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

by

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

ABSTRACT

This paper describes the 2007 northern shrimp (*Pandalus borealis*, Kroyer) assessment completed for NAFO divisions 3LNO. Status of the resource was inferred by examining trends in commercial catch, catch-per-unit effort, fishing pattern and size, sex and age compositions of catches, as well as, Canadian multi-species survey bottom trawl indices. The catch table (to October 2007) and biomass estimates (autumn 1995 – spring 2007) are updated within this report. Preliminary data indicate that 24,015 t of shrimp were taken against a 22,000 TAC in 2006 while 17,008 t were taken against a 22,000 t TAC in 2007.

The autumn 2006 biomass index was estimated to be 215 400 t, the third highest on record. The spring 2006 3LNO biomass index was 288 600 tons, the highest in either biomass time series. Indices derived from spring surveys are thought to be less precise because the confidence intervals are sometimes broad with negative lower confidence limits.

Biomass and abundance of shrimp increased significantly since 1999 and remained broadly distributed over the study area. Consequently standardized catch rates for large Canadian vessels have been fluctuating around the long term mean since 2000 with the 2007 catch rate above average but similar to the 2002 – 2004 and 2006 catch rates. The Canadian small vessel standardized CPUE increased significantly since 2004.

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

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

Additionally, during the September 2007 NAFO SC meeting, Fisheries Commission requested that an analysis be completed to determine the exploitation level if the TAC was raised to 26,000 t or 30,000 t. This report provides the results of a TAC determination based upon the inverse variance weighted average fishable biomass from the four most recent Canadian bottom trawl surveys in NAFO Divisions 3LNO.

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 divisions 3LNO, have been under TAC regulation since 1999. At that time, a 6,000 t quota was established and fishing was restricted to Division 3L, at depths greater than 200 m. The 6,000 t 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 Divs. 2HJ3K) (Orr *et al.* 2007). 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 t quota was established in the Exclusive Economic Zone (EEZ) for Canada while a 1,000 t 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 t. Accordingly, SC recommended that the TAC for shrimp in Div. 3LNO in 2003 and 2004 should

not exceed 13,000 t. At that time, SC reiterated its recommendation that the fishery be restricted to Div. 3L and that the use of a sorting grate with a maximum bar spacing of 22 mm be mandatory for all vessels in the fishery (NAFO, 2002).

In 2004, an analysis was completed to determine a TAC for the 2006 fishery. Due to the highly variable nature of the spring survey indices, Scientific Council (SC) felt it was necessary to change the methodology used in determining TACs. 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 t. Had this new method been used in 2003, it is likely that the adviced TAC calculated for 2005 would have been around 22,000 t instead of the 13,000 t 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 t was in place for 3 years, however the current TAC of 13,000 t had been in place since the beginning of 2003. A two year period was insufficient to determine the impact of a 13,000 t catch level upon the stock; therefore SC recommended that the 13,000 TAC be maintained through 2005. Scientific Council recommended that the 2006 TAC for shrimp in Divs. 3LNO should not exceed 22,000 t. 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 2006 shrimp assessment, SC decided that this advice should extend through 2008, and that the advice would be reviewed in September 2007 (NAFO, 2006).

Until the 2007 shrimp stock assessment, biomass and abundance indices and length frequencies have been estimated using stratified area expansion calculations (Cochran, 1997; using SAS programs written by D. Orr). This method makes use of three main assumptions:

catches are normally distributed,

there is no correlation between catches in adjacent strata, and

the within stratum environment is uniform; therefore catches within a stratum may be averaged and extrapolated to the entire stratum.

Unfortunately these assumptions are not always realized. Data are probably not normally distributed if the survey includes one or two very large catches. For example, the spring 2000 survey included two anomalously high catches (500 and 511 kg) while the spring 2004 survey included one anomalously high catch (1060 kg). These catches resulted in biomass and abundance indices that were thought to be imprecise because 95% confidence intervals were broad with negative lower confidence limits. As noted in Evans *et al.* (2000), the survey makes use of a groundfish stratification scheme therefore the sample design may not be suited to monitor shrimp stock status. It is likely that observations in adjacent strata but nearby locations (taking depth into account) are more similar than observations within the same stratum but at opposite ends of the stratum (Fig. 1). A continuous approach to index calculation may be more appropriate. Therefore, during the October – November 2006 NIPAG shrimp stock assessment meeting, it was decided that biomass/ abundance and population adjusted length frequencies could be calculated using Ogive Mapping (Evans *et* al. 2000).

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

3LNO in the time between the assessment and the commission meetings. The additional biomass information derived from these surveys is provided, within interim monitoring reports, to NAFO SC just prior to the annual Fishery Commission meetings. The last interim monitoring report was presented to NAFO SC during September 2007.

The present document was produced for the November 2007 NIPAG assessment meeting and therefore provides a full assessment of the Divs. 3LNO shrimp resource.

For these reasons, the biomass and abundance indices as well as population adjusted length frequencies were re-calculated using OGive MAPping (ogmap). This paper compares indices, length frequencies and TACs calculated by stratified areal expansion methods with those calculated using ogmap.

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.

Additionally, during the September 2007 NAFO SC meeting, Fisheries Commission requested that an analysis be completed to determine the exploitation level if the TAC was raised to 26,000 t or 30,000 t. This report provides the results of a TAC determination based upon the inverse variance weighted average fishable biomass from the four most recent Canadian bottom trawl surveys in NAFO Divisions 3LNO.

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 13 large (>500 t) fishing vessels and more than 300 smaller (<=500 t; <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, while the small vessels have a target of 10% observer coverage. 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 that dataset includes the number of trawls and usage of windows (escape openings) whereas the logbook dataset does not. Raw catch-per-unit effort data was standardized by multiple regression, weighted by effort, in an attempt to account for variation due to year, month, number of trawls, gross registered tonnage (grt) etc. The multiplicative model has the following logarithmic form:

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

Where: $\mathrm{CPUE}_{\mathrm{ijkml}}$ is the CPUE for grt k, fishing x number of trawls, in month j during year l (k=1,…..,a; j=1,…..,s; l=1,…..,y);

ln(u) is the overall mean ln(CPUE);

S_j is the effect of the j^{th} *month;*

V_k is the effect of the k^{th} grt;

T_m is the effect of m number of trawls;

Y_l is the effect of the l^{th} *year;*

e_{ijkml} is the error term assumed to be normally distributed $\mathrm{N}(0,\sigma^2/n)$ where n is the number of observations in a cell and σ^2 is the variance.

Standardized CPUE indices are the antilog of the year coefficient. Final models included all significant class variables with the YEAR effect used to track the trend in stock size over time. The difference (or similarity) between the 2007 YEAR parameter estimate and those of previous years was inferred from the output statistics.

In order to track only experienced fishers, the standard dataset 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.

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 3%.

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

International observer and logbook information:

These data were made available by Contracting Parties that fish shrimp in Div. 3L. They were used in CPUE calculations and were added to the Canadian catches when determining a total catch. Where no information was provided by a Contracting Party, information was augmented through the use of Canadian surveillance data, as well as, NAFO Statlant 21A and monthly provisional catch tables. Estonia, Greenland, Norway, Spain and Russia provided catch and effort data over a number of years making it possible to derive standardized 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 Divisions 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. Analyses of the autumn 1995-2003 and 2005 survey data indicate that the 3L strata missed in 2004 (93-549 m) are important in determining the biomass indices. Typically these strata account for 25-61% of the 3L biomass (Orr *et al*., 2006).

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

All strata were surveyed during autumn 2005 and 2006.

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

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

males;

transitionals;

primiparous females;

ovigerous females,

and multiparous females

as defined by Ramussen (1953), Allen (1959) and McCrary (1971). Oblique carapace lengths (0.1 mm) were recorded while number and weight per set were estimated from the sampling data. Inshore strata were not sampled in all years; therefore, the analysis was restricted to data collected from offshore strata only (Fig. 1). Length frequencies were estimated using stratified area expansion calculations (Cochran, 1997; using SAS programs written by D. Orr) and compared with Ogmap estimates (Evans *et al.* 2000). 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 $\text{males}_{\text{year}}$ were plotted against fishable $\text{biomass}_{\text{year}+2}$ to determine whether a recruitment – stock relationship exists. Such a relationship could be used to predict stock prospects.

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

lower 95% confidence interval below the biomass index,

female biomass (SSB), and

fishable biomass.

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

$Wt(g) = 0.00088*lt(mm)^{2.857}$ for autumn samples

$Wt(g) = 0.000966*lt(mm)^{2.842}$ for spring samples

(these models were derived from length weight relationships described above)

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

All indices (biomass, abundance, fishable biomass, female biomass (SSB)) as well as population adjusted shrimp carapace length frequencies, calculated by stratified areal expansion methods were compared with respective values calculated using Ogmap (Evans *et al.* 2000).

<u>OGive MAPping (ogmap):</u>

OGive MAPping was developed by Dr. G. Evans (DFO – NL Region) to calculate abundance and biomass indices, and population adjusted length frequencies. The method described within Evans (2000) and Evans *et al.* (2000) assumes that:

trawl sets are independent random samples from the probability distributions at set locations; and

nearby distributions are related.

As a first step in the exercise, a dense set of Delauney triangles of known position and depth were developed from the 1995 – 2002 autumn surveys (Figs. 2 - 4). Catch information was then used to determine the appropriate horizontal and vertical steps used by Ogmap in weighting values according to distances (horizontal and vertical) from each sample location. Points closer to the sample location receive higher weights. Step determination is described in Evans *et al.* (2000). The appropriate horizontal and vertical steps for the present set of analyses were 30.81 km and .99 m respectively.

Ogmap is then used to compute the expected value of the distribution at every vertex in each Delauney triangle. The expected value for shrimp biomass within each triangle is integrated using bilinear interpolation. The expected biomass within 3LNO is the sum over all triangles. A Monte Carlo simulation resamples the whole probability distribution at every survey point to provide a new biomass point estimate. Five hundred such simulations are run to provide a probability distribution for the estimated biomass. The point estimate is provided from the entire survey dataset, while the probability distribution is determined through Monte Carlo simulation. Non-parametric 95% percent confidence intervals are then read from the probability distribution (Fig. 5).

TAC determinations:

TAC calculations were based upon the inverse variance weighted average fishable biomass from the four most recent Canadian bottom trawl multi-species surveys. The formula used was determined as follows:

Variance measure = Ogmap biomass estimate – lower 95% confidence interval

inverse variance weighted average fishable biomass =

$$\sum_{i=4}^{1 \text{ to } 4} \left(\text{fishable biomass}_i/(\text{variance measure})^2\right) \Big/ \sum_{i=4}^{1 \text{ to } 4} 1/(\text{variance measure})^2$$

Catch rates were determined as the catches prescribed by Fisheries Commission divided by the inverse variance weighted average fishable biomass. Additionally, Shrimp Fishing Area (SFA) 6, which is adjacent to Division 3L, has an exploitation rate (catch/ fishable biomass from the previous survey) that has averaged 12% over the past four years; therefore one of the TAC's was based upon 12% of the inverse variance weighted average fishable biomass.

RESULTS AND DISCUSSION

FISHERY DATA

Catch trends

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

Catches increased dramatically since 1999, with the beginning of a regulated fishery. Since then, sixteen contracting nations have exercised their privileges to fish shrimp in 3L. Over the period 2000 – 2004, catches were 4 869, 10 566, 6 977, 11,947 and 12,622 t respectively (Table 1; Fig. 6). Catch data indicate that 14,137 t of shrimp were taken against a 13,000 t quota in 2005 while 24 015 t were taken against a 22,000 t TAC in 2006. Preliminary data indicate that by October 2007, 17,008 t had been taken against a 22,000 t TAC.

As per NAFO agreements, Canadian vessels took most of the catch during each year. Canadian catches increased from 4 250 t in 2000 to 18,271 t in 2006. Catches by Non Canadian nations increased from 619 t to 5 5615 t over this period. Preliminary data indicate that by October 2007, 2 573 t had been taken against a non Canadian TAC of 3 675 t.

Canadian fleet

Since 2000, small (<=500 t) and large (>500 t) shrimp fishing vessels catches have been taken from a broad area (Figs. 7 - 9) from the northern border with 3K south east along the 200 – 500 m contours to the NRA border. As noted in Orr *et al.* (2005) there are similarities between the distribution of small vessel logbook catches and autumn survey catches with a one year lag (Fig. 9). The area occupied by small and large vessels has been fairly stable over much of the time series with an increase in area fished after 2005. The area accounting for 95% of the autumn survey catches also showed stability with an increase after 2003 (no index in 2004; Fig. 9). Relative stability with an increase in the past few years is reflected in the small and large vessel CPUE time series (Fig. 10).

Due to a lack of data (Fig. 7) it was not possible to model small vessel CPUE during 2007. Small vessel CPUE (2000 – 2006) was modeled using month, year and size class (class 1 = <50' LOA; 50' LOA <=class 2< 60' LOA; class 3 => 60' LOA) as explanatory variables. The final model explained 91% of the variance in the data and indicated that the annual, standardized catch rates have increased significantly since 2004 with all estimates being significantly lower than the 2005 and 2006 estimates ($P < 0.005$; 662 kg/hr during 2005 and 586 kg/hr during 2006; Tables 2 and 3; Fig. 10). No clear trends were found in the plots of residuals (Fig. 11).

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 76% of the variance in the catch rate data. Standardized catch rates for large Canadian vessels have been fluctuating around the long term mean since 2000 with the 2007 standardized catch rate index (2304 kg/hr; Table 5) above average and similar to the catch rates for 2002 – 2004 and 2006 (Tables 4 and 5; Fig. 10). There were no trends in the residuals around parameter estimates (Fig. 12).

The fact that the area fished by large and small vessels has increased over the past few years at a time when CPUE increased implying that the resource is healthy.

International fleet

A standardized catch rate model was produced using data from Estonian, Greenlandic, Icelandic, Norwegian and Russian vessels fishing shrimp in the NRA. Ship and year were significant independent variables and produced a model that explained 72% of the variance. Catch rates increased by 109% from 506 kg/hr in 2001 to 1057 kg/hr in 2004 but then decreased by 40% over the next three years resulting in a 637 kg/hr catch rate during 2007 (Tables 6 and 7; Fig. 13). The 2007 model catch rate was lower than the 2003 and 2004 catch rates but similar to all others. There were no trends in the residuals around parameter estimates (Fig. 14).

Catch data were also available from Spain for 2005 and 2006. The raw Spanish catch rates for these two years were 640 kg/hr and 763 kg/hr respectively.

Size composition

Several length frequency observations were taken from large vessel catches (Fig. 15). Catch at length from samples taken by observers on large vessels consisted of a broad size range of males and females believed to be at least three years of age. The male modes overlapped to the extent that it was not possible to complete Mix distribution analysis; however, the male modes often had two faint sub-peaks implying the presence of more than one year class. Given that the modes were usually near 18 mm and 20 mm, these animals were probably 3 and 4 years of age respectively. The female length frequency distributions were also broad indicating that the female portion of the catch probably consists of more than one age group. Catch rates had been maintained at over 200,000 animals per hour. The within year frequency weighted average carapace lengths for males ranged between 18.4 mm and 19.7 mm, while the weighted average carapace lengths for females ranged between 22.9 mm and 23.7 mm. There were no trends in the average size of either males or females. Unfortunately no length frequency data was available, from either the Canadian or non Canadian fleets, for the 2007 shrimp assessment.

Figures 16 presents the length frequencies from the 2006 Spanish catches. It also shows a broad range in sizes of shrimp, probably from at least three year classes.

RESEARCH SURVEY DATA

Stock size

The remainder of the tables and figures within this report compare results derived using areal expansion and Ogmap calculations. Ogmap calculations normally, but not always, provided slightly lower point estimates in comparison with area expansion methods. The Ogmap confidence intervals were always narrower than the areal expansion confidence intervals and were never negative. The following discussion will indicate tables from both types of analyses but will be based upon only Ogmap results.

As illustrated in figure 17, the autumn 2003 – 2006 research catches are concentrated within NAFO Div. 3L at depths between 200 and 500 m. Figure 18 provides the Ogmap densities (t/sq. km) demonstrating that the derived densities are highest in areas with high research catches.

The autumn 2006 survey resulted in a biomass estimate of 215,400 t; the third highest in the time series (Tables 8 and 9; Fig. 19). While the spring 2007 Div. 3LNO trawlable biomass was 288, 600 t, the highest value in the time series. However, it must be noted that in general, the spring indices are thought to be less precise because the 95% confidence intervals are sometimes broad relative to autumn intervals.

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

Between 90.5 and 100% of the total 3LNO biomass was found within Division 3L, mostly within depths from 185 to 550 m. Over the study period, the area outside 200 Nmi accounted for between 11 and 28% of the estimated total 3LNO biomass (Tables 10 - 13; Figs. 17 and 18). Three year running averages were estimated in order to smooth the peaks and troughs within the data. They indicate that 10.7 – 21.0% of the total 3LNO autumn biomass is within the NRA (Table 10). Over the period 2000 – 2006 the overall average autumn percent biomass within the NRA was 17.4%. However, during the spring, the percent biomass within the NRA ranged between 11.2 and 27.6% (Table 12). Over the period 1999 – 2007 the average spring percent biomass with the NRA was 22.2%.

In all surveys, Division 3N accounted for .4-10.6% of the total 3LNO biomass (Tables 10 and 12). More than 33.3% of the 3N biomass was found outside the 200 Nmi limit. Division 3O accounted for less than 1% of the 3LNO biomass. A negligible amount of the Division 3O biomass was found outside the 200 Nmi limit.

Stock composition

Length distributions representing abundance – at – length from the autumn 1995 - spring 2007 surveys are compared in figures 20 and 21. These figures demonstrate that Ogmap calculations of number at length track areal expansion calculations of number at length. Modes increase in height as one moves from ages 1 – 3 indicating that modes become more overlapping and that catchability of the research trawl probably improves as the shrimp increase in size. Tables 14 - 17 provide the modal analysis and the estimated demographics from each survey. These time series provides a basis for comparison of relative year-class strength and illustrate the changes in stock composition over time. There appear to be two regimes; one prior to 2000 at a time during which abundances at age are low and a second period after 1999 during which abundances are much higher. The 1997 year-class first appeared in the 1998 survey as one year old shrimp and was the first in a series of strong year-classes. This year class was strong and could be followed throughout the next three years. However, it is important to note that the age 1 modes do not always give a clear recruitment signal. For instance, the 1998 age 1 mode appeared weak in 1999, but was almost as strong as the 1997 year class in later years. Strong age 2 modes appear strong throughout their history, conversely weak year classes such as the 1995 and 1996 appear weak as 2 males and remain weak throughout their history.

Modal length at age varies between years reflecting different growth rates for the different cohorts. However, there is some inter-annual consistency in modal positions and the relative strength of cohorts is maintained from one year to the next (Tables 15 - 17; Figs. 20 and 21).

Shrimp aged 3 and 4 dominated the male component of the length frequencies in spring 2007 (2004 and 2003 year classes respectively) survey with carapace length frequency modes at 16.66 and 19.89 mm respectively. Abundance estimates from the autumn 2006 survey were dominated by shrimp aged 2 - 4 (2004, 2003 and 2002 year classes respectively) with modes at 14.5, 17.97 and 20.09 mm respectively. While shrimp aged 2 – 4 dominated the spring 2006 survey (2004, 2003 and 2002 year classes). The 2004 year class, as seen in the autumn 2006 survey, the most abundant age 2 year class in any of the length frequency analyses. Similarly, the 2004 year class is the most abundant age 3 year class in any of the spring length frequency analyses.

