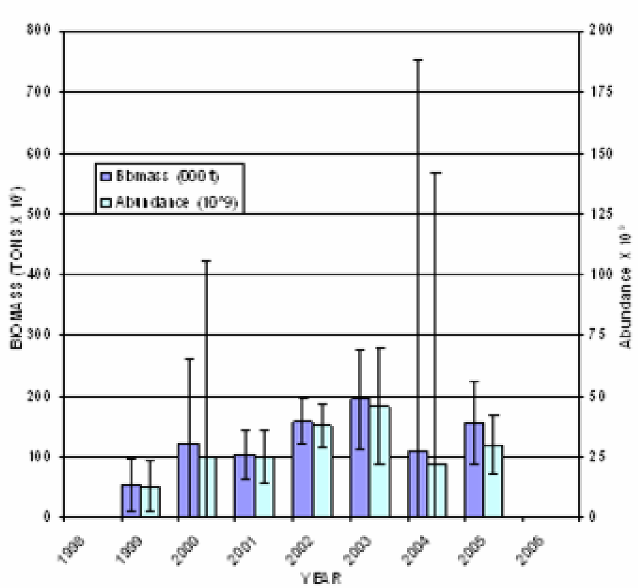

Fig. 19. Spring northern shrimp (*Pandalus borealis*) biomass and abundance indices within NAFO Div. 3LNO, as determined using stratified areal expansion calculations. Data were form Canadian multi-species bottom trawl surveys using a Campelen 1800 shrimp trawl. (Standardized 15 min. tows).