The spring and autumn surveys showed an increase in the abundance of female (transitionals + females) shrimp over much of the time series. Autumn male abundance indices increased until 2003 and have since remained stable at a high level while spring male abundance indices have varied over time (Tables 18 - 21; Fig. 22).

Fishable biomass has increased throughout much of the spring and autumn time series (Tables 22 and 23; Fig. 23). The autumn 2006 fishable biomass was 173, 227 t; the second highest in the autumn time series while the spring 2007 fishable biomass was 278, 407 t; the highest in either of the fishable biomass time series. Female biomass (transitionals and all females = SSB) indices have followed similar trends (Tables 18 – 21; Fig. 24). The autumn female biomass was 82,600 t in 2006; the second highest in the autumn time series. While the 2007 spring female biomass was 176,700 t; the highest in either of the female biomass time series.

Given the relative strength of the 2002 - 2004 year classes, fishable biomass has been increasing or remaining high and the female portion of the population is relatively abundant, probably consisting of more than one year class, the present fishery should be sustainable over the next few years.

Recruitment Index

Recruitment indices (age 2 abundance) were constructed from the autumn 1995-2006 and spring 1999 - 2007 surveys. Due to the incomplete survey in autumn 2004, this value was excluded from the autumn time series. Recruitment indices were based upon modal analysis of length frequencies. With the exception of the 95 and 96 year classes, the autumn 93 to 98 year classes appeared progressively stronger, the 99 year class remained strong; however, the 00 – 03 yaer classes were average while the 04 year class is the strongest recorded (Tables 14 and 15; Fig. 25). Spring recruitment indices have been fluctuating around the mean with the 04 and 05 year classes being the strongest in the time series (Tables 16 and 17; Fig. 25).

Figure 26 presents fishable biomass with a two year lag regressed against the recruitment indices (age 2 abundance) using Canadian autumn survey data. This predictive relationships are statistically significant and the model using Ogmap values may be written as the following model:

Fishable biomass$_{year+2}$= 20.694 (autumn recruitment index$_{year}$) + 15492.

If the Ogmap autumn 2006 recruitment index (12.121 X 10^9 animals) is applied to the simple Ogmap model then the predicted fishable biomass would be 266,324 t in 2007. If the areal expansion autumn 2006 recruitment index (13.760 X 10^9 animals) is applied to the areal expansion model then the predicted fishable biomass would be 289,205 t in 2007.

Exploitation Rates

Exploitation levels using ratios of catch divided by the previous year's Canadian survey index, in this case: lower 95% confidence interval below the biomass estimate, spawning stock biomass fishable biomass. In general, they all follow similar trajectories (Tables 24 and 25). Overall, exploitation has been low even though catches have increased over time because the stock parameters also increased. Figure 27 presents the exploitation rate index determined as catch/ previous year's autumn fishable biomass. The 2007 exploitation rate index was 9.8% using Ogmap values.

By-catch

Tables 26 and 27 indicate that relatively low numbers and weights of Atlantic cod (*Gadus morhua*) and American plaice (*Hippoglossoides platessoides*) had been taken by Canadian shrimp fishing fleets. The 2007 total estimated by-catch of Atlantic cod and American plaice were approximately 0.46, 5.6 t respectively.

Relative to other species, high levels of redfish (*Sebastes* spp.) and Greenland halibut (*Rheinhardtius hippoglossoides*) are taken in the shrimp fishery. 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 relatively high 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.

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 2004 – 2007. Small vessel observer coverage ranged between 2.6% (correction factor = 38.8 in 2006) and 1.2% (correction factor = 83.4 in 2007). 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.

Resource Status

Canadian large (>500 t) fishing vessel catch rates have fluctuated around the long term mean since 2000 with the 2007 catch rate index above average and similar to the 2002 – 2004 and 2006 catch rates. The Canadian small vessel standardized CPUE increased by 106% over the period 2001 – 2005 and remained near that level during 2006. The large vessel CPUE increased at a time when the distribution of this portion of the fishery and the resource has been expanding. However, there was not sufficient small vessel data to complete an analysis of distribution for 2007.

The standardized non-Canadian CPUE made use of data from Estonia, Greenland, Iceland, Norway and Russia. Catch rates increased by 109% from 506 kg/hr in 2001 to 1057 kg/hr in 2004 but then decreased by 40% over the next three years resulting in a 637 kg/hr catch rate during 2007.

Based on Canadian surveys, over 90% of the biomass was found in Div. 3L, distributed mainly along the northeast slope in depths from 185-550 m. There was a significant increase in autumn shrimp biomass indices between 1995 and 2001 and this index has since remained stabilize at a high level. The autumn 2005 index was 215,400 t (47 billion animals), the third highest in the autumn time series. The spring 2007 biomass index was 288,600 t (54 billion animals), the highest in either biomass time series.

The spring and autumn surveys showed an increase in the abundance of female (transitionals + females) shrimp over the full time series. Autumn male abundance indices increased until 2003 and have since remained stable at a high level while spring male abundance indices have varied over time.

With the exception of the 95 and 96 year classes, the autumn 93 to 98 year classes appeared progressively stronger, the 99 year class remained strong; however, the 00 – 03 year classes were average while the 04 year class is the strongest recorded. Spring recruitment indices have been fluctuating around the mean with the 04 and 05 year classes being the strongest in the time series.

Shrimp aged 3 and 4 dominated the male component of the length frequencies in spring 2007 (2004 and 2003 year classes respectively) survey with carapace length frequency modes at 16.66 and 19.89 mm respectively. Abundance estimates from the autumn 2006 survey were dominated by shrimp aged 2 - 4 (2004, 2003 and 2002 year classes respectively) with modes at 14.5, 17.97 and 20.09 mm respectively. While shrimp aged 2 – 4 dominated the spring 2006 survey (2004, 2003 and 2002 year classes). The 2004 year class, as seen in the autumn 2006 survey, the most abundant age 2 year class in any of the length frequency analyses. Similarly, the 2004 year class is the most abundant age 3 year class in any of the spring length frequency analyses.

A broad mode of females was present in all surveys implying the presence of more than one year class of females.

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

Given the relative strength of the 2002 - 2004 year classes, fishable biomass has been increasing or remaining high and the female portion of the population is relatively abundant, probably consisting of more than one year class, the present fishery should be sustainable over the next few years.

Scientific Council considers that the point at which a valid index of stock size has declined by 85% from the maximum observed index level provides a proxy for B_{lim} for northern shrimp in Div. 3LNO. It is not possible to calculate a limit reference point for fishing mortality. Currently, the SSB is estimated to be well above B_{lim} (Figure 28).

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.

TAC:

Table 28 provides the TAC determinations for various scenarios. If the inverse variance weighted average fishable biomass is 183,890 t then a 12% catch rate would result in leaving the TAC at 22,000 t. In response to Fishery Commission's question concerning the respective catch rates with TAC's of 26,000 and 30,000 t, these TAC's would result in catch rates of 14.1 and 16.31 % respectively. Unfortunately, there is no analytical assessment for this stock therefore there is no risk analysis.

Literature Cited

Allen, J.A., 1959. On the biology of *Pandalus borealis* Kroyer, with reference to a population off the Northumberland coast. J. mar. biol. Ass. 38: 89 – 220.

Brodie, W.B. 1996. A description of the 1995 fall groundfish survey in Division 2J3KLMNO. NAFO SCR. Doc. 96/27, Serial No. N2700. 7p.

Brodie, W.B. 2005. A description of the fall multispecies surveys in SA2+ Divisions 3KLMNO from 1995-2004. NAFO SCR. Doc. 05/08. Serial No. N5083.

Cochran, W. G. 1997. Sampling Techniques. Third Edition. John Wiley & Sons. Toronto. 428 p.

Díaz, P. 2001. Northern shrimp (*Pandalus borealis*) on Flemish Cap in July 2001. NAFO SCR Doc. 01/172. Serial No. N4517. 18p.

Evans, G.T. 2000. Local estimation of probability distribution and how it depends on covariates. Can. Stock Advisory Secr. Res. Doc. 2000/120. 11pp. http://www.dfompo.gc.ca/CSAS/Csas/English/Research_Years/2000/2000_120e.htm

Evans, G.T., D.G. Parsons, P.J. Veitch and D.C. Orr. 2000. A local-influence method of estimating biomass form trawl surveys, with Monte Carlo confidence intervals. J. Northw. Atl. Fish. Sci. Vol. 27: 133-138.

Golden Software, Inc. 2002. Surfer Version 8.0. contouring and 3D surface mapping for scientists and engineers. Golden Colorado. U.S.A.

Healey, B.P. and K.S. Dwyer. 2005. A simple examination of Canadian autumn survey trends in NAFO Division 3LNO for Greenland halibut and American plaice: the impact of the incomplete coverage of this survey in 2004. NAFO SCR. Doc. 05/34. Serial No. N5117. 28p.

MacDonald, P.D.M., and T. J. Pitcher. 1979. Age-groups from size-frequency data: a versatile and efficient method of analyzing distribution mixtures. J. Fish. Res. Broad. Can. 36:987 – 1001.

McCallum, B.R. and S.J. Walsh. 1996. Groundfish survey trawls used at the Northwest Atlantic Fisheries Centre, 1971 – present. NAFO SCR Doc. 96/50. Serial No. N2726. 18p.

McCrary, J.A. 1971. Sternal spines as a characteristic for differentiating between females of some Pandalidae. J. Fish. Res. Bd. Can.., 28: 98 – 100.

NAFO, 1999. Scientific Council Reports . p 207-215.

NAFO 2002. Scientific Council Reports. p. 237-238.

NAFO 2006. Scientific Council Reports. p.217-218.

Nicolajsen, A. 2002. Biomass estimate, growth, length and age distribution of the northern shrimp (*Pandalus borealis*) stock on Flemish Cap (NAFO division 3M) in June 2002. 20 p.

Orr, D.C., P.J. Veitch and D.J. Sullivan. 2007. Northern shrimp (*Pandalus borealis*) off Baffin Island, Labrador and northeastern Newfoundland. CSAS Res. Doc. In press.

Orr, D. C., P.J. Veitch and D. Sullivan. 2006. An update of Information pertaining to northern shrimp (*Pandalus borealis*) and groundfish in NAFO Divisions 3LNO. NAFO SCR. 06/73. Serial No. 5323. 56p.

Rasmussen, B. 1953. On the geographical variation in growth and sexual development of the Deep Sea Prawn (*Pandalus borealis*, Kr.). Norweg. Fish. And Mar. invest. Rep., 10 (3): 1-160.

SAS, 1993. Version 8.01. Carey, South Carolina. USA.

Shumaway, S.E., H.C. Perkins, D.F. Schick and A.P. Stickney, 1985. Synopsis of biological data on the pink shrimp *Pandalus borealis*, Kroyer. 1838 NOAA Technical Report NMFS30 FAO Fisheries Synopsis No. 144, 57 p.

Swain, D.P. and R. Morin. 1996. Relationships between geographic distribution and abundance of American plaice (*Hippoglossoides platessoides*) in the southern Gulf of St. Lawrence. Can. J. Fish. Aquat. Sci. Vol 53: 106 – 119.

Table 1. Annual nominal catches by country of northern shrimp (*Pandalus borealis*) caught in NAFO division 3L.

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Canada	78[1]	4,250[2]	5,129[2]	5,414[2]	10,008[2]	10,613[2]	11,176[2]	18,271[2]	14,435[2]	
Cuba				70[3]	146[1]	145[1]	136[1]			
Estonia		64[1]	2,264[4]	450[5]	152[1]	87[1]				
European Union					117[1]	159[1]	767[1]	1751[1]	1017[1]	
Faroe Islands	706[1]	42[1]	2,052[4]	620[5]		614[1]	1044[1]	947[1]	513[1]	
France (SPM)		67[1]		36[3]			147[1]			
Greenland		34[1]			672[8]	296[1]	302[1]	453[8]	455[8]	
Iceland		97[1]	55[7]	55[7]	133[7]	105[7]	140[11]	226[7]		
Latvia		64[1]	67[1]	59[3]	144[1]	105[1]				
Lithuania		67[1]	51[3]	67[3]	142[1]	62[1]				
Norway		77[1]	78[6]	70[6]	145[9]	148[1]	144[1]		246[1]	
Poland		40[1]	54[1]			144[1]				
Portugal			61[5]							
Russia		67[1]	67[1]	67[3]			144[1]	248[1]	97[1]	
Spain	11[1]		699[4]							
Ukraine			57[1]		144[1]	144[1]		119[10]		
USA				69[3]	144[1]		137[1]		245[1]	
Estimated additional								2,000[5]		
GRAND TOTAL	795	4,869	10,566	6,977	11,947	12,622	14,137	24,015	17,008	
TAC (tons)		6,000	6,000	6,000	13,000	13,000	13,000	22,000	22,000	22,000

Sources:

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

Table 2. Multiplicative year, month and vessel size model for Canadian small vessels (<= 500 t; <65') fishing northern shrimp in NAFO Div. 3L over the period 2000 – 2007. (Weighted by effort, single trawl, no windows, logbook data, history of at least two years in the fishery).

The GLM Procedure

Class Level Information

Class	Levels	Values
year	7	2000 2001 2002 2003 2004 2005 2006
month	6	5 7 8 9 10 99
size_class	3	1 2 3

Number of Observations Read	85
Number of Observations Used	85

Dependent Variable: lncpue
Weight: wfactor

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	7027.837747	540.602904	58.23	<.0001
Error	71	659.190920	9.284379		
Corrected Total	84	7687.028667			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.914246	49.54708	3.047028	6.149763

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	6	6421.173012	1070.195502	115.27	<.0001
month	5	442.765703	88.553141	9.54	<.0001
size_class	2	163.899032	81.949516	8.83	0.0004

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	6	3140.207007	523.367834	56.37	<.0001
month	5	489.235493	97.847099	10.54	<.0001
size_class	2	163.899032	81.949516	8.83	0.0004

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		6.560907797	B	0.03478894	188.59	<.0001
year	2000	-0.591892999	B	0.04811821	-12.30	<.0001
year	2001	-0.605471885	B	0.05466444	-11.08	<.0001
year	2002	-0.566964161	B	0.05323314	-10.65	<.0001
year	2003	-0.403301115	B	0.04733958	-8.52	<.0001
year	2004	-0.241349240	B	0.04257240	-5.67	<.0001
year	2005	0.121250535	B	0.04540668	2.67	0.0094
year	2006	0.000000000	B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
2000	5.781778	5.691742	5.871815
2001	5.768199	5.685112	5.851287
2002	5.806707	5.723157	5.890257
2003	5.970370	5.910128	6.030612
2004	6.132322	6.053441	6.211203
2005	6.494922	6.413156	6.576688
2006	6.373671	6.305579	6.441763

Table 3. Small vessel (<= 500 t; <65') shrimp fishing fleet catch rate indices for NAFO Div. 3L, 2000 – 2006.

YEAR	TAC (t)	CATCH[1] (t)	PERCENT OF[2] CATCH IN STANDARD DATASET	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE INDEX	EFFORT[3] (HR)	STANDARDIZED RELATIVE CPUE	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1999		17							
2000	2,500	3,247	78.0	317	0.555	10,230	0.553	324	10,011
2001	2,500	2,482	84.0	293	0.512	8,473	0.546	320	7,756
2002	2,500	2,861	85.7	302	0.528	9,479	0.567	333	8,605
2003	6,566	6,457	85.7	364	0.636	17,763	0.668	392	16,487
2004	6,566	6,576	91.1	455	0.796	14,458	0.786	461	14,280
2005	6,566	7,147	84.6	634	1.110	11,269	1.129	662	10,800
2006	12,297	12,112	67.5	571	1.000	21,194	1.000	586	20,662

[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 4. Multiplicative year, month ship and gear type model for Canadian large (>500 t) vessels fishing northern shrimp in NAFO Div. 3L over the period 2000 – 2007. (Weighting by effort, no windows, observer data, history of at least 2 years in the fishery).

The GLM Procedure

Class Level Information

Class	Levels	Values
year	8	2000 2001 2002 2003 2004 2005 2006 2007
month	7	1 2 3 4 5 6 12
CFV	12	
gear	2	double trawl single trawl

Number of Observations Read	140
Number of Observations Used	140

Dependent Variable: lncpue

Weight: effort effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	25	1672.335348	66.893414	14.79	<.0001
Error	114	515.710711	4.523778		
Corrected Total	139	2188.046058			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.764305	28.71830	2.126918	7.406140

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	7	714.1570022	102.0224289	22.55	<.0001
month	6	367.9724316	61.3287386	13.56	<.0001
CFV	11	498.0096312	45.2736028	10.01	<.0001
gear	1	92.1962826	92.1962826	20.38	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	7	368.3419540	52.6202791	11.63	<.0001
month	6	375.1338918	62.5223153	13.82	<.0001
CFV	11	456.1960987	41.4723726	9.17	<.0001
gear	1	92.1962826	92.1962826	20.38	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		7.798112913	B	0.17322693	45.02	<.0001
year	2000	-0.791721167	B	0.16346130	-4.84	<.0001
year	2001	-0.535990785	B	0.14417501	-3.72	0.0003
year	2002	-0.162768310	B	0.14835522	-1.10	0.2749
year	2003	0.098923124	B	0.15041475	0.66	0.5121
year	2004	-0.276983729	B	0.14755077	-1.88	0.0630
year	2005	-0.442151843	B	0.13981771	-3.16	0.0020
year	2006	-0.193355008	B	0.14332147	-1.35	0.1800
year	2007	0.000000000	B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
2000	6.950596	6.760610	7.140582
2001	7.206327	7.042841	7.369812
2002	7.579549	7.404649	7.754449
2003	7.841240	7.690663	7.991818
2004	7.465334	7.328197	7.602470
2005	7.300166	7.170846	7.429485
2006	7.548962	7.419151	7.678773
2007	7.742317	7.477074	8.007561

Table 5. Large vessel (>500 t) shrimp fishing fleet catch rate indices for NAFO Div. 3L, 2000 – 2007.

YEAR	TAC (t)	CATCH[1] (t)	PERCENT[2] CATCH OBSERVED	CPUE (KG/HR)	UNSTANDARDIZED CPUE INDEX	EFFORT (HR)	RELATIVE[3] CPUE	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1998		82							
1999		61							
2000	2,500	982	72	892	0.437	1,101	0.453	1,044	941
2001	2,500	2,394	78	1,362	0.666	1,758	0.585	1,348	1,776
2002	2,500	2,455	95	1,987	0.973	1,235	0.850	1,958	1,254
2003	4,267	3,956	83	3,222	1.577	1,228	1.104	2,543	1,555
2004	4,267	4,037	60	1,917	0.938	2,106	0.758	1,746	2,312
2005	4,267	4,037	71	1,733	0.848	2,330	0.643	1,481	2,727
2006	5,268	3,868	79	1,847	0.904	2,094	0.824	1,899	2,037
2007	6,023	2,073	35	2,043	1.000	1,015	1.000	2,304	900

[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 ship model for non Canadian vessels fishing northern shrimp in the NAFO Div. 3L NRA over the period 2000 – 2007. The model made use of Estonian, Icelandic, Greenlandic, Norwegian and Russian data.