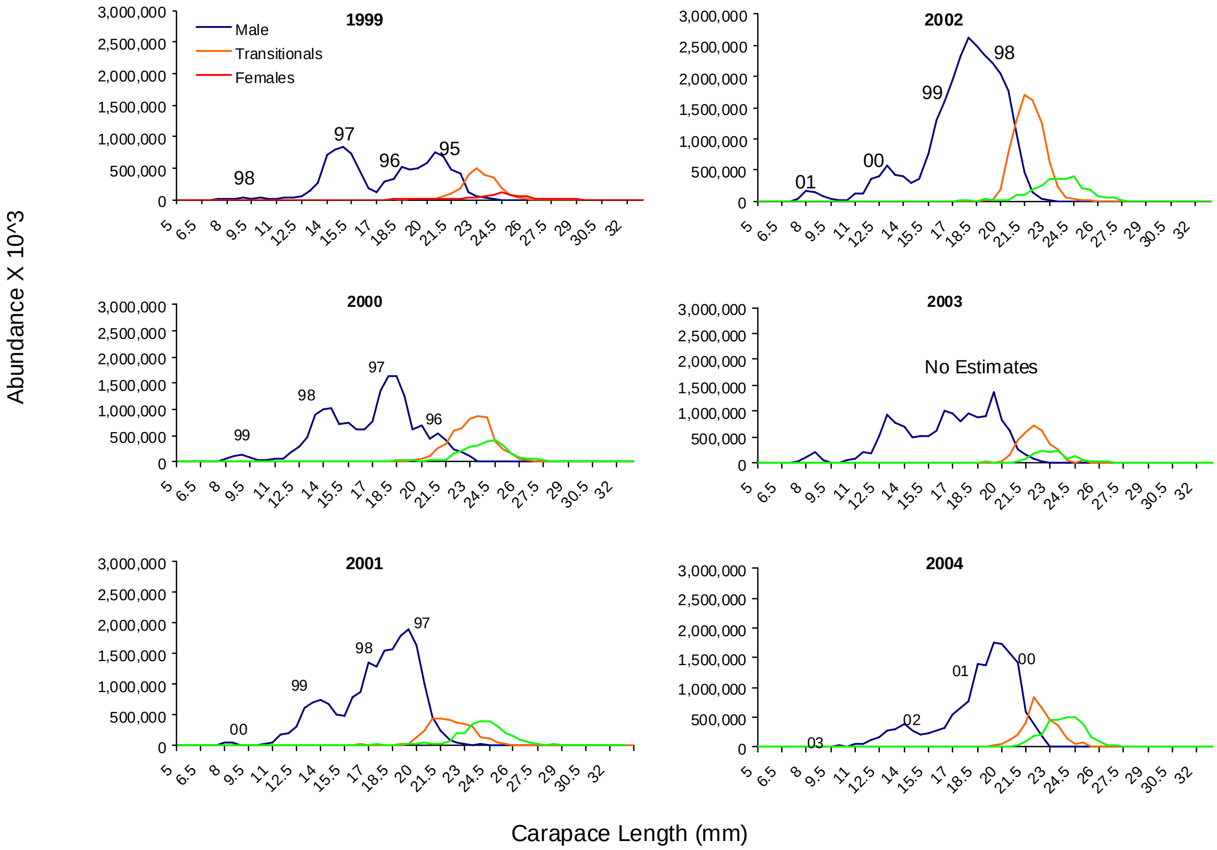

Fig. 20. Abundance at length for NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) estimated by stratified areal expansion analysis of Canadian spring multi-species bottom trawl survey data 1999-2004.

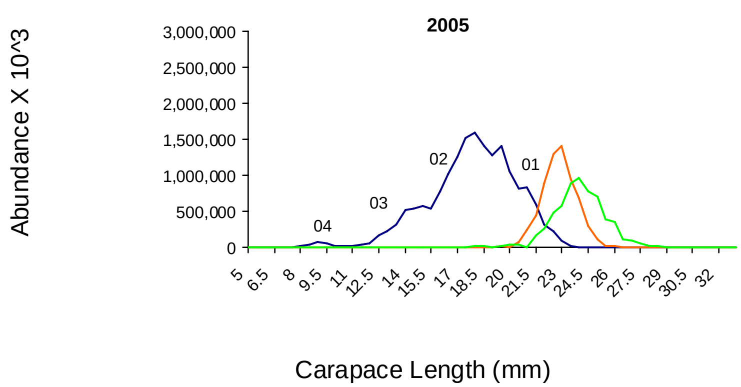

Fig. 20. (continued) Abundance at length for NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) estimated by stratified areal expansion analysis of Canadian spring multi-species bottom trawl survey data 2005.

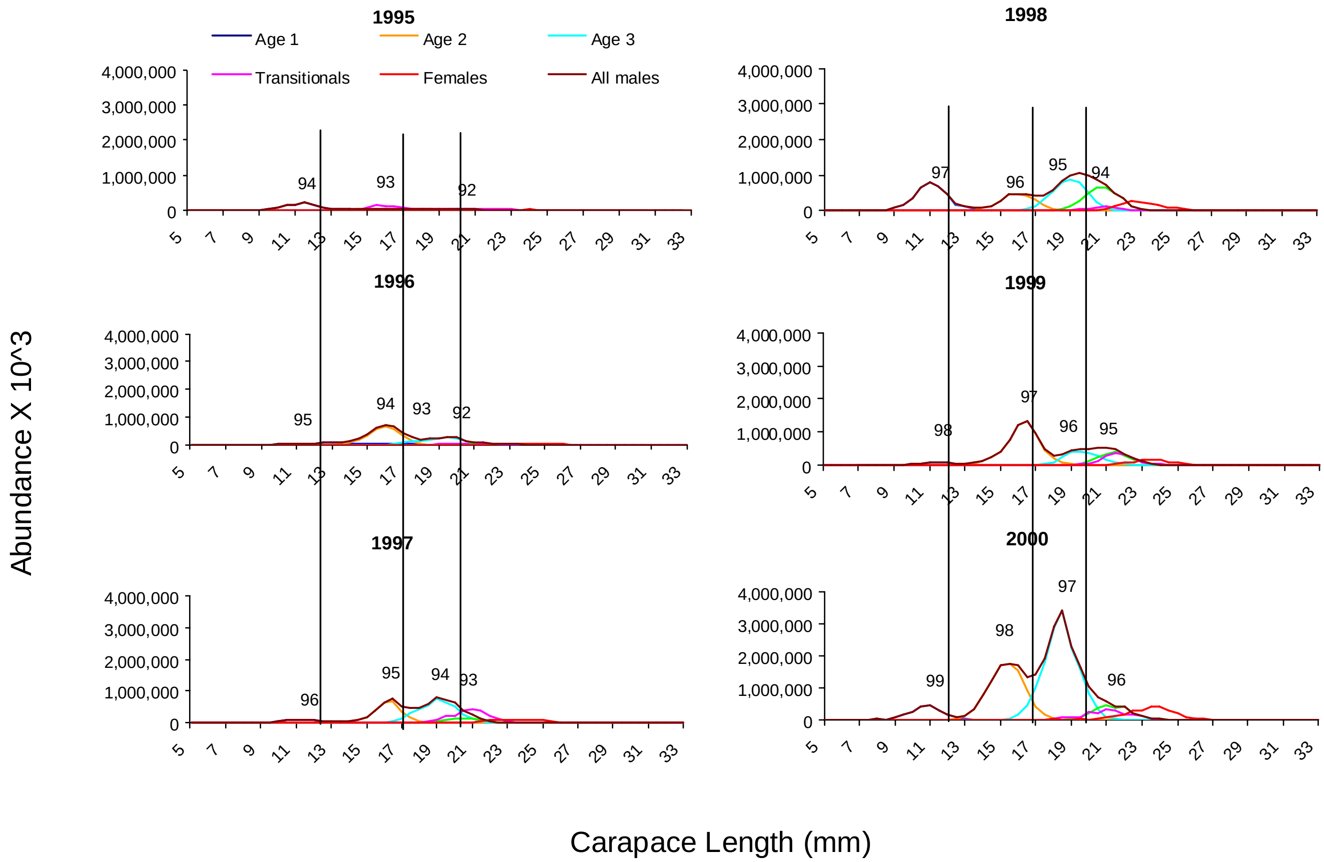

Fig. 21. Abundance at length for NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) estimated by stratified areal -expansion analysis of Canadian autumn multi-species bottom trawl survey data 1995-2000. Vertical lines indicate that there is inter-annual consistency in the Mix 3.01 modal analysis.

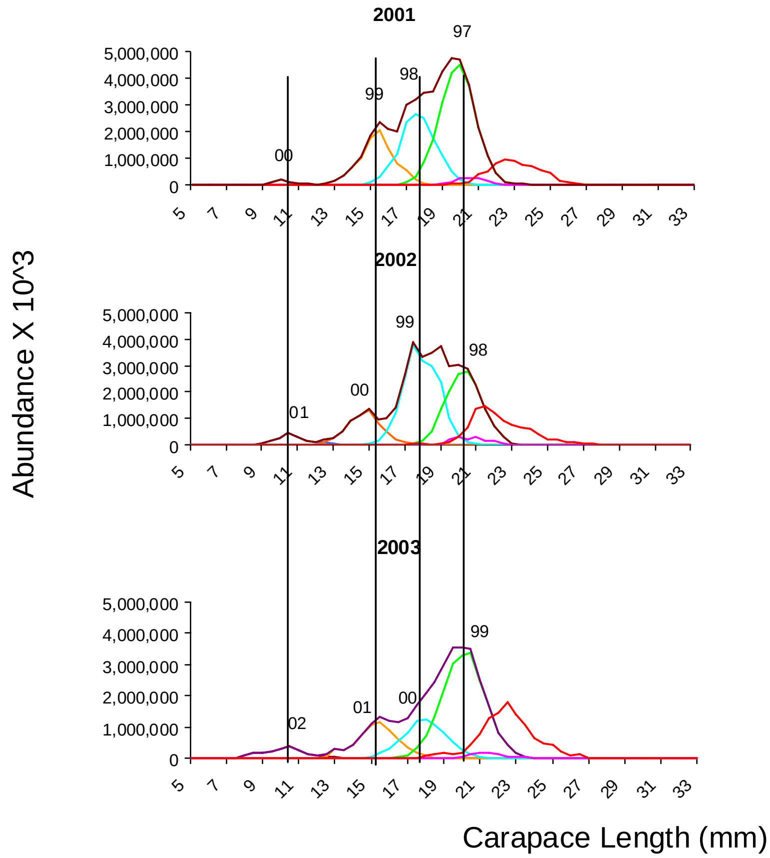

Fig. 21. (continued) Abundance at length for NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) estimated by stratified areal expansion analysis of Canadian autumn multi-species bottom trawl survey data 1995-2000. Vertical lines indicate that there is inter-annual consistency in the Mix 3.01 modal analysis.