The GLM Procedure

Class Level Information

Class	Levels	Values
year	8	2000 2001 2002 2003 2004 2005 2006 2007
ship	9	A C D H O P Q R S

Number of Observations Read	101
Number of Observations Used	101

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	15	1722.001820	114.800121	14.53	<.0001
Error	85	671.451147	7.899425		
Corrected Total	100	2393.452967			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.719463	41.88848	2.810592	6.709701

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	7	324.297291	46.328184	5.86	<.0001
ship	8	1397.704529	174.713066	22.12	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	7	132.561989	18.937427	2.40	0.0275
ship	8	1397.704529	174.713066	22.12	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		7.523773653	B	0.11559118	65.09	<.0001
year	2000	-0.034981434	B	0.26541638	-0.13	0.8955
year	2001	-0.229892520	B	0.26247471	-0.88	0.3836
year	2002	0.170978280	B	0.32467832	0.53	0.5998
year	2003	0.307708119	B	0.14409510	2.14	0.0356
year	2004	0.506431157	B	0.16036333	3.16	0.0022
year	2005	0.214173762	B	0.13554938	1.58	0.1178
year	2006	0.087129557	B	0.10497926	0.83	0.4089
year	2007	0.000000000	B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
2000	6.421759	6.004779	6.838739
2001	6.226848	5.782957	6.670739
2002	6.627719	6.056661	7.198776
2003	6.764448	6.516044	7.012853
2004	6.963172	6.675478	7.250865
2005	6.670914	6.436423	6.905406
2006	6.543870	6.349355	6.738385
2007	6.456740	6.218600	6.694881

Table 7. Estonian, Icelandic, Greenlandic, Norwegian and Russian shrimp fishing catch rate indices for the NAFO Div. 3L NRA, 2000 – 2007.

YEAR	TAC (t)	CATCH (t)	PERCENT CATCH OBSERVED	UNSTANDARDIZED CPUE (KG/HR)	CPUE INDEX	EFFORT (HR)	STANDARDIZED RELATIVE CPUE	MODELLED CPUE	EFFORT (HRS)
2000	1,000	619	27	724	0.77	855	0.97	615	1,006
2001	1,000	5505	1	381	0.40	14,466	0.79	506	10,876
2002	1,000	1563	4	650	0.69	2,406	1.19	756	2,068
2003	2,167	1939	46	1,272	1.35	1,524	1.36	866	2,238
2004	2,167	2009	41	1,700	1.80	1,182	1.66	1,057	1,901
2005	2,167	2961	33	980	1.04	3,023	1.24	789	3,752
2006	3,675	5744	35	943	1.00	6,093	1.09	695	8,265
2007	3,675	2573	43	944	1.00	2,725	1.00	637	4,039

Table 8. Northern shrimp stock size estimates in NAFO divisions 3LNO as calculated using ogmap. Data were obtained from annual spring and autumn Canadian multi-species bottom trawl surveys, 1995 – 2004. (Offshore strata only with standard 15 min. tows).

Spring stock size estimates.

Please note that it was not possible to sample all allocated stations within divs. 3NO; however all stations were sampled in 3L during spring 1996 (Fig. 2). The 1996 estimates are for Div. 3L only since at least 90% of the shrimp biomass and abundance is found within that division.

	Biomass (tons)			Abundance (numbers x 10-6)			Survey Sets
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	
1999	27,080	49,500	76,520	6,592	11,437	17,310	313
2000	65,710	113,300	176,700	13,150	21,356	31,590	298
2001	52,680	82,500	117,000	12,240	19,714	28,540	300
2002	87,390	133,800	204,700	20,730	31,260	47,660	300
2003	118,300	169,600	237,500	26,210	38,998	57,840	300
2004	40,030	100,900	172,300	7,830	19,444	34,480	296
2005	87,970	133,400	181,100	17,120	25,541	34,710	289
2006	105,700	176,500	241,300	21,490	34,038	46,670	195
2007	190,200	288,600	379,200	35,340	54,304	72,790	295

Autumn stock size estimates

It was not possible to sample all of the Div. 3L stations during 2004 therefore there are no estimates for autumn 2004.

	Biomass (tons)			Abundance (numbers x 10-6)			Survey Sets
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	
1995	7,132	8,500	14,830	2,108	2,733	4,800	337
1996	20,170	24,700	35,150	5,324	6,575	9,370	304
1997	32,410	44,000	61,940	7,545	9,911	13,860	318
1998	48,310	60,700	76,640	11,950	14,975	19,120	347
1999	43,160	54,900	72,390	10,620	12,993	16,510	313
2000	83,990	107,000	139,200	20,890	27,898	35,830	337
2001	155,300	215,400	259,600	36,890	51,730	62,040	362
2002	135,500	191,700	239,500	31,100	44,472	54,750	365
2003	143,300	191,100	244,600	30,310	39,515	49,240	316
2004		???			???		
2005	182,600	223,700	259,000	37,250	45,272	52,620	333
2006	172,900	215,400	252,000	36,460	47,051	55,710	312

Table 9. Northern shrimp stock size estimates in NAFO divisions 3LNO as calculated using stratified areal expansion methods. Data were obtained from annual spring and autumn Canadian multi-species bottom trawl surveys, 1995 – 2004. (Offshore strata only with standard 15 min. tows)

Spring stock size estimates.

Please note that it was not possible to sample all allocated stations within divs. 3NO; however all stations were sampled in 3L during spring 1996 (Fig. 2). The 1996 estimates are for Div. 3L only since at least 90% of the shrimp biomass and abundance is found within that division.

Year	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	No. Sets	No. Sets	No. Sets
1999	12,564	55,317	98,069	3,178	12,702	22,227	313	145	168
2000	-15,869	121,815	259,498	-54,743	25,012	104,768	298	134	164
2001	62,359	102,566	142,773	13,417	24,845	36,272	300	142	158
2002	121,067	159,491	197,916	28,311	37,512	46,714	300	142	158
2003	117,918	198,169	278,421	22,638	47,120	71,604	300	142	158
2004	-529,764	110,827	751,418	-97,747	21,696	141,395	296	139	157
2005	88,504	155,627	222,751	17,441	29,976	42,510	289	133	156
2006	69,546	180,642	291,738	56,127	35,199	14,271	195	141	54
2007	192,101	280,372	368,644	35,238	54,607	73,977	295	137	158

Autumn stock size estimates

It was not possible to sample all of the Div. 3L stations during 2004 therefore there are no estimates for autumn 2004.

	Biomass (tons)			Abundance (numbers x 10-6)			Survey
Year	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1995	3,639	5,921	8,202	659	2,054	3,449	337
1996	10,230	20,088	29,948	1,985	5,867	9,748	304
1997	25,530	46,202	66,875	6,280	10,523	14,766	318
1998	40,011	59,914	79,816	10,787	15,326	19,866	347
1999	36,202	53,144	70,086	9,588	13,060	16,533	313
2000	93,132	118,180	143,227	25,840	32,066	38,292	337
2001	77,563	223,995	370,427	20,177	54,077	87,978	362
2002	126,180	215,008	303,837	30,469	50,257	70,044	365
2003	106,338	223,568	340,798	29,708	47,281	64,853	316
2004		???			???		
2005	199,173	263,815	328,456	40,080	52,964	65,847	333
2006	200,006	248,791	297,575	43,246	53,909	64,570	312

Table 10. NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) biomass estimates for entire Divisions and outside the 200 Nmi limit. Shrimp were collected during the annual Canadian autumn multi-species research bottom trawl surveys using a Campelen 1800 shrimp trawl. (Standard 15 min. tows; no estimate for 3L in 2004 due to an incomplete survey; estimates derived by Ogmap calculations).

			Entire Division		Outside 200 Nmi limit			
Season	Year	Division	iomass estimate (t)	Percent by division	Biomass estimate (t)	Percent biomass by division	percent biomass in NRA	3 year running average percen biomass in NRA
Autumn	1995	3L	7,700	90.59	1,100	64.71	14.29	14.29
Autumn	1996	3L	22,900	92.71	4,000	85.11	17.47	15.88
Autumn	1997	3L	43,400	98.64	5,500	91.67	12.67	14.81
Autumn	1998	3L	56,000	92.26	8,900	81.65	15.89	15.34
Autumn	1999	3L	54,500	99.27	8,000	96.39	14.68	14.41
Autumn	2000	3L	105,800	98.88	22,100	98.22	20.89	17.15
Autumn	2001	3L	213,700	99.21	40,800	97.14	19.09	18.22
Autumn	2002	3L	187,800	97.97	35,200	92.39	18.74	19.57
Autumn	2003	3L	185,300	96.96	35,300	91.69	19.05	18.96
Autumn	2004	3L	???	???	???	???	??	??
Autumn	2005	3L	222,300	99.37	26,200	97.40	11.79	10.28
Autumn	2006	3L	213,700	99.21	27,100	96.44	12.68	12.23
Autumn	1995	3N	900	10.59	600	35.29	66.67	66.67
Autumn	1996	3N	2,000	8.10	700	14.89	35.00	50.83
Autumn	1997	3N	700	1.59	500	8.33	71.43	57.70
Autumn	1998	3N	4,700	7.74	2,000	18.35	42.55	49.66
Autumn	1999	3N	500	0.91	300	3.61	60.00	57.99
Autumn	2000	3N	700	0.65	400	1.78	57.14	53.23
Autumn	2001	3N	1,700	0.79	1,200	2.86	70.59	62.58
Autumn	2002	3N	4,000	2.09	2,900	7.61	72.50	66.74
Autumn	2003	3N	4,700	2.46	3,200	8.31	68.09	70.39
Autumn	2004	3N	2,600	???	2,100	???	???	???
Autumn	2005	3N	1000	0.45	700	2.60	70.00	46.03
Autumn	2006	3N	1500	0.70	1000	3.56	66.67	68.33
Autumn	1995	3O	0	0.00	0	0.00	0.00	0.00
Autumn	1996	3O	0	0.00	0	0.00	0.00	0.00
Autumn	1997	3O	0	0.00	0	0.00	0.00	0.00
Autumn	1998	3O	100	0.16	0	0.00	0.00	0.00
Autumn	1999	3O	0	0.00	0	0.00	0.00	0.00
Autumn	2000	3O	0	0.00	0	0.00	0.00	0.00
Autumn	2001	3O	0	0.00	0	0.00	0.00	0.00
Autumn	2002	3O	100	0.05	0	0.00	0.00	0.00
Autumn	2003	3O	200	0.10	0	0.00	0.00	0.00
Autumn	2004	3O	200	???	0	???	???	???
Autumn	2005	3O	100	0.04	0	0.00	0.00	0.00
Autumn	2006	3O	0	0.00	0	0.00	0.00	0.00
	all divisions							
Autumn	1995		8,500	101	1,700	100	20.00	20.00
Autumn	1996		24,700	101	4,700	100	19.03	19.51
Autumn	1997		44,000	100	6,000	100	13.64	17.55
Autumn	1998		60,700	100	10,900	100	17.96	16.87
Autumn	1999		54,900	100	8,300	100	15.12	15.57
Autumn	2000		107,000	100	22,500	100	21.03	18.03
Autumn	2001		215,400	100	42,000	100	19.50	18.55
Autumn	2002		191,700	100	38,100	100	19.87	20.13
Autumn	2003		191,100	100	38,500	100	20.15	19.84
Autumn	2004		???		???		???	???
Autumn	2005		223,700	100	26,900	100	12.03	10.72
Autumn	2006		215,400	100	28,100	100	13.05	12.54

Table 11. NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) biomass estimates for entire Divisions and outside the 200 Nmi limit. Shrimp were collected during the annual Canadian autumn multi-species research bottom trawl surveys using a Campelen 1800 shrimp trawl. (Standard 15 min. tows; no estimate for 3L in 2004 due to an incomplete survey; estimates derived by areal expansion calculations).

			Entire Division		Outside 200 Nmi limit			
Season	Year	Division	iomass estimate (t)	Percent by division	Biomass estimate (t)	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	45,383	94.92	20.56	20.32
Autumn	2004	3L	???	???	???	???	??	??
Autumn	2005	3L	263,307	99.81	29,409	98.55	11.17	10.58
Autumn	2006	3L	248,067	99.71	26,847	97.65	10.82	11.00
Autumn	1995	3N	533	9.00	497	32.34	93.29	93.29
Autumn	1996	3N	1,514	7.54	1,356	23.12	89.52	91.40
Autumn	1997	3N	427	0.92	391	7.09	91.52	91.44
Autumn	1998	3N	3,360	5.61	2,786	24.21	82.91	87.98
Autumn	1999	3N	272	0.51	232	2.59	85.57	86.67
Autumn	2000	3N	270	0.23	240	0.84	88.80	85.76
Autumn	2001	3N	836	0.37	809	1.52	96.77	90.38
Autumn	2002	3N	4,444	2.07	3,295	8.44	74.14	86.57
Autumn	2003	3N	2,785	1.25	2,421	5.06	86.93	85.95
Autumn	2004	3N	1,422	???	1,392	???	???	???
Autumn	2005	3N	423	0.16	403	1.35	95.27	60.73
Autumn	2006	3N	705	0.28	635	2.31	90.07	92.67
Autumn	1995	3O	31	0.52	1	0.04	1.82	1.82
Autumn	1996	3O	9	0.04	1	0.02	12.50	7.16
Autumn	1997	3O	17	0.04	4	0.07	23.79	12.70
Autumn	1998	3O	69	0.12	15	0.13	21.23	19.17
Autumn	1999	3O	9	0.02	3	0.03	33.59	26.21
Autumn	2000	3O	8	0.01	1	0.00	8.02	20.95
Autumn	2001	3O	10	0.00	3	0.01	30.00	23.87
Autumn	2002	3O	113	0.05	32	0.08	28.32	22.11
Autumn	2003	3O	72	0.03	8	0.02	11.11	23.14
Autumn	2004	3O	77	???	12	???	???	???
Autumn	2005	3O	84	0.03	30	0.10	35.71	15.61
Autumn	2006	3O	18	0.01	10	0.04	55.56	45.63
	all divisions							
Autumn	1995		5,921	100	1,537	100	25.96	25.96
Autumn	1996		20,089	100	5,862	100	29.18	27.57
Autumn	1997		46,202	100	5,509	100	11.92	22.35
Autumn	1998		59,914	100	11,508	100	19.21	20.10
Autumn	1999		53,144	100	8,969	100	16.88	16.00
Autumn	2000		118,180	100	28,687	100	24.27	20.12
Autumn	2001		223,995	100	53,104	100	23.71	21.62
Autumn	2002		215,008	100	39,029	100	18.15	22.04
Autumn	2003		223,568	100	47,813	100	21.39	21.08
Autumn	2004		???		???		???	???
Autumn	2005		263,815	100	29,842	100	11.31	10.90
Autumn	2006		248,790	100	27,492	100	11.05	11.18

Table 12. NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) biomass estimates for entire Divisions and outside the 200 Nmi limit. Shrimp were collected during the annual Canadian spring multi-species research bottom trawl surveys using a Campelen 1800 shrimp trawl. (Standard 15 min. tows; no estimate for 3L in 2004 due to an incomplete survey; estimates derived by Ogmap calculations).

			Entire Division		Outside 200 Nmi limit			3 year running
Season	Year	Division	iomass estimate (t)	Percent by division	Biomass estimate (t)	Percent biomass by division	percent biomass in NRA	average percen biomass in NRA
Spring	1999	3L	47,500	95.96	10,200	85.71	21.47	21.47
Spring	2000	3L	108,700	95.94	23,800	88.15	21.90	21.68
Spring	2001	3L	82,700	100.24	11,400	99.13	13.78	19.05
Spring	2002	3L	128,100	95.74	34,300	90.33	26.78	20.82
Spring	2003	3L	165,400	97.52	29,900	86.92	18.08	19.55
Spring	2004	3L	99,500	98.61	27,100	97.48	27.24	24.03
Spring	2005	3L	133,200	99.85	14,200	94.67	10.66	18.66
Spring	2006	3L	176,500	???	42,500	???	24.08	20.66
Spring	2007	3L	282,100	97.75	78,200	97.02	27.72	20.82
Spring	1999	3N	2,200	4.44	1,700	14.29	77.27	77.27
Spring	2000	3N	4,700	4.15	3,200	11.85	68.09	72.68
Spring	2001	3N	300	0.36	100	0.87	33.33	59.56
Spring	2002	3N	5,800	4.33	3,670	9.67	63.28	54.90
Spring	2003	3N	5,400	3.18	4,500	13.08	83.33	59.98
Spring	2004	3N	1,200	1.19	700	2.52	58.33	68.31
Spring	2005	3N	1,400	1.05	800	5.33	57.14	66.27
Spring	2006	3N	???	???	???	???	???	???
Spring	2007	3N	3,100	1.07	2,400	2.98	77.42	67.28
Spring	1999	3O	100	0.20	0	0.00	0.00	0.00
Spring	2000	3O	100	0.09	0	0.00	0.00	0.00
Spring	2001	3O	0	0.00	0	0.00	0.00	0.00
Spring	2002	3O	100	0.07	0	0.00	0.00	0.00
Spring	2003	3O	200	0.12	0	0.00	0.00	0.00
Spring	2004	3O	200	0.20	0	0.00	0.00	0.00
Spring	2005	3O	100	0.07	0	0.00	0.00	0.00
Spring	2006	3O	???	???	???	???	0.00	0.00
Spring	2007	3O	0	0.00	0	0.00	0.00	0.00
	all divisions							
Spring	1999		49,500	100.61	11,900	100.00	24.04	24.04
Spring	2000		113,300	100.18	27,000	100.00	23.83	23.94
Spring	2001		82,500	100.61	11,500	100.00	13.94	20.60
Spring	2002		133,800	100.15	37,970	100.00	28.38	22.05
Spring	2003		169,600	100.83	34,400	100.00	20.28	20.87
Spring	2004		100,900	100.00	27,800	100.00	27.55	25.40
Spring	2005		133,400	100.97	15,000	100.00	11.24	19.69
Spring	2006		???		???		???	???
Spring	2007		288,600	98.82	80,600	100.00	27.93	19.59

Table 13. NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) biomass estimates for entire Divisions and outside the 200 Nmi limit. Shrimp were collected during the annual Canadian spring multi-species research bottom trawl surveys using a Campelen 1800 shrimp trawl. (Standard 15 min. tows; no estimate for 3L in 2004 due to an incomplete survey; estimates derived by areal expansion calculations).