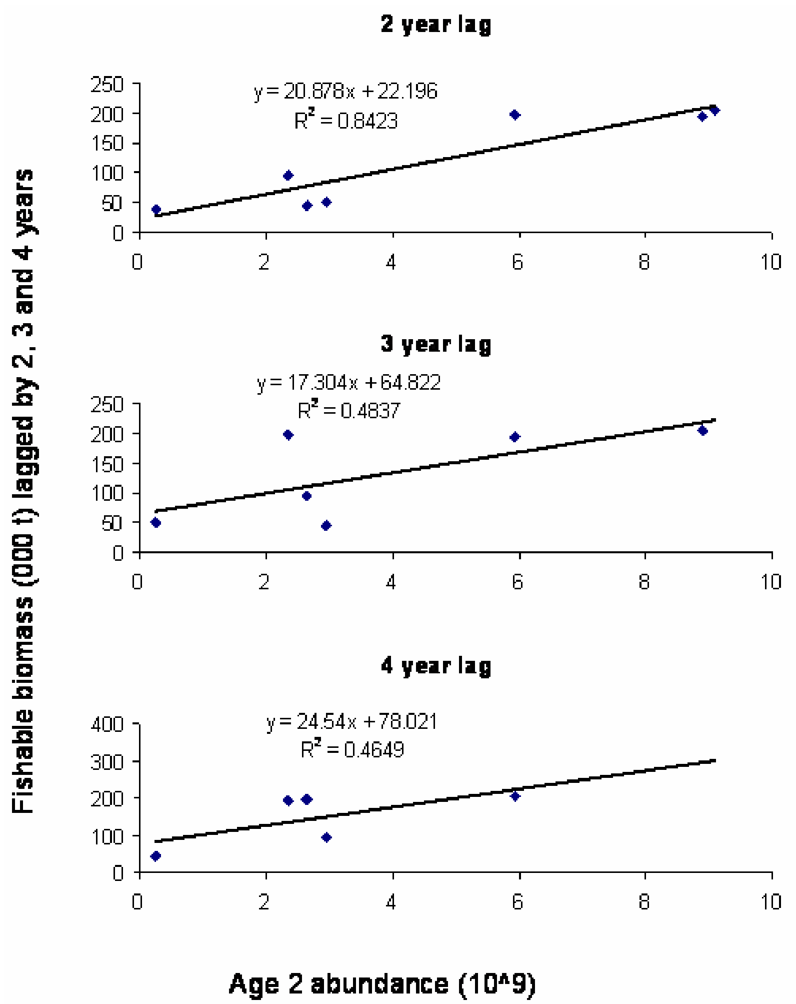

Fig. 22. Relationships between fishable biomass lagged by 2, 3 and 4 years and the autumn recruitment index (age 2 abundance).

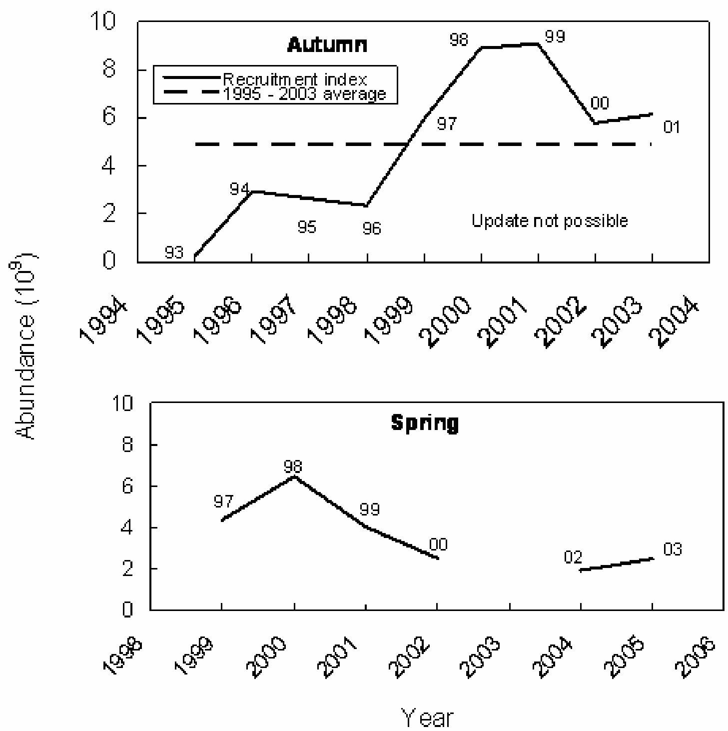

Fig. 23. Shrimp in Div. 3LNO: age 2 recruitment indices as determined form Canadian autumn and spring multi-species surveys 1995-2005 (number indicate year-classes).