			Entire Division		Outside 200 Nmi limit			3 year running
Season	Year	Division	Biomass estimate (t)	Percent by division	Biomass estimate (t)	Percent biomass by division	percent biomass in NRA	average percent biomass in NRA
Spring	1999	3L	53,934	97.50	14,731	91.74	27.31	27.31
Spring	2000	3L	119,521	98.12	36,127	94.30	30.23	28.77
Spring	2001	3L	102,493	99.93	18,397	99.75	17.95	25.16
Spring	2002	3L	155,061	97.22	47,288	92.79	30.50	26.22
Spring	2003	3L	195,121	98.46	42,876	93.79	21.97	23.47
Spring	2004	3L	109,589	98.88	27,262	96.37	24.88	25.78
Spring	2005	3L	154,970	99.58	18,983	97.27	12.25	19.70
Spring	2006	3L	185,156	???	52,271	???	28.23	21.79
Spring	2007	3L	280,091	99.90	76,882	99.69	27.45	22.64
Spring	1999	3N	1,349	2.44	1,327	8.26	98.37	98.37
Spring	2000	3N	2,248	1.85	2,178	5.69	96.89	97.63
Spring	2001	3N	53	0.05	45	0.24	84.91	93.39
Spring	2002	3N	4,395	2.76	3,670	7.20	83.50	88.43
Spring	2003	3N	2,852	1.44	2,835	6.20	99.40	89.27
Spring	2004	3N	1,098	0.99	1,019	3.60	92.81	91.90
Spring	2005	3N	530	0.34	515	2.64	97.17	96.46
Spring	2006	3N	???	???	???	???	???	???
Spring	2007	3N	269	0.10	232	0.30	86.25	91.71
Spring	1999	3O	34	0.06	0	0.00	0.00	0.00
Spring	2000	3O	46	0.04	6	0.02	13.04	6.52
Spring	2001	3O	20	0.02	2	0.01	10.00	7.68
Spring	2002	3O	35	0.02	4	0.01	11.43	11.49
Spring	2003	3O	196	0.10	2	0.00	1.02	7.48
Spring	2004	3O	138	0.12	9	0.03	6.52	6.32
Spring	2005	3O	127	0.08	17	0.09	13.39	6.98
Spring	2006	3O	???	???	???	???	???	???
Spring	2007	3O	12	0.00	5	0.01	41.67	27.53
	all divisions							
Spring	1999		55,317	100.00	16,058	100.00	29.03	29.03
Spring	2000		121,815	100.00	38,311	100.00	31.45	30.24
Spring	2001		102,566	100.00	18,444	100.00	17.98	26.15
Spring	2002		159,491	100.00	50,962	100.00	31.95	27.13
Spring	2003		198,169	100.00	45,713	100.00	23.07	24.33
Spring	2004		110,827	100.00	28,289	100.00	25.53	26.85
Spring	2005		155,627	100.00	19,515	100.00	12.54	20.38
Spring	2006		???		???		???	???
Spring	2007		280,372	100.00	77,119	100.00	27.51	20.02

Table 14. Modal analysis using Mix 3.01 (MacDonald and Pitcher, 1993) of *P. borealis* in NAFO Divs. 3LNO from autumn Canadian multi-species bottom trawl surveys. Abundance at length determined via Ogmap calculations.

Mean Carapace Length (Standard Error)

	Age			
Year	1	2	3	4
1995	10.47 (.034)	15.35 (.058)	19.37 (.17)	
1996	10.81 (.076)	15.42 (.035)	18.78 (.070)	20.69 (.594)
1997	10.52 (.062)	15.60 (.067)	18.52 (.094)	20.32 (.446)
1998	10.24 (.018)	15.36 (.123)	18.63 (.135)	20.48 (.170)
1999	10.55 (.048)	15.45 (.018)	18.64 (.073)	20.47 (.050)
2000	9.99 (.029)	14.73 (.033)	17.66 (.021)	20.05 (.121)
2001	9.67 (.043)	14.52 (.022)	16.86 (.031)	19.10 (.015)
2002	9.82 (.027)	14.00 (.044)	17.10 (.030)	19.49 (.042)
2003	9.60 (.034)	14.61 (.031)	17.52 (.066)	19.44 (.030)
2004	Incomplete survey			
2005	10.11 (.022)	14.30 (.028)	17.02 (.025)	19.76 (.024)
2006	10.39 (.029)	14.50 (.016)	17.99 (.033)	20.11 (.025)

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

	Age				
Year	1	2	3	4	Total
1995	.509 (.012)	.412 (.014)	.079 (.009)		1.000
1996	.074 (.004)	.631 (.0115)	.218 (.037)	.077 (.032)	1.000
1997	.069 (.003)	.422 (.021)	.457 (.062)	.052 (.047)	1.000
1998	.234 (.004)	.204 (.017)	.428 (.068)	.133 (.054)	0.999
1999	.050 (.002)	.541 (.006)	.204 (.010)	.205 (.011)	1.000
2000	.061 (.002)	.342 (.007)	.460 (.015)	.137 (.011)	1.000
2001	.016 (.001)	.184 (.004)	.309 (.005)	.491 (.005)	1.000
2002	.032 (.001)	.136 (.004)	.438 (.016)	.394 (.014)	0.999
2003	.047 (.013)	.179 (.004)	.247 (.012)	.527 (.013)	1.000
2004	Incomplete survey				
2005	.033 (.001)	.137 (.004)	.454 (.005)	.376 (.007)	1.000
2006	.067 (.001)	.326 (.003)	.308 (006)	.299 (.006)	1.000

Distributional Sigmas (Standard Error and constraints)

	Age			
Year	1	2	3	4
1995	0.96 (.027)	1.22 (.060)	1.04 (.120)	
1996	1.16 (Fixed)	1.24 (.033)	.80 (.073)	1.25 (.240)
1997	1.13 (.051)	1.04 (.043)	.93 (.112)	.704 (.156)
1998	0.89 (.014)	1.21 (.073)	1.08 (.135)	0.75 (.070)
1999	0.97 (.011 Eq)	0.97 (.011 Eq)	0.97 (.011 Eq)	0.97 (.011 Eq)
2000	0.90 (.023)	1.12 (.024)	0.84 (.022)	1.20 (.056)
2001	0.99 (.008 Eq)	0.99 (.008 Eq)	0.99 (.008 Eq)	0.99 (.008 Eq)
2002	0.76 (.022)	1.03 (.032)	0.93 (.028)	1.01 (.020)
2003	1.12 (.012 Eq)	1.12 (.012 Eq)	1.12 (.012 Eq)	1.12 (.012 Eq)
2004	Incomplete survey			
2005	0.69 (C.V. = .068)	0.69 (C.V. = .068)	0.69 (C.V. = .068)	0.69 (C.V. = .068)
2006	1.12 (.008 Eq)	1.12 (.008 Eq)	1.12 (.008 Eq)	1.12 (.008 Eq)

Population at Age Estimates (10^6)

	Male Ages					Females	Total
Year	0	1	2	3	4		
1995	6	990	793	164	0	736	2,689
1996	3	441	3,724	1,288	458	657	6,571
1997	4	495	3,007	3,259	384	2,710	9,857
1998	1	3,006	2,614	5,492	1,727	2,132	14,972
1999	5	522	5,364	2,027	2,080	3,001	12,999
2000	5	1,454	8,081	10,875	3,269	4,248	27,932
2001	9	695	7,976	13,430	21,466	8,135	51,711
2002	3	1,154	4,865	15,165	13,682	9,597	44,465
2003	8	1,348	5,118	7,080	15,101	10,747	39,424
2004	Incomplete survey						
2005	13	1,188	4,786	15,859	13,166	11,056	46,067
2006	8	2,533	12,121	11,478	11,283	9,636	47,059

Table 15. Modal analysis using Mix 3.01 (MacDonald and Pitcher, 1993) of *P. borealis* in NAFO Divs. 3LNO from autumn Canadian multi-species bottom trawl surveys. Abundance at length determined via areal expansion calculations.

Mean Carapace Length (Standard Error)

	Age			
Year	1	2	3	4
1995	10.53 (.001)	13.27 (.006)	16.04 (.002)	19.5 (.012)
1996	11.32 (.002)	15.30 (.001)	18.75 (.002)	20.97 (.020)
1997	10.60 (.002)	15.61 (.001)	18.56 (.001)	20.65 (.010)
1998	10.34 (.001)	15.35 (.003)	18.61 (.003)	20.52 (.004)
1999	10.88 (.002)	15.50 (.000)	18.74 (.002)	20.60 (.001)
2000	10.03 (.001)	14.69 (.001)	17.63 (.001)	19.87 (.004)
2001	9.65 (.001)	14.59 (.001)	16.90 (.001)	19.12 (.000)
2002	9.80 (.001)	13.95 (.001)	17.14 (.001)	19.51 (.001)
2003	9.39 (.001)	14.55 (.001)	17.23 (.002)	19.34 (.001)
2004	Incomplete survey			
2005	10.12 (.001)	14.31 (.001)	17.06 (.001)	19.74 (.001)
2006	10.36 (.001)	14.50 (.001)	17.97 (.001)	20.09 (.001)

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

	Age				
Year	1	2	3	4	Total
1995	.666 (.012)	.057 (.001)	.184 (.001)	.093 (.001)	1.000
1996	.070 (.000)	.679 (.000)	.202 (.001)	.048 (.001)	0.999
1997	.070 (.000)	.392 (.000)	.517 (.000)	.021 (.001)	1.000
1998	.260 (.000)	.197 (.000)	.423 (.002)	.120 (.001)	1.000
1999	.043 (.000)	.565 (.000)	.197 (.000)	.195 (.023)	1.001
2000	.068 (.000)	.350 (.000)	.446 (.000)	.137 (.000)	1.001
2001	.014 (.000)	.197 (.000)	.301 (.000)	.488 (.000)	1.000
2002	.035 (.000)	.145 (.000)	.454 (.001)	.365 (.000)	0.999
2003	.054 (.000)	.175 (.000)	.210 (.000)	.561 (.000)	1.001
2004	Incomplete survey				
2005	.032 (.000)	.141 (.000)	.458 (.000)	.369 (.000)	1.000
2006	.066 (.001)	.324 (.000)	.302 (.000)	.308 (.001)	1.000

Distributional Sigmas (Standard Error and constraints)

	Age			
Year	1	2	3	4
1995	.85 (.001)	.63 (.007)	1.02 (.006)	1.35 (.007)
1996	1.07 (fixed)	1.08 (.001)	.86 (.003)	1.20 (.009)
1997	1.09 (.001)	0.89 (.001)	1.00 (.002)	.56 (.005)
1998	.87 (.000)	1.13 (.002)	1.06 (.003)	.72 (.002)
1999	.957 (Sigma eq .000)	.957 (Sigma eq .000)	.957 (Sigma eq .000)	.957 (Sigma eq .000)
2000	.86 (.001)	1.05 (.001)	.81 (.001)	1.27 (.002)
2001	.982 (Sigma eq .000)	.982 (Sigma eq .000)	.982 (Sigma eq .000)	.982 (Sigma eq .000)
2002	.75 (.001)	.97 (.001)	.97 (.001)	.99 (.001)
2003	1.16 (Sigma eq .000)	1.16 (Sigma eq .000)	1.16 (Sigma eq .000)	1.16 (Sigma eq .000)
2004	Incomplete survey			
2005	.68 (CV=.068)	.97 (CV=.068)	1.15 (CV=.068)	1.34 (CV=.068)
2006	1.12 (sigma eq. .000)	1.12 (sigma eq. .000)	1.12 (sigma eq. .000)	1.12 (sigma eq. .000)

Population at Age Estimates (10^6)

	Male Ages					All females	Total
Year	0	1	2	3	4		
1995	3	836	71	230	117	819	2,076
1996	0	392	3,704	1,101	268	402	5,857
1997	3	540	2,995	3,948	171	2,867	10,524
1998	0	3,456	2,620	5,635	1,611	2,007	15,330
1999	3	485	5,844	2,040	2,052	2,640	13,064
2000	9	1,886	9,716	12,388	3,821	4,333	32,152
2001	7	676	8,989	13,777	22,364	8,263	54,075
2002	0	1,409	5,768	18,056	14,523	10,500	50,256
2003	27	1,912	6,159	7,381	19,709	11,403	46,591
2004	Incomplete survey						
2005	18	1,282	5,612	18,206	14,685	13,163	52,967
2006	1	2,814	13,760	12,819	13,051	11,277	53,721

Table 16. Modal analysis using Mix 3.01 (MacDonald and Pitcher, 1993) of *P. borealis* in NAFO Divs. 3LNO from spring Canadian multi-species bottom trawl surveys. Abundance at length determined via Ogmap calculations.

Mean Carapace Length (Standard Error)

	Age			
Year	1	2	3	4
1999		13.93 (.025)	17.68 (.002)	19.96 (.043)
2000	8.22 (.044)	13.73 (.034)	17.49 (.024)	20.24 (.070)
2001	7.55 (.056)	13.21 (.052)	16.34 (.056)	18.60 (.045)
2002	7.78 (.062)	12.34 (.028)	16.45 (.021)	18.90 (.017)
2003	7.88 (.077)	12.79 (.026)	16.43 (.036)	18.85 (.019)
2004		13.02 (.094)	17.55 (1.049)	19.40 (.159)
2005	8.30 (.046)	13.39 (.042)	16.68 (.057)	19.05 (.054)
2006	8.91 (.075)	13.24 (.015)	16.80 (.058)	19.44 (.026)
2007		13.06 (.019)	16.66 (.019)	19.89 (.014)

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

	Age				
Year	1	2	3	4	Total
1999		.472 (.006)	.134 (.012)	.394 (.011)	1.000
2000	.022 (.001)	.353 (.006)	.454 (.012)	.171 (.009)	1.000
2001	.005 (.001)	.235 (.006)	.237 (.020)	.522 (.017)	0.999
2002	.018 (.001)	.101 (.002)	.396 (.006)	.485 (.006)	1.000
2003	.012 (.001)	.148 (.003)	.273 (.007)	.567 (.007)	1.000
2004		.111 (.008)	.333 (.252)	.556 (.245)	1.000
2005	.015 (.001)	.138 (.004)	.433 (.014)	.414 (.015)	1.000
2006	.005 (.000)	.288 (.003)	.184 (.007)	.523 (.008)	.999
2007		.205 (.003)	.374 (.004)	.421 (.004)	1.000

Distributional Sigmas (Standard Error and constraints)

	Age			
Year	1	2	3	4
1999		.914 (.001)	.796 (.001)	.932 (.001)
2000	.705 (.036)	1.317 (.026)	.916 (.026)	1.023 (.038)
2001	.443 (.044)	1.279 (.034)	.801 (.050)	1.02 (.024)
2002	.482 (.022)	1.018 (.028)	1.489 (.036)	.707 (.036)
2003	1.14 (sigmas eq; .010)	1.14 (sigmas eq; .010)	1.14 (sigmas eq; .010)	1.14 (sigmas eq; .010)
2004		1.11 (.053)	1.45 (.461)	1.06 (.082)
2005	.654 (CV = .079)	1.055 (CV = .079)	1.31 (CV = .079)	1.50 (CV = .079)
2006	.624 (CV = .07)	.928 (CV=.07)	1.18 (CV=.07)	1.36 (CV=.07)
2007	1.15 (sigmas eq: .007)	1.15 (sigmas eq: .007)	1.15 (sigmas eq: .007)	1.15 (sigmas eq: .007)

Population at Age Estimates (10^6)

	Male Ages					Females	Total
Year	0	1	2	3	4		
1999	38	95	4,063	1,155	3,398	2,669	11,417
2000	0	334	5,217	6,701	2,523	6,560	21,335
2001	0	76	3,540	3,568	7,938	4,687	19,809
2002	3	413	2,255	8,876	10,949	8,748	31,243
2003	24	331	3,908	7,209	15,009	12,485	38,967
2004	11	47	1,508	4,390	7,332	6,099	19,387
2005	5	224	2,045	6,396	6,144	10,746	25,560
2006	0	128	5,981	3,824	11,108	13,010	34,051
2007	3	66	6,866	12,514	14,247	25,214	58,911

Table 17. Modal analysis using Mix 3.01 (MacDonald and Pitcher, 1993) of *P. borealis* in NAFO Divs. 3LNO from spring Canadian multi-species bottom trawl surveys. Abundance at length determined via areal expansion calculations.

Mean Carapace Length (Standard Error)

	Age			
Year	1	2	3	4
1999		14.07 (.001)	17.62 (.002)	19.94 (.002)
2000		13.41 (.001)	17.22 (.001)	19.69 (.002)
2001		13.42 (.001)	16.83 (.001)	19.10 (.001)
2002		12.32 (.001)	16.19 (.001)	18.66 (.001)
2003		12.97 (.001)	16.50 (.001)	18.82 (.001)
2004		13.02 (.002)	17.57 (.022)	19.42 (.004)
2005		13.33 (.001)	16.65 (.001)	19.08 (.001)
2006		13.27 (.000)	16.94 (.002)	19.55 (.001)
2007		13.08 (.001)	16.38 (.001)	19.57 (.001)

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

	Age				
Year	1	2	3	4	Total
1999		.453 (.001)	.153 (.000)	.394 (.000)	1.000
2000		.319 (.000)	.515 (.000)	.166 (.000)	.999
2001		.210 (.000)	.290 (.000)	.500 (.000)	1.000
2002		.094 (.001)	.368 (.001)	.537 (.001)	.999
2003		.158 (.000)	.300 (.000)	.541 (.000)	1.000
2004		.124 (.000)	.356 (.006)	.520 (.006)	1.000
2005		.137 (.000)	.445 (.000)	.418 (.000)	1.000
2006		.294 (.000)	.204 (.000)	.501 (.001)	.999
2007		.215 (.000)	.314 (.000)	.471 (.000)	1.000

Distributional Sigmas (Standard Error and constraints)

	Age			
Year	1	2	3	4
1999		1.026 (.001)	.678 (.001)	1.03 (.001)
2000		.95 (CV=.071)	1.22 (CV=.071)	1.40 (.071)
2001		1.12 (sigma eq .000)	1.12 (sigma eq .000)	1.12 (sigma eq .000)
2002		.853 (CV=.067)	1.12 (CV=.067)	1.27 (CV=.067)
2003		1.08 (sigmas eq; 000)	1.08 (sigmas eq; 000)	1.08 (sigmas eq; 000)
2004		1.11 (.001)	1.44 (.010)	1.04 (.002)
2005		1.03 (CV = .075)	1.28 (CV = .075)	1.46 (CV=.075)
2006		.942 (CV=.071)	1.20 (CV=.071)	1.39 (CV=.071)
2007		1.13 (.001)	.898 (.001)	1.29 (.001)

Population at Age Estimates (10^6)

	Male Ages					Females	Total
Year	0	1	2	3	4		
1999	6	117	4,283	1,832	3,485	2,981	12,704
2000	7	434	5,196	8,388	2,833	8,044	25,013
2001	7	89	4,013	5,538	9,577	5,769	24,994
2002	17	442	2,618	9,633	14,068	10,731	37,509
2003	47	430	5,493	9,758	17,573	13,798	47,098
2004	6	177	2,073	6,244	6,546	3,175	21,645
2005	11	264	2,975	8,227	5,954	6,061	29,973
2006	5	151	6,615	4,596	11,274	8,986	36,087
2007	0	71	7,160	10,447	15,839	21,059	54,577

Table 18. Male and female biomass/ abundance indices estimated using Ogmap calculations from Canadian autumn research bottom trawl survey data, 1995 – 2006. Please note that there was an incomplete survey during 2004 therefore there are no values for that survey.

	Biomass (tons)			Abundance (numbers x 10^6)		
	Males	Females	Total	Males	Females	Total
1995	4,100	4,300	8,400	1,974	740	2,714
1996	18,900	5,800	24,700	5,904	659	6,564
1997	24,800	19,200	44,000	7,192	2,719	9,911
1998	42,500	18,200	60,700	12,842	2,133	14,975
1999	33,200	21,700	54,900	9,994	2,999	12,993
2000	74,500	32,600	107,100	23,649	4,249	27,898
2001	152,000	63,500	215,500	43,593	8,137	51,730
2002	122,300	69,500	191,800	34,878	9,595	44,472
2003	107,600	82,400	190,000	28,761	10,754	39,515
2004						
2005	128,400	95,300	223,700	34,033	11,238	45,271
2006	132,800	82,600	215,400	37,412	9,638	47,050

Table 19. Male and female biomass/ abundance indices estimated using Ogmap calculations from Canadian spring research bottom trawl survey data, 1999 – 2007. Please note that the survey was incomplete in Divs. 3NO during spring 2006; however, over 90% of the biomass/ abundance is found in 3L therefore the 2006 estimates are for 3L only.

	Biomass (tons)			Abundance (numbers x 10^6)		
	Males	Females	Total	Males	Females	Total
1999	29,400	20,100	49,500	8,767	2,670	11,437
2000	46,900	50,300	97,200	14,795	6,561	21,356
2001	50,000	32,500	82,500	15,066	4,648	19,714
2002	79,200	54,600	133,800	22,503	8,757	31,260
2003	91,100	78,500	169,600	26,516	12,482	38,998
2004	56,100	44,900	101,000	13,330	6,114	19,444
2005	52,700	80,700	133,400	14,803	10,738	25,541
2006	76,200	100,300	176,500	21,037	13,001	34,038
2007	111,900	176,700	288,600	31,334	22,970	54,304

Table 20. Male and female biomass/ abundance indices estimated using areal expansion calculations from Canadian autumn research bottom trawl survey data, 1995 – 2006. Please note that there was an incomplete survey during 2004 therefore there are no values for that survey.

	Biomass (t)			Abundance (numbers X 10^6)		
	Males	Females	Total	Males	Females	Total
1995	2,155	3,766	5,921	1,235	819	2,054
1996	16,576	3,513	20,089	5,466	401	5,867
1997	26,637	19,565	46,202	7,655	2,868	10,523
1998	43,121	16,793	59,914	13,319	2,007	15,326
1999	34,617	18,527	53,144	10,420	2,640	13,060
2000	85,663	32,517	118,180	27,735	4,331	32,066
2001	159,918	64,077	223,995	45,814	8,263	54,077
2002	138,564	76,444	215,009	39,757	10,500	50,257
2003	132,084	91,484	223,568	35,347	11,934	47,281
2004	??	??	??	??	??	??
2005	149,937	113,877	263,815	39,801	13,163	52,964
2006	152,003	96,787	248,790	42,631	11,277	53,908

Table 21. Male and female biomass/ abundance indices estimated using areal expansion calculations from Canadian autumn research bottom trawl survey data, 1999 – 2007. Please note that the survey was incomplete in Divs. 3NO during spring 2006; however, over 90% of the biomass/ abundance is found in 3L therefore the 2006 estimates are for 3L only.

	Biomass (tons)			Abundance (numbers x 10^6)		
	Males	Females	Total	Males	Females	Total
1999	33,055	22,262	55,317	9,722	2,981	12,703
2000	61,424	60,391	121,815	16,969	8,044	25,012
2001	62,778	39,788	102,566	19,130	5,714	24,845
2002	92,880	66,611	159,491	26,780	10,733	37,512
2003	112,201	85,969	198,169	33,323	13,798	47,121
2004	62,381	48,446	110,827	15,083	6,613	21,696
2005	61,773	93,854	155,627	17,432	12,544	29,976
2006	79,057	101,585	180,642	22,026	13,173	35,199
2007	117,781	162,591	280,372	33,543	21,063	54,607

Table 22. Fishable biomass (t) indices (total weight of all females + the weight of all males with carapace lengths=> 17.5 mm) as determined by areal expansion and Ogmap calculations from autumn and spring Canadian multi-species bottom trawl survey data, 1995 – 2007.

Areal expansion

	survey	
year	spring	autumn
1995		4,414
1996		9,993
1997		35,695
1998		46,785
1999	45,370	38,179
2000	92,808	85,003
2001	82,300	179,021
2002	129,540	174,720
2003	170,365	191,981
2004	97,869	
2005	135,154	213,983
2006	162,210	200,444
2007	245,631	

Ogmap

	survey	
year	spring	autumn
1995		5,251
1996		14,591
1997		34,129
1998		48,346
1999	43,015	40,999
2000	87,049	79,194
2001	72,454	173,138
2002	120,922	157,054
2003	159,393	166,240
2004	94,989	
2005	122,878	183,818
2006	165,069	173,117
2007	278,407	

Table 23. Recruitment indices (age 2 abundance) determined using Mix analysis of the shrimp carapace length frequency data. Length were obtained from the annual Canadian spring and autumn bottom trawl surveys (1995 –2007) and then calculations were made using areal expansion and Ogmap methods.

Areal expansion

	spring	autumn
1995		71
1996		3,704
1997		2,995
1998		2,620
1999	4,283	5,844
2000	5,196	9,716
2001	4,013	8,989
2002	2,618	5,768
2003	5,493	6,159
2004	2,073	????
2005	2,975	5,612
2006	6,615	13,760
2007	7,160	

Ogmap

	spring	autumn
1995		793
1996		3,724
1997		3,007
1998		2,614
1999	4,063	5,364
2000	5,217	8,081
2001	3,540	7,976
2002	2,255	4,865
2003	3,908	5,118
2004	1,508	
2005	2,045	4,786
2006	5,981	12,121
2007	6,866	

Table 24. Exploitation rate indices for NAFO Divs. 3LNO as determined using Canadian autumn survey and total catch data over the period 1996 – 2007. Ogmap methods were used in determining stock size indices.

Year	Catch (t)	Lower 95% CL of biomass index (t)	Spawning Stock biomass (SSB) (t)	Fishable biomass (t)
1995		7,132	4,300	5,251
1996	179	20,170	5,800	14,591
1997	485	32,410	19,200	34,129
1998	626	48,310	18,200	48,346
1999	795	43,160	21,700	40,999
2000	4,869	83,990	32,600	79,194
2001	10,566	155,300	63,500	173,138
2002	6,977	135,500	69,500	157,054
2003	11,947	143,300	82,400	166,240
2004	12,620			
2005	14,137	182,600	95,300	183,818
2006	24,015	172,900	82,600	173,117
2007	17,008			

Year		Catch / lower CL biomass	Catch/SSB	Catch/ fishable biomass
1995				
1996		0.025	0.042	0.034
1997		0.024	0.084	0.033
1998		0.019	0.033	0.018
1999		0.016	0.044	0.016
2000		0.113	0.224	0.119
2001		0.126	0.324	0.133
2002		0.045	0.110	0.040
2003		0.088	0.172	0.076
2004		0.088	0.153	0.076
2005				
2006		0.132	0.252	0.131
2007		0.098	0.206	0.098

Table 25. Exploitation rate indices for NAFO Divs. 3LNO as determined using Canadian autumn survey and total catch data over the period 1996 – 2007. Areal expansion methods were used in determining stock size indices.

Year	Catch (t)	Lower 95% CL of biomass index (t)	Spawning Stock biomass (SSB) (t)	Fishable biomass (t)
1995		3,639	3,766	4,414
1996	179	10,230	3,513	9,993
1997	485	25,530	19,565	35,695
1998	626	40,011	16,793	46,785
1999	795	36,202	18,527	38,179
2000	4869	93,132	32,517	85,003
2001	10566	77,563	64,077	179,021
2002	6977	126,180	76,444	174,720
2003	11947	106,338	91,484	191,981
2004	12620		??	
2005	14137	199,173	113,877	213,983
2006	24015	200,006	96,787	200,444
2007	17008			

Year		Catch / lower CL biomass	Catch/SSB	Catch/ fishable biomass
1995				
1996		0.049	0.048	0.041
1997		0.047	0.138	0.049
1998		0.025	0.032	0.018
1999		0.020	0.047	0.017
2000		0.134	0.263	0.128
2001		0.113	0.325	0.124
2002		0.090	0.109	0.039
2003		0.095	0.156	0.068
2004		0.119	0.138	0.066
2005				
2006		0.121	0.211	0.112
2007		0.085	0.176	0.085

Table 26. Estimated bycatch within the large vessel (>500 t) fleet fishing shrimp in 3L over the period 2004 - 2007.

	Atlantic cod				American plaice			
Year	2004	2005	2006	2007	2004	2005	2006	2007
Observed shrimp catch (t)	4,549	4,545	6,458	2,185	4,060	4,057	5,049	1,660
Logbook shrimp catch (t)	4,037	4,039	6,019	1,913	4,037	4,039	5,268	1,913
correction factor	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0434	1.1526
estimated bycatch (kg)	89	66	90	44	852	701	2,158	98
Bycatch (kg)/ (t) shrimp	0.02	0.02	0.01	0.02	0.21	0.17	0.36	0.05

	redfish				Greenland halibut			
Year	2004	2005	2006	2007	2004	2005	2006	2007
Observed shrimp catch (t)	4,060	4,057	5,049	1,660	4,060	4,057	5,049	1,660
Logbook shrimp catch (t)	4,037	4,039	5,268	1,913	4,037	4,039	5,268	1,913
correction factor	1.0000	1.0000	1.0434	1.1526	1.0000	1.0000	1.0434	1.1526
estimated bycatch (kg)	2,321	3,340	2,169	626	7,353	6,183	5,434	1,213
Bycatch (kg)/ (t) shrimp	0.57	0.83	0.41	0.33	1.82	1.53	1.03	0.63

Table 27. Estimated bycatch within the small vessel (<=500 t; LOA <100') fleet fishing shrimp in 3L over the period 2004 - 2007.

	Atlantic cod				American plaice			
Year	2004	2005	2006	2007	2004	2005	2006	2007
Observed shrimp catch (t)	318	182	725	133	318	182	725	133
Logbook shrimp catch (t)	6,576	7,070	12,261	11,063	6,576	7,070	12,261	11,063
correction factor	20.65	38.85	16.91	83.41	20.65	38.85	16.91	83.41
estimated bycatch (kg)	186	0	964	417	2,313	3,224	3,450	5,505
Bycatch (kg)/ (t) shrimp	0.03	0.00	0.08	0.04	0.35	0.46	0.28	0.50

	redfish				Greenland halibut			
Year	2004	2005	2006	2007	2004	2005	2006	2007
Observed shrimp catch (t)	318	182	725	133	318	182	725	133
Logbook shrimp catch (t)	6,576	7,070	12,261	11,063	6,576	7,070	12,261	11,063
correction factor	20.65	38.85	16.91	83.41	20.65	38.85	16.91	83.41
estimated bycatch (kg)	5,183	1,398	18,195	12,094	5,575	5,089	8,472	5,505
Bycatch (kg)/ (t) shrimp	0.79	0.20	1.48	1.09	0.85	0.72	0.69	0.50

Table 28. Various TAC scenarios using the inverse variance weighted average fishable biomass from the four most recent Canadian research surveys into 3LNO. Please note that due to rounding, it may not be possible to derive exactly the same fishable biomass or catch rates using the numbers presented in the tables below; however, the derived values should be within a few percent of the values shown in the tables.

Survey	Ogmap Fishable biomass (t)	Ogmap Biomass estimate – lower 95% C.I.= variance measure	Fishable biomass/ (variance measure)^2	1/(Variance measure)^2
Autumn 2005	183,818	41,100	1.0882 E^{-4}	5.9199 E^{-10}
Spring 2006	165,069	70,800	3.2931 E^{-5}	1.9950 E^{-10}
Autumn 2006	173,117	42,500	9.5843 E^{-5}	5.5363 E^{-10}
Spring 2007	278,407	98,400	2.8753 E^{-5}	1.0328 E^{-10}
Grand total			2.66346 E^{-4}	1.4484 E^{-9}

Inverse variance weighted average fishable biomass = 2.66346 E^{-4}÷1.4484 E^{-10}

= 183,890 t

Variance weighting factor = fishable biomass/ (variance measure)^2 ÷∑ fishable biomass/ (variance measure)^2

Survey	Ogmap Fishable biomass (t)	Variance weighting factor
Autumn 2005	183,818	0.409
Spring 2006	165,069	0.124
Autumn 2006	173,117	0.360
Spring 2007	278,407	0.108
Grand total		1.001

TAC options at various percent exploitation rates (catch/fishable biomass)

Inverse variance weighted average Ogmap fishable biomass (t)	12%	14.14%	16.31%
183,890	22,067	26,000	30,000

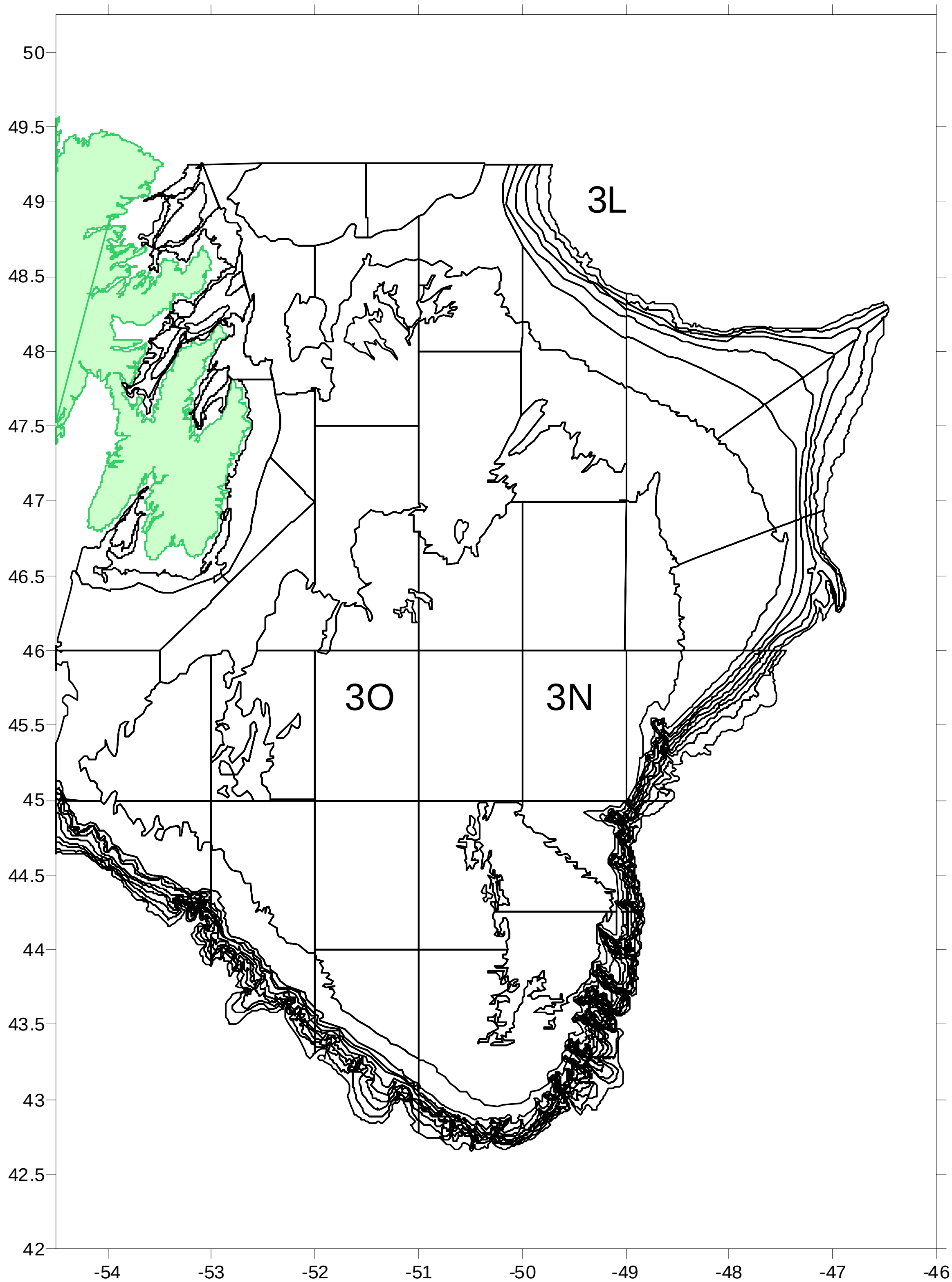


Figure 1. The NAFO Divs. 3LNO stratification scheme used in the Canadian multi-species research bottom trawl survey set allocation.

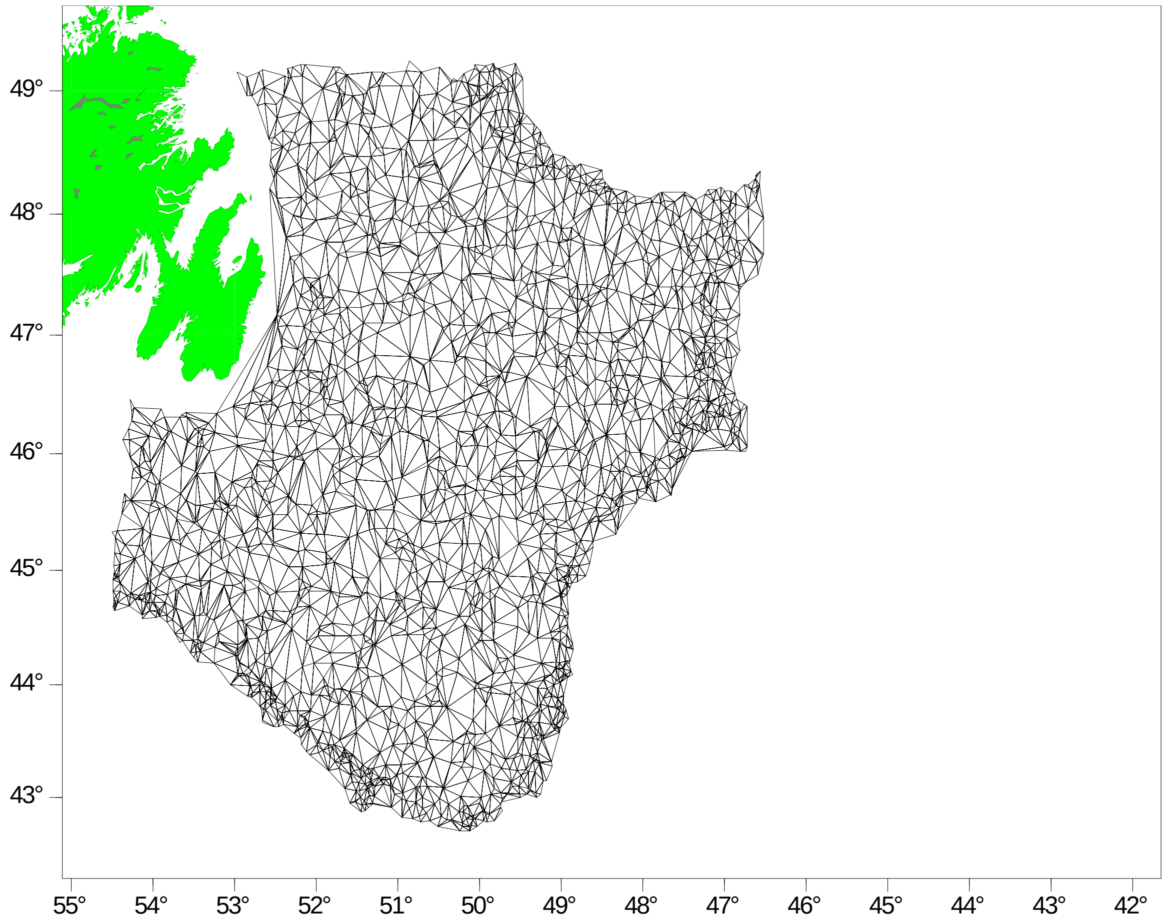


Figure 2. NAFO Divisions 3LNO – offshore Delauney triangulation used to derive the 3LNO biomass, abundance, fishable biomass, female biomass indices as well as population adjusted length frequencies using Ogmap.