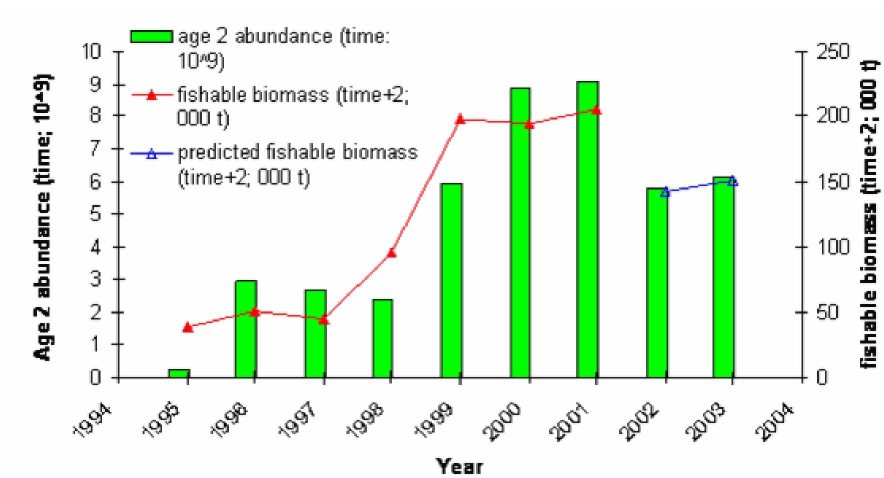

Fig. 24. The 2004 and 2005 autumn fishable biomass (lagged by two years) predicted from the age 2 abundance (autumn recruitment index). The relationship is fishable biomass (time+2) = 20.878(age two abundance) +22.196