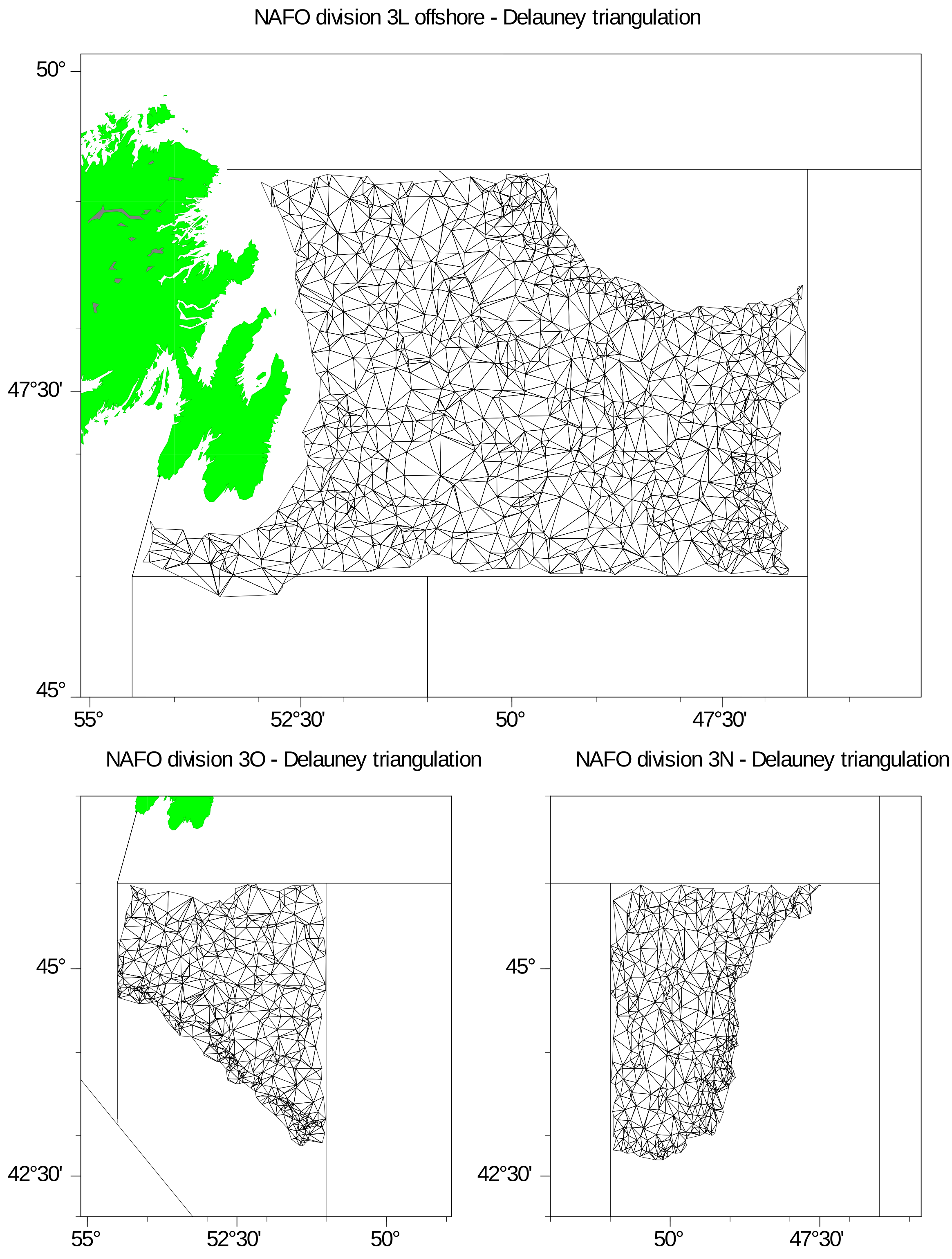


Figure 3. The Delauney triangulation used to derive within NAFO division ogmap biomass and abundance indices.

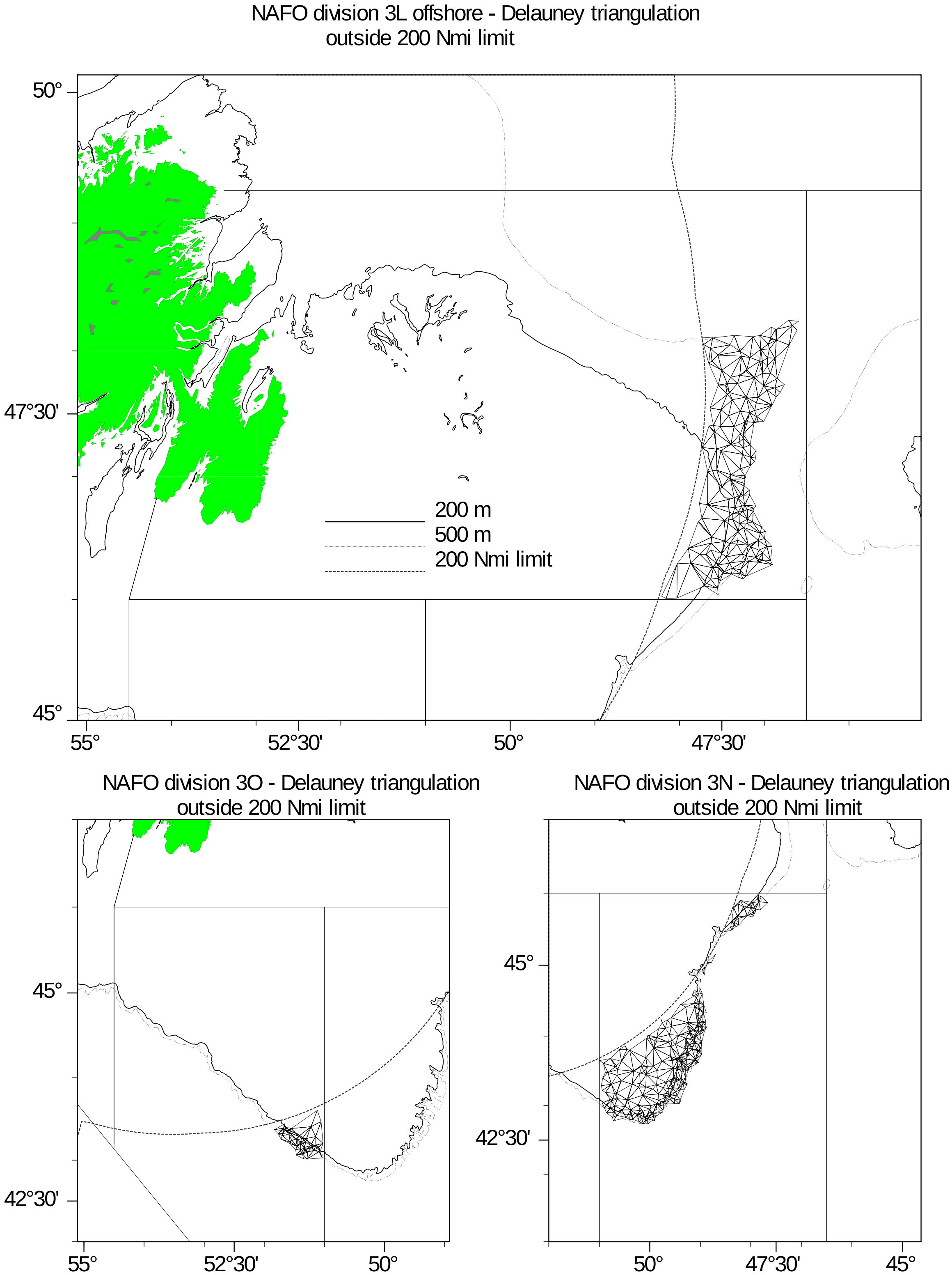


Figure 4. The Delauney triangulation used to derive the outside 200 Nmi limit ogmap biomass and abundance indices.

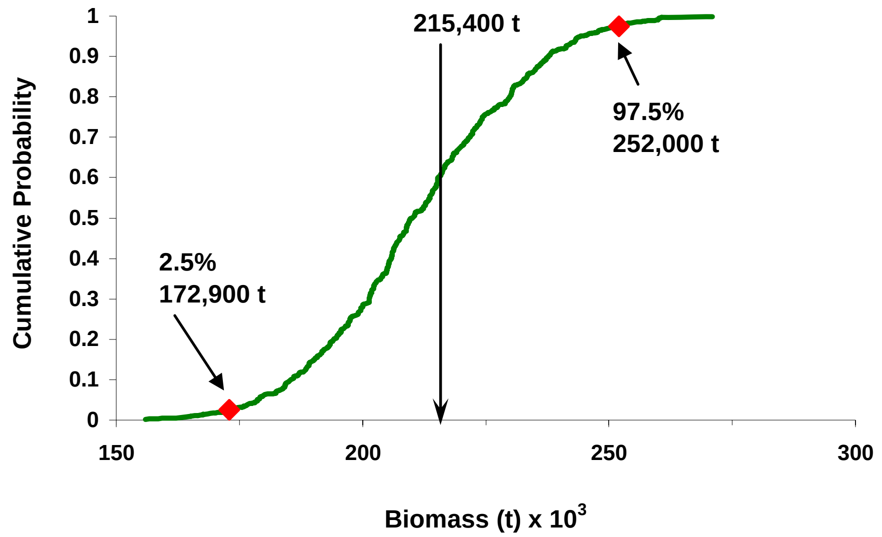


Figure 5. The Monte Carlo distribution for expected biomass of northern shrimp (*Pandalus borealis*) integrated over NAFO division 3LNO. Please note that the expected biomass index is calculated from the entire distribution rather than from the Monte Carlo simulations. The 95% confidence limits are found on the distribution ogive. The data used in this analysis were obtained during the autumn 2006 Canadian research bottom trawl survey.

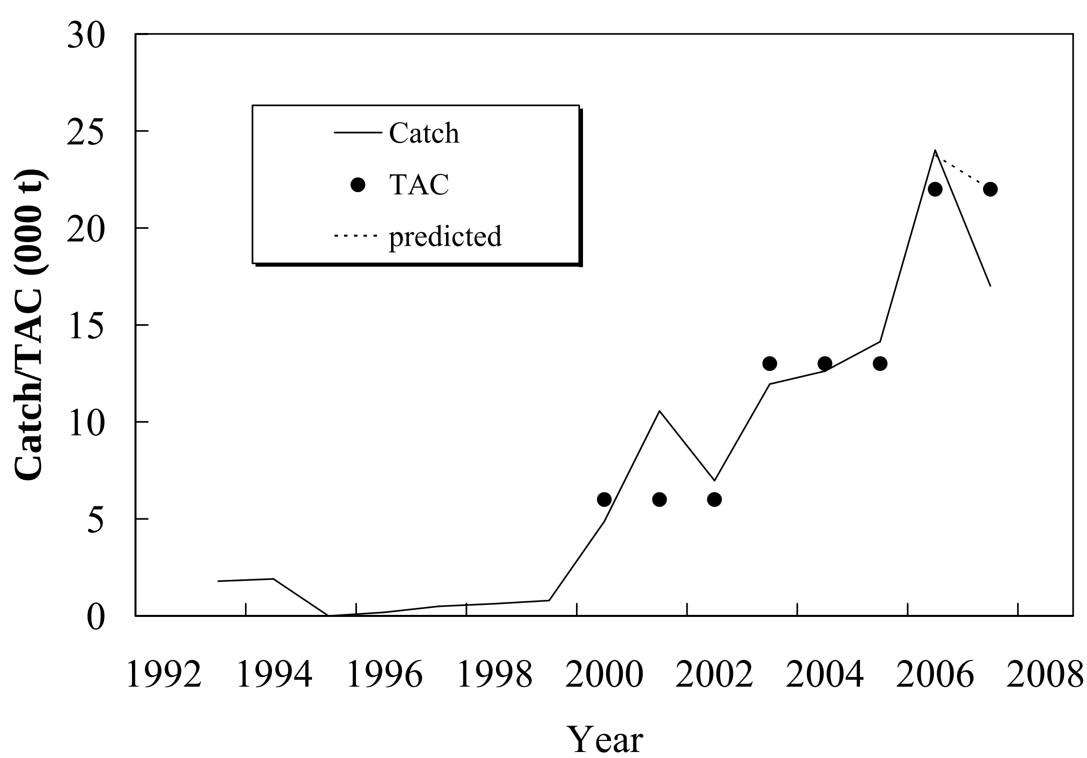


Figure 6. Trends in NAFO Div. 3L northern shrimp (*Pandalus borealis*) catch and TAC over the period 1993 – 2007.

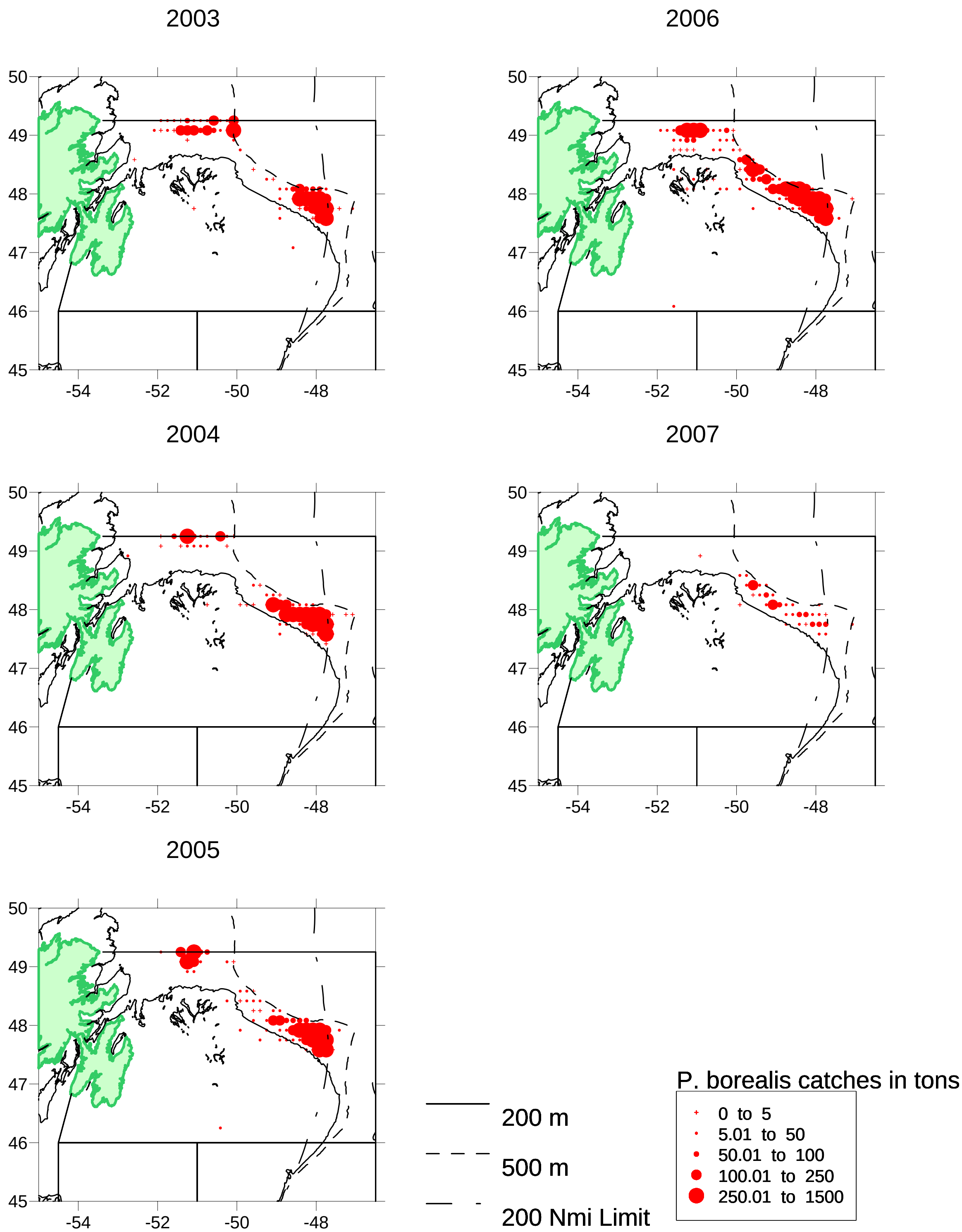


Figure 7. Distribution of Canadian small vessel (<= 500 t) shrimp catches in NAFO Div. 3L, 2003-2007. (Logbook data aggregated into 10 min X 10 min cells).

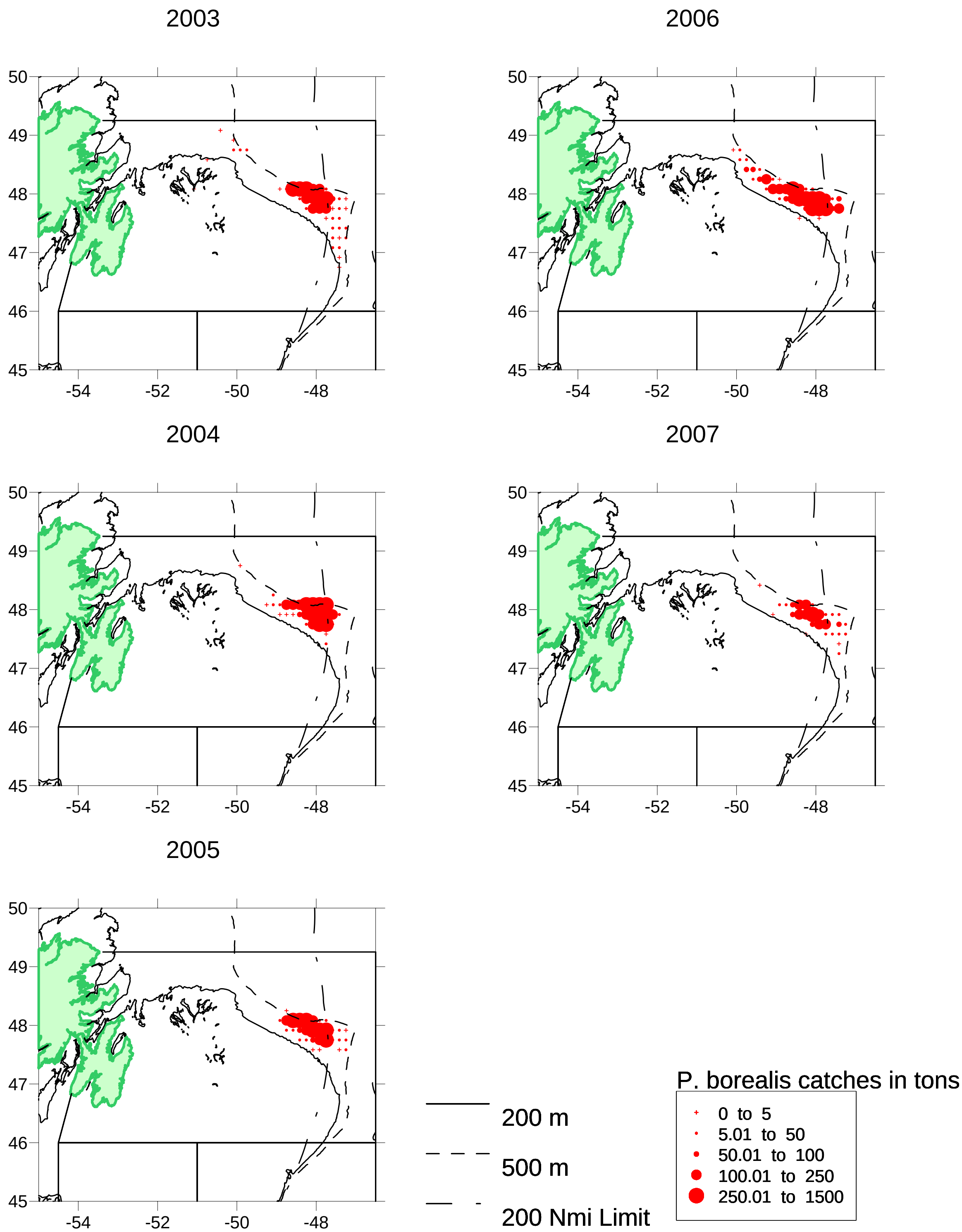


Figure 8. Distribution of Canadian large vessel (>500 t) shrimp catches in NAFO Div. 3L, 2003 – 2007. (Observer data aggregated into 10 min X 10 min cells).