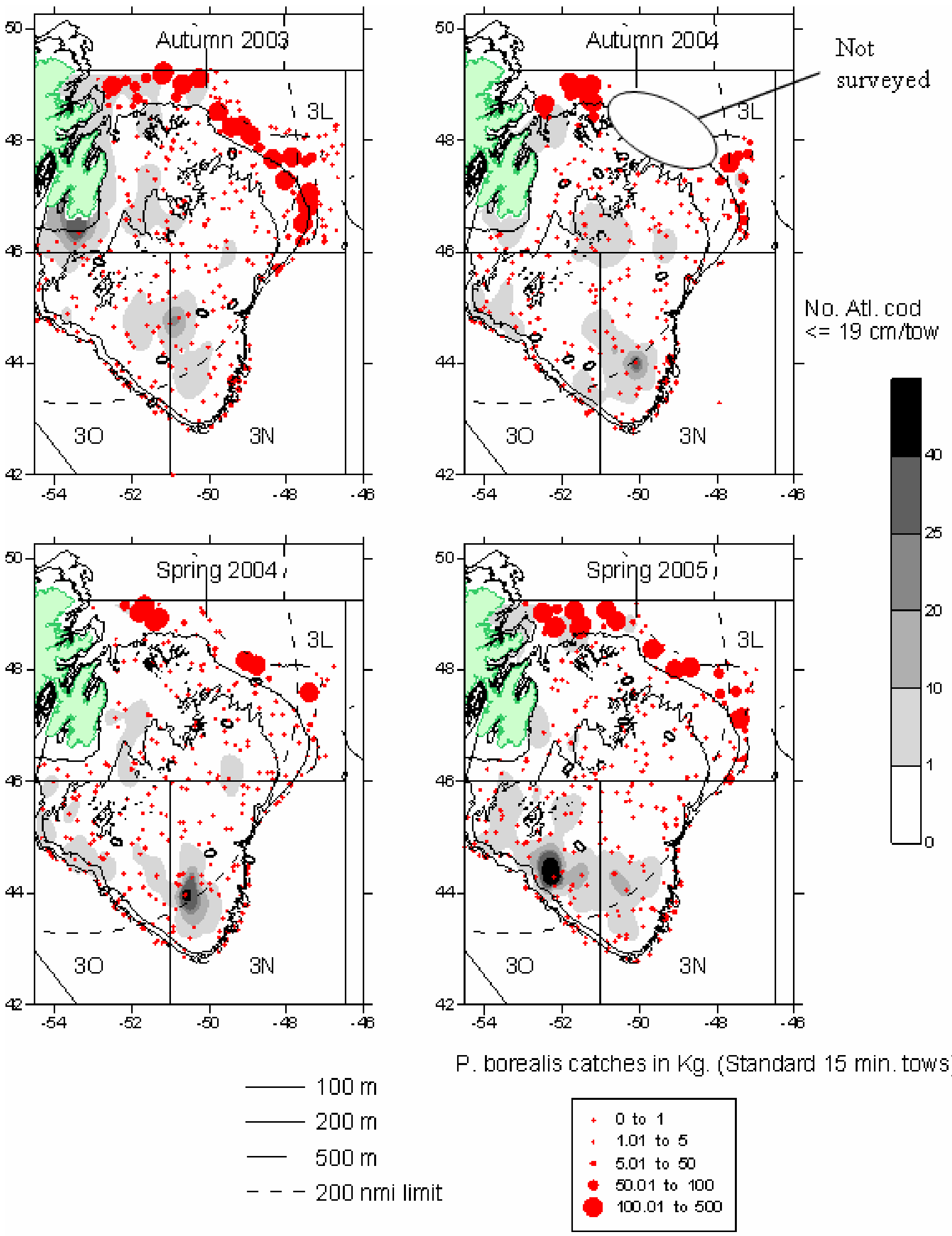

Fig. 25. Distribution of northern shrimp in relation to Atlantic cod (TL<=19 cm) collected during Canadian autumn 2003-spring 2005 multi-species bottom trawl surveys. Catches were made using a Campelen 1800 shrimp trawl; standard 15 min. tows).