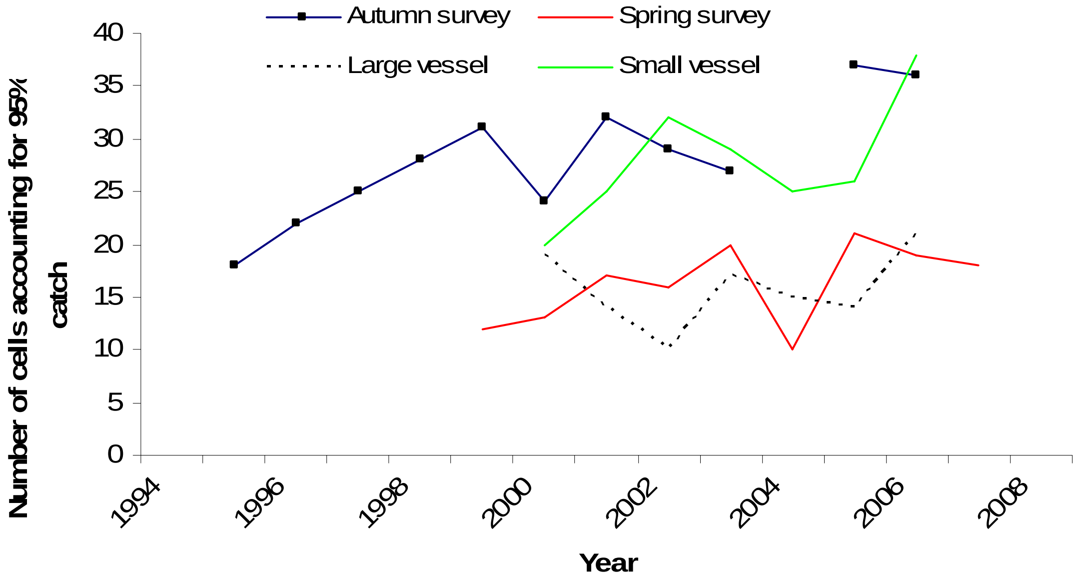


Figure 9. Trends in area occupied by northern shrimp (*Pandalus borealis*), within NAFO Divisions 3LNO, as determined from spring and autumn Canadian research survey and commercial shrimp catches.

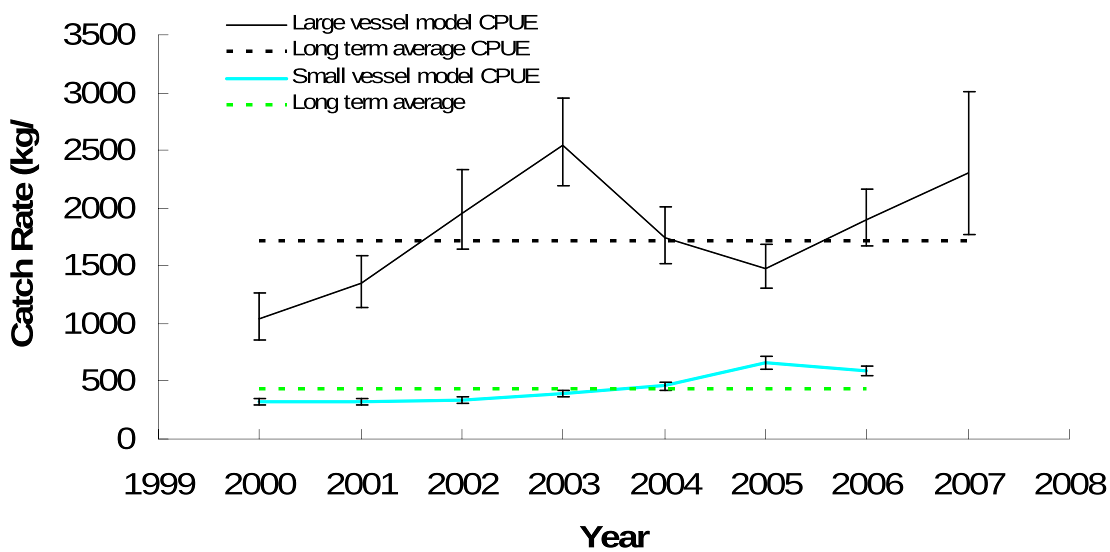
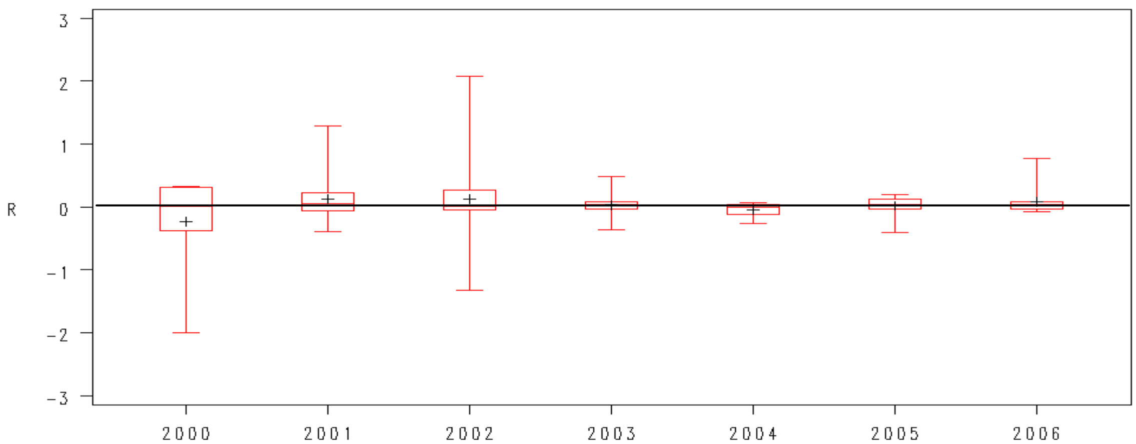
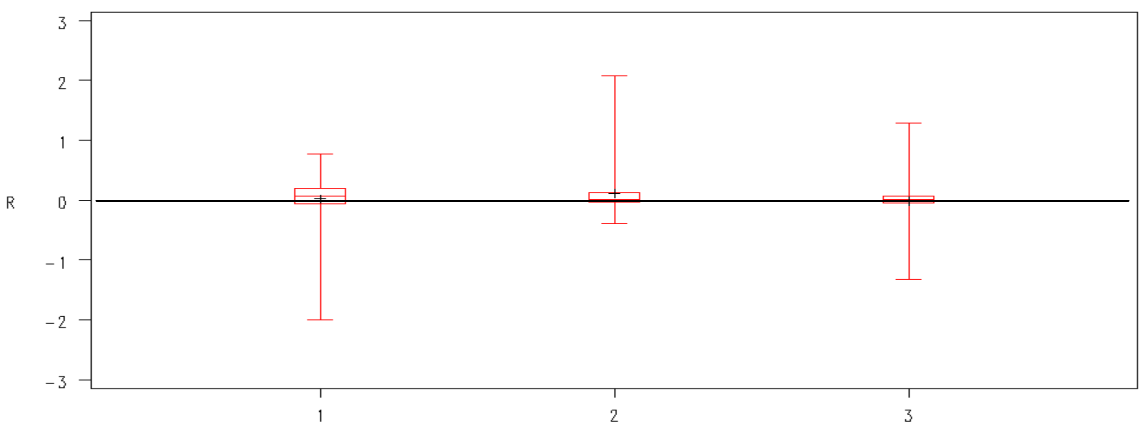


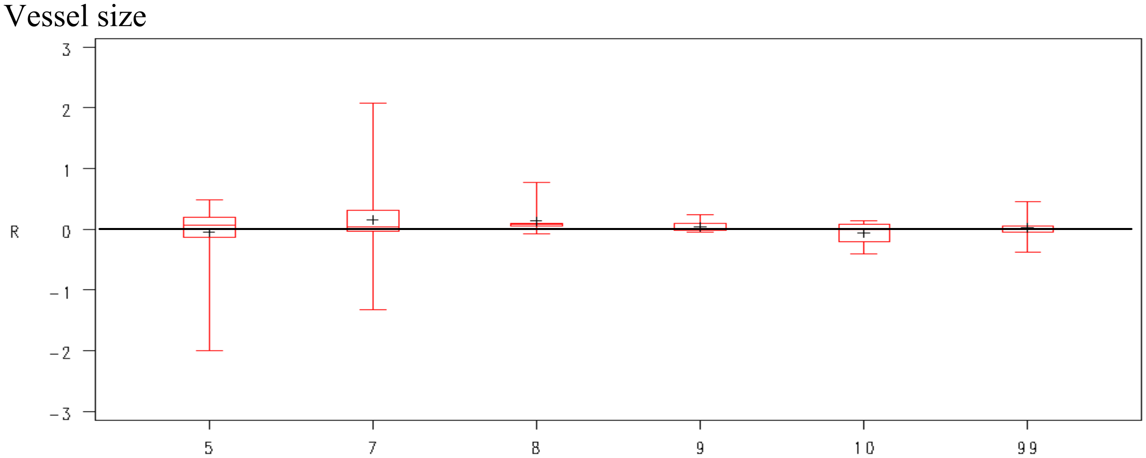
Figure 10. Model catch rates for Canadian large (>500 t) (2000 – 2007) and small (<=500 t; <65') (2000 – 2006) vessels fishing for shrimp in NAFO Div. 3L.



Year

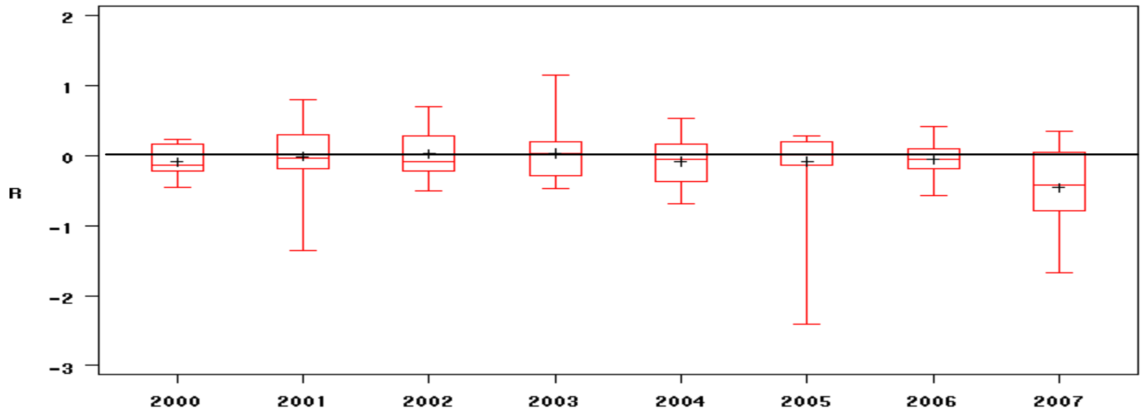


Vessel size

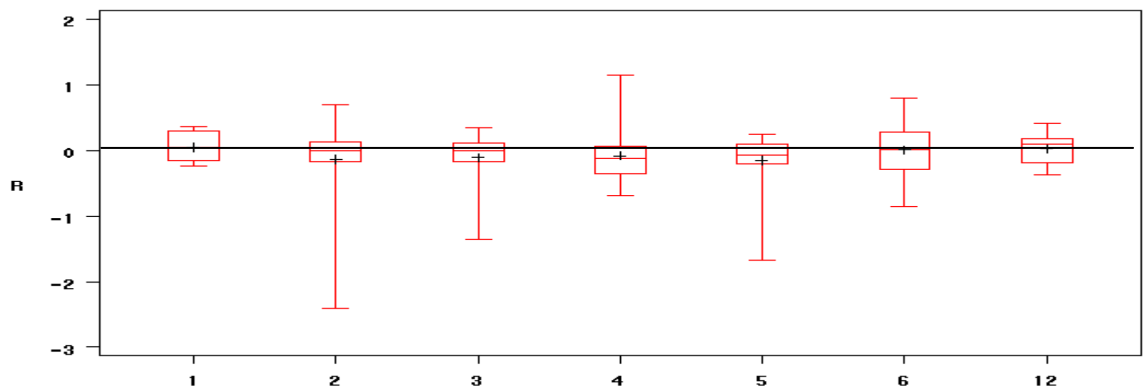


Month

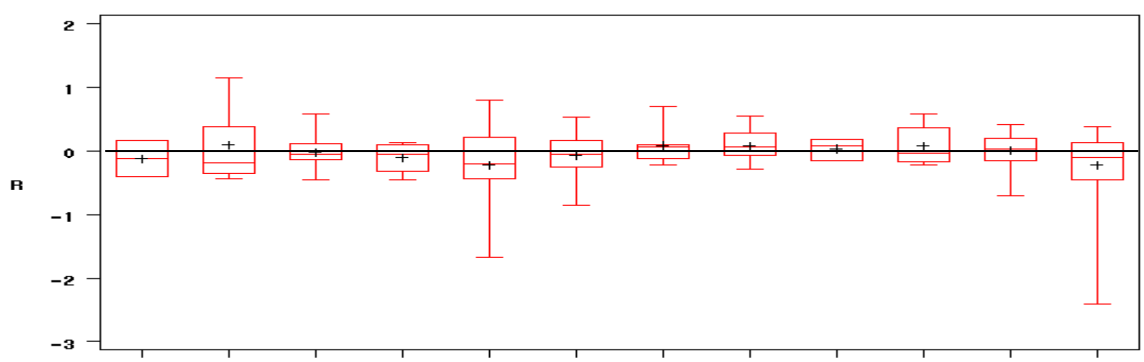
Figure 11. Distribution of residuals around estimated values for parameters used to model Canadian small vessel Div. 3L shrimp catch rates, 2000 – 2006.



Year



Month



Ship

Figure 12. Distribution of residuals around estimated values for parameters used to model Canadian large vessel Div. 3L shrimp catch rates, 2000 – 2007.

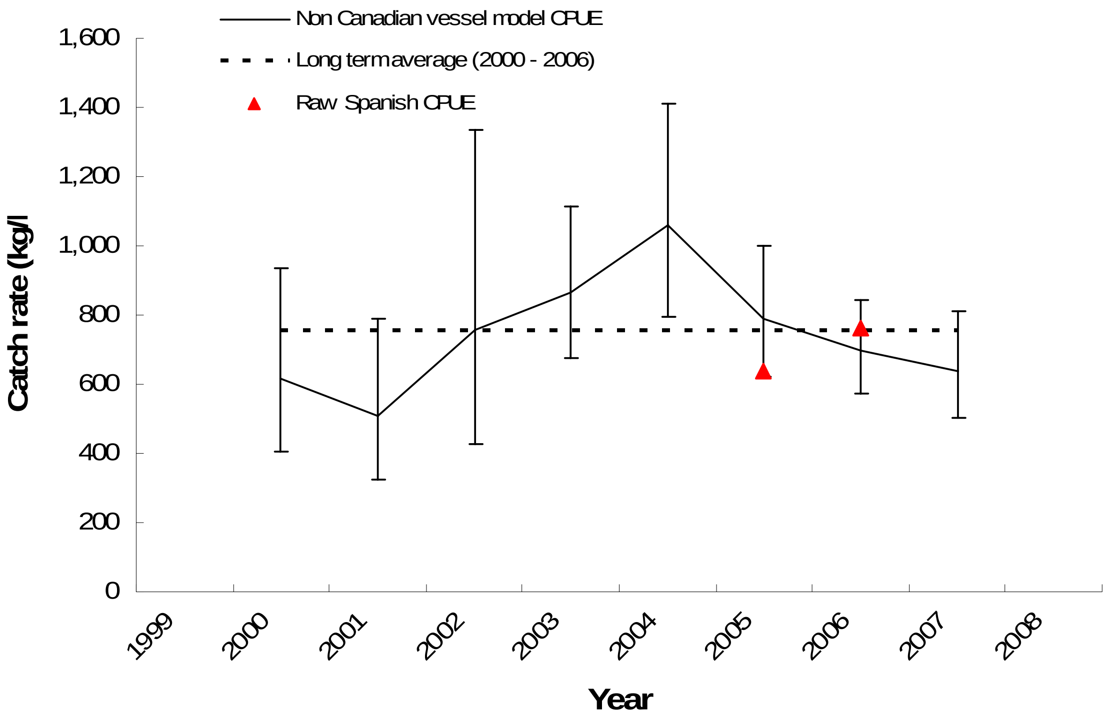
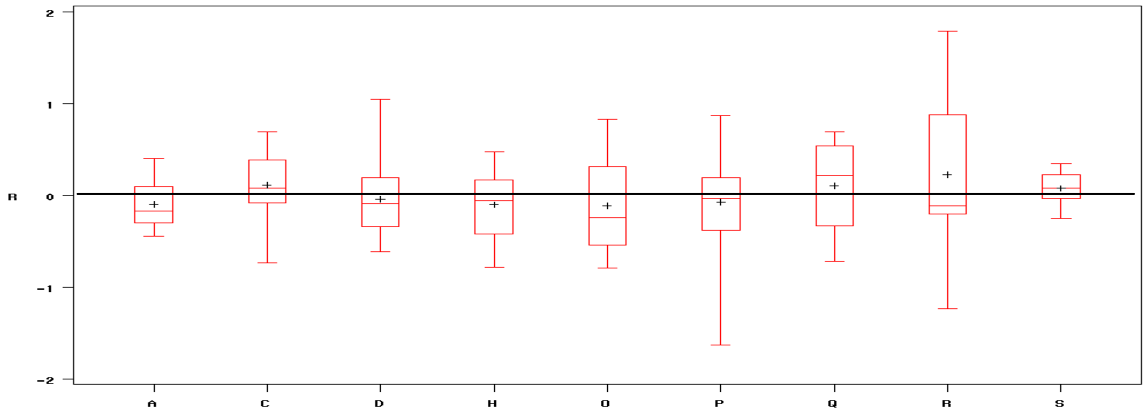
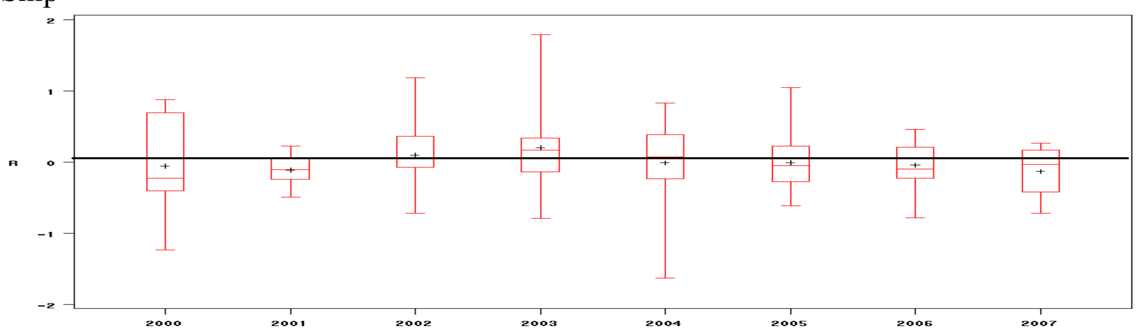


Figure 13. Model and raw catch rates for non Canadian vessels fishing shrimp in the NAFO Div. 3L NRA, 2000 – 2007. The modeled CPUE made use of data from Estonia, Iceland, Greenland and Norway. The raw CPUE values were from Spain.