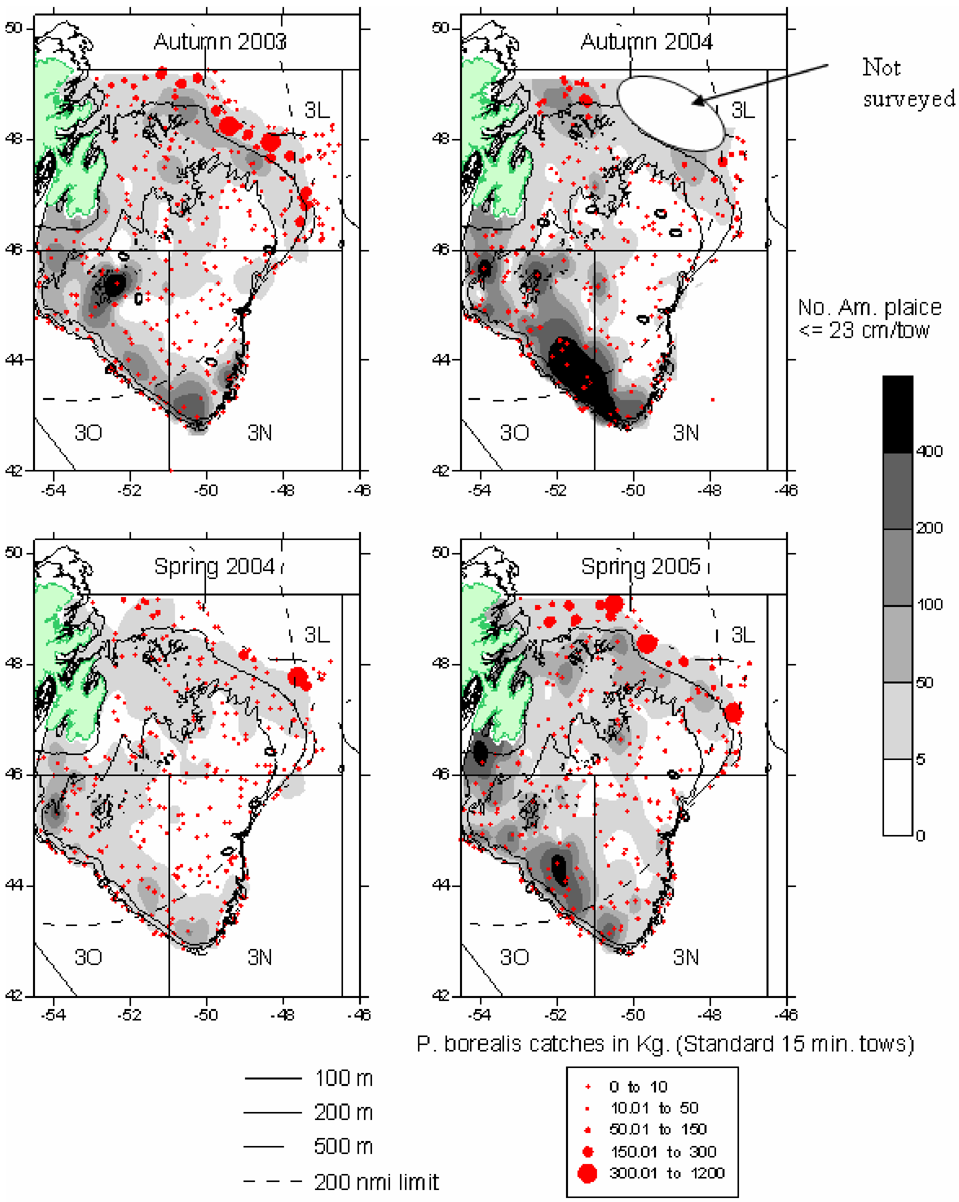

Fig. 26. Distribution of northern shrimp in relation to American plaice (TL<=23 -cm) collected during Canadian autumn 2003-spring 2005 multi-species -bottom trawl surveys. Catches were made using a Campelen 1800 shrimp -trawl; standard 15 min. tows).

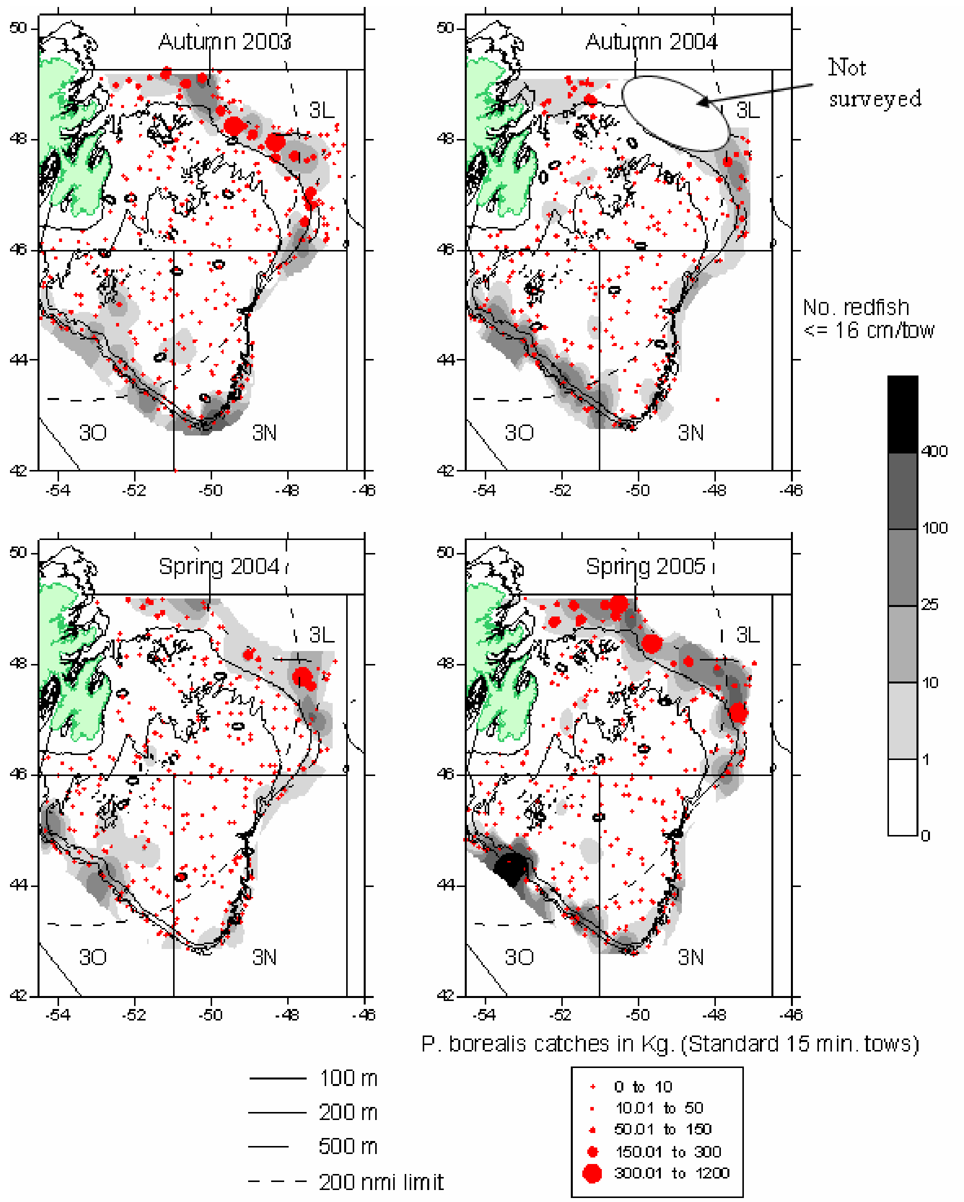

Fig. 27. Distribution of northern shrimp in relation to redfish (TL<=16 cm) collected during Canadian autumn 2003-spring 2005 multi-species bottom trawl surveys. Catches were made using a Campelen 1800 shrimp trawl; standard 15 min. tows).

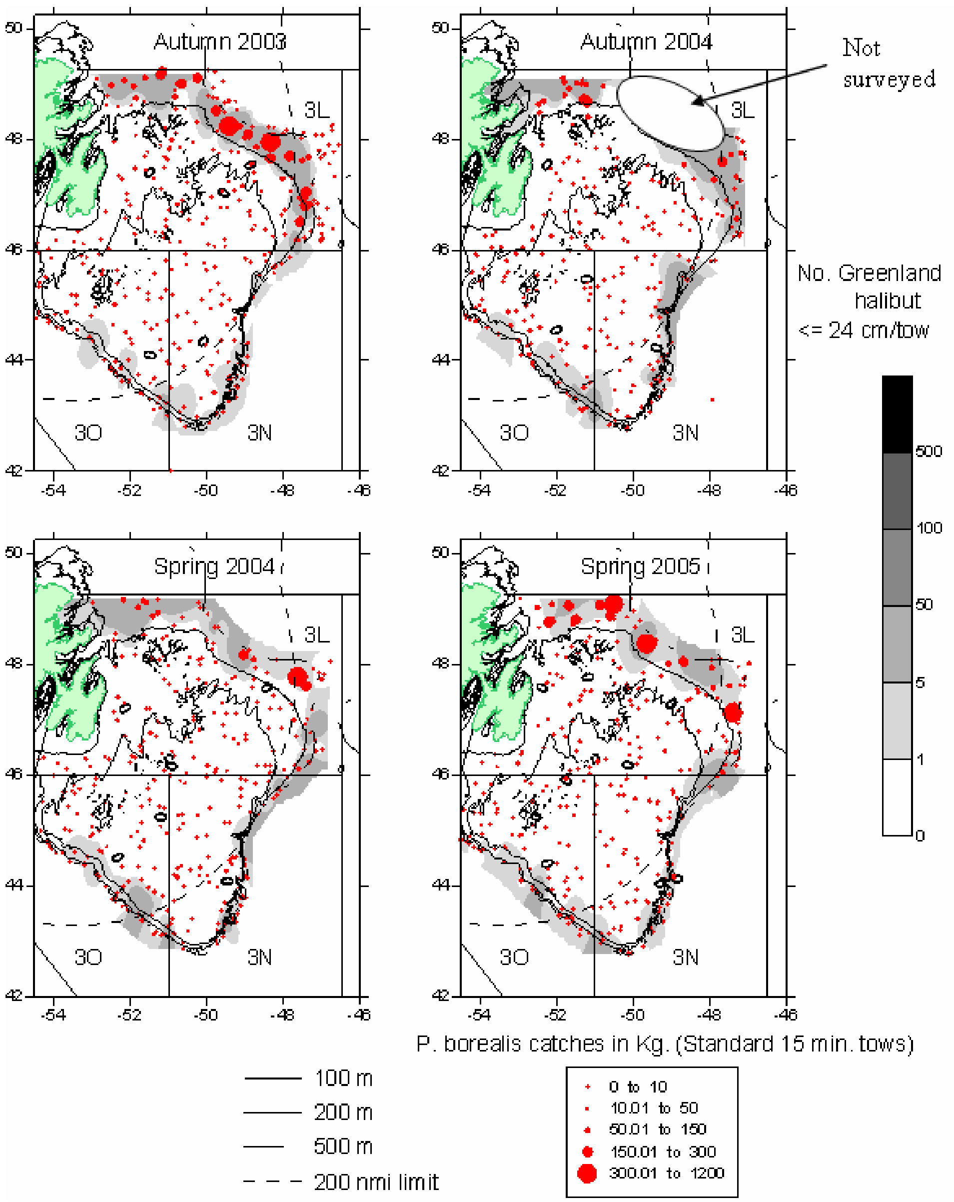

Fig. 28. Distribution of northern shrimp in relation to Greenland halibut (TL<=24 cm) collected during Canadian autumn 2003-spring 2005 multi-species bottom trawl surveys. Catches were made using a Campelen 1800 shrimp trawl; standard 15 min. tows).