Ship



Year

Figure 14. The distribution of residuals around estimated values for parameters used to model non Canadian vessel Div. 3L shrimp catch rates, 2000 – 2007.

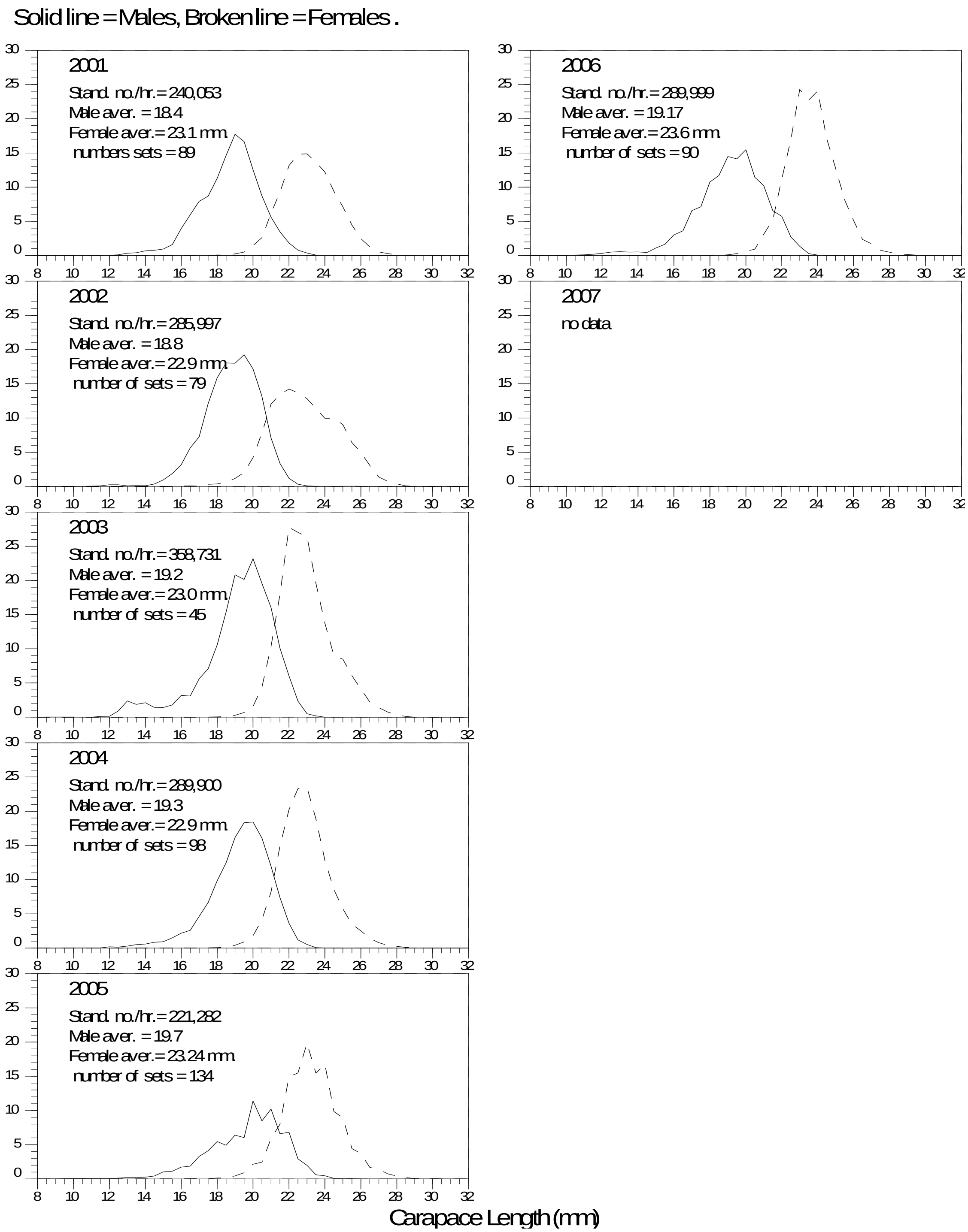


Figure 15. Observed northern shrimp (*Pandalus borealis*) length frequencies from the Canadian large vessel (>500 t) fleet fishing shrimp in NAFO Div. 3L over the period 2001 – 2006.

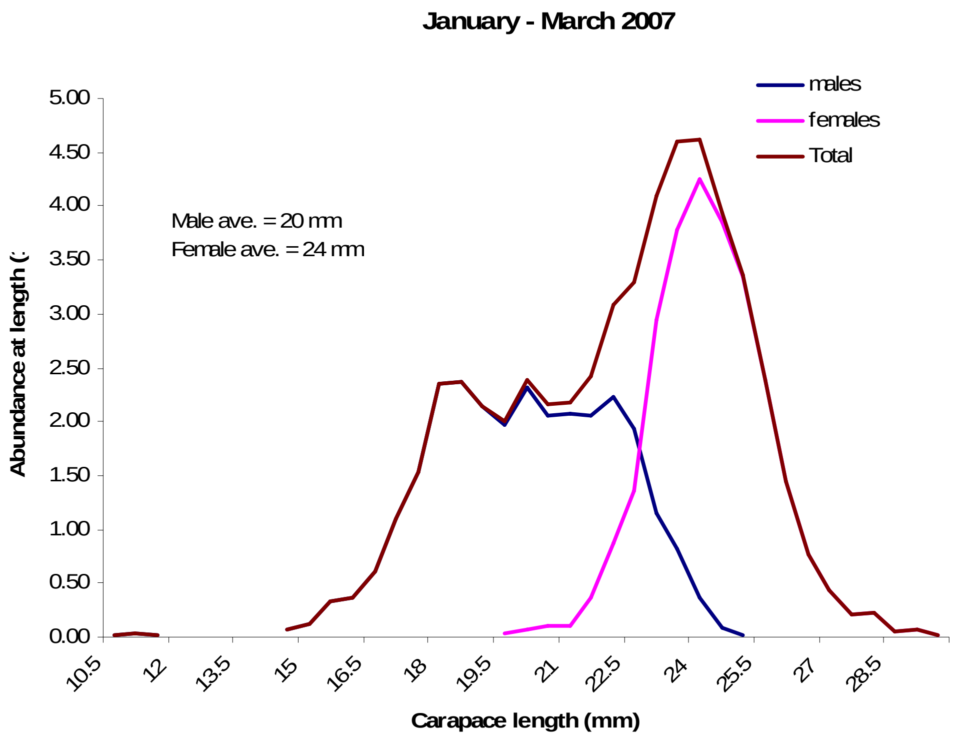


Figure 16. Observed length frequencies from the Spanish northern shrimp fishery in 3L during January – March, 2007.

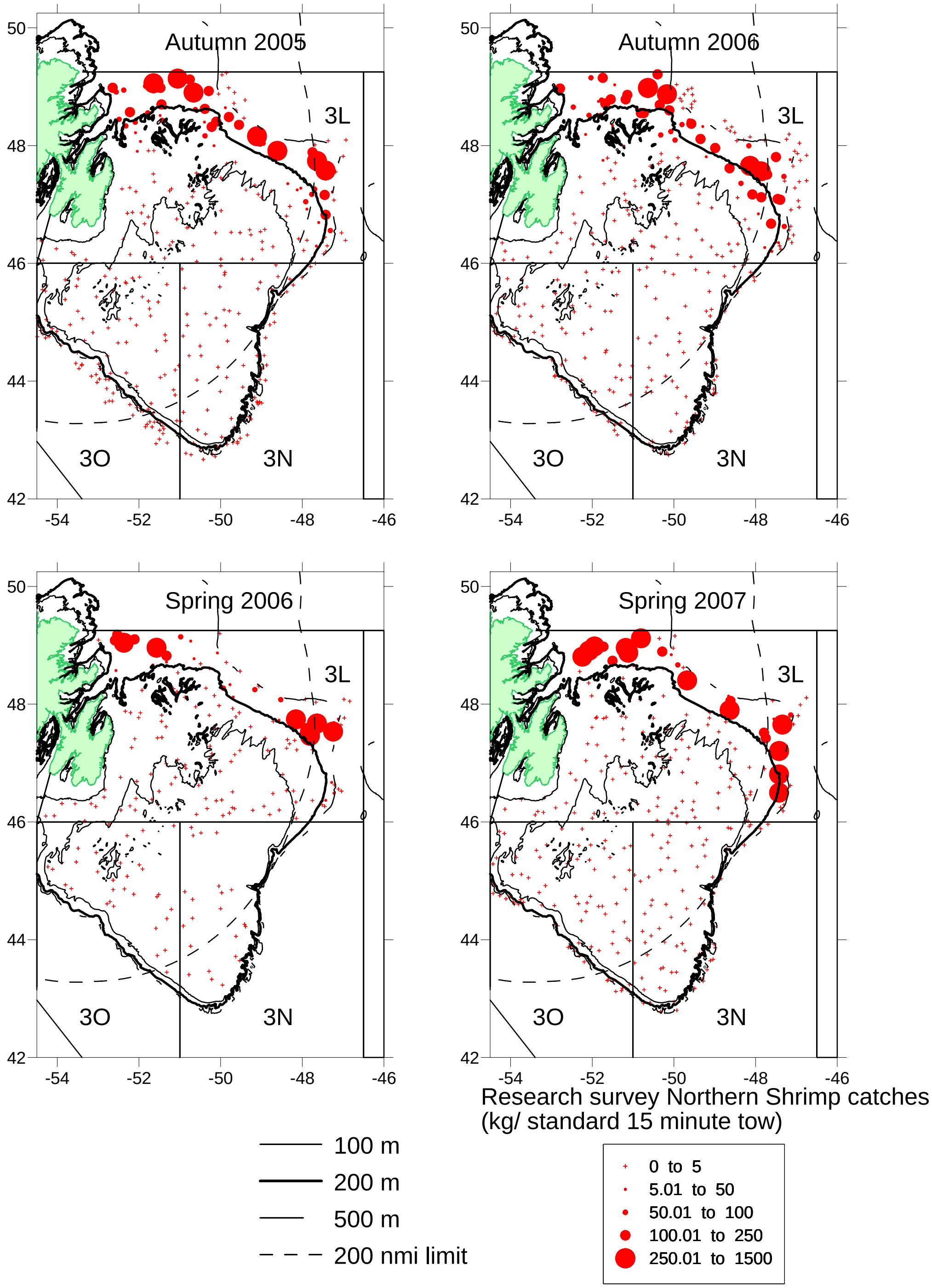


Figure 17. Distribution of NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) catches kg/tow) as obtained from autumn research bottom trawl surveys conducted over the period 2005-2007.

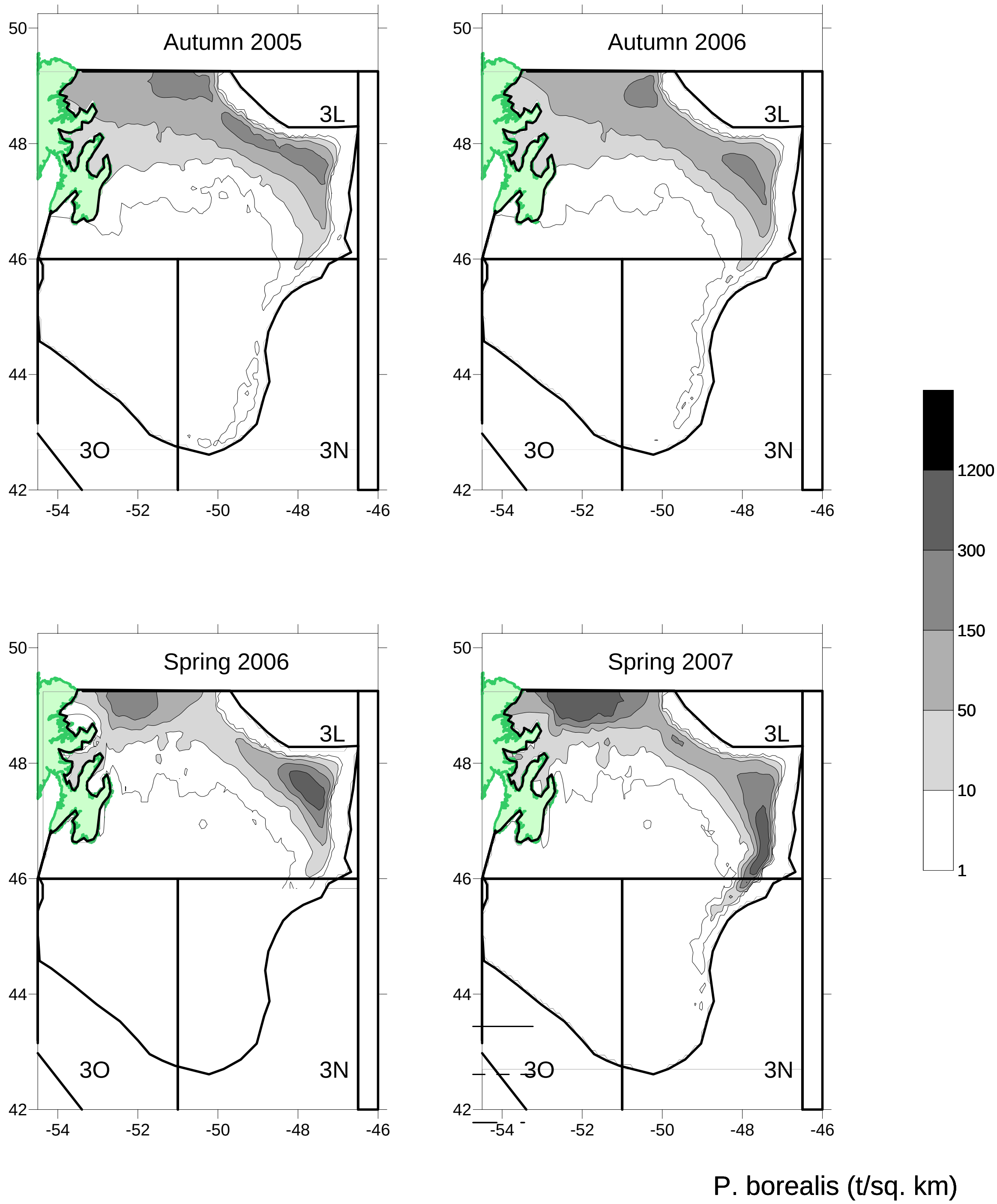


Figure 18. The estimated northern shrimp (*Pandalus borealis*) densities (t/sq. km) as calculated using ogmap. The data were obtained from spring and autumn Canadian research bottom trawl surveys conducted over the period 2005 – 2007 using a Camplen 1800 shrimp trawl. Please note that the spring 2006 was created from the 3L triangulation file since not all of 3NO was surveyed this is in keeping with the index estimation.

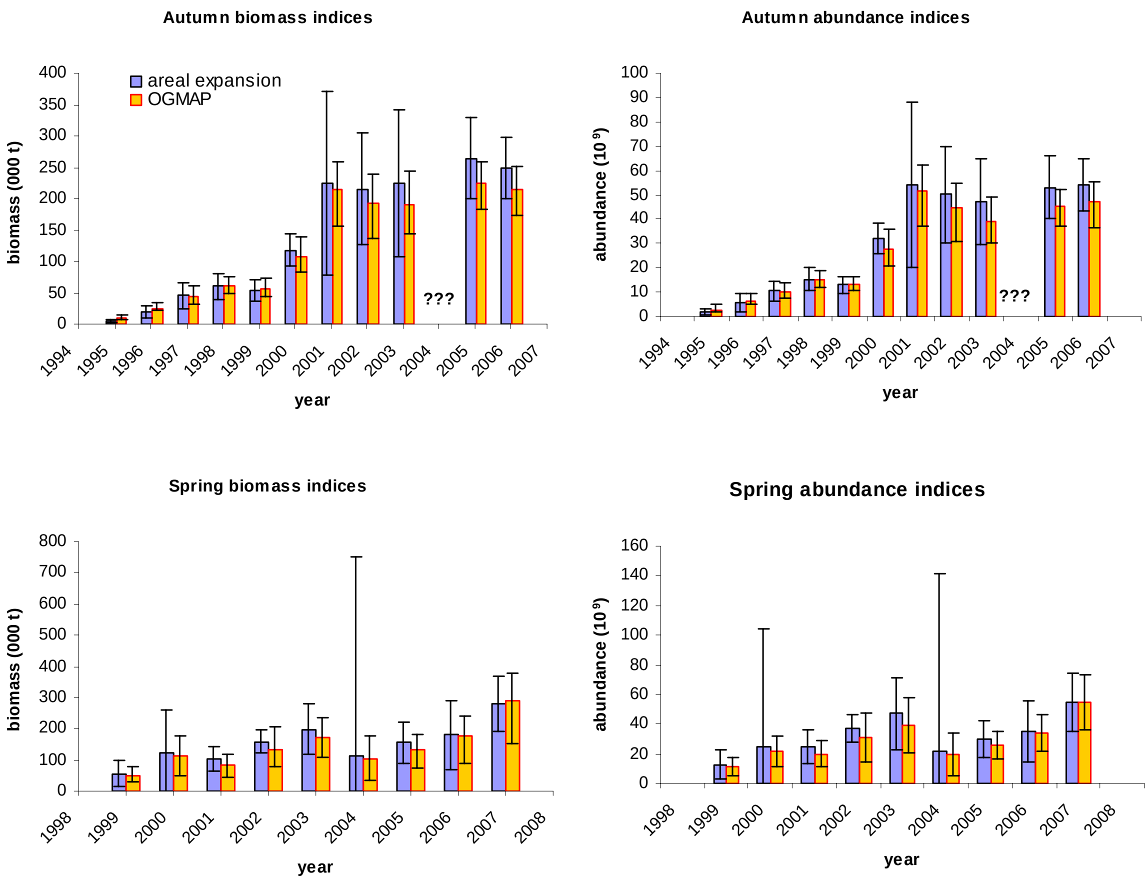


Figure 19. NAFO divisions 3LNO northern shrimp biomass and abundance indiceswith 95% confidence intervals as calculated using stratified areal expansion and ogmap methods. The data were obtained from annual spring and autumn Canadian research bottom trawl multi-species surveys. Note that the autumn 2004 survey was incomplete within important 3L strata and therefore there are no indices for that survey. The spring 2006 survey was also incomplete; however, all of 3L was surveyed therefore the 2006 indices are for 3L only.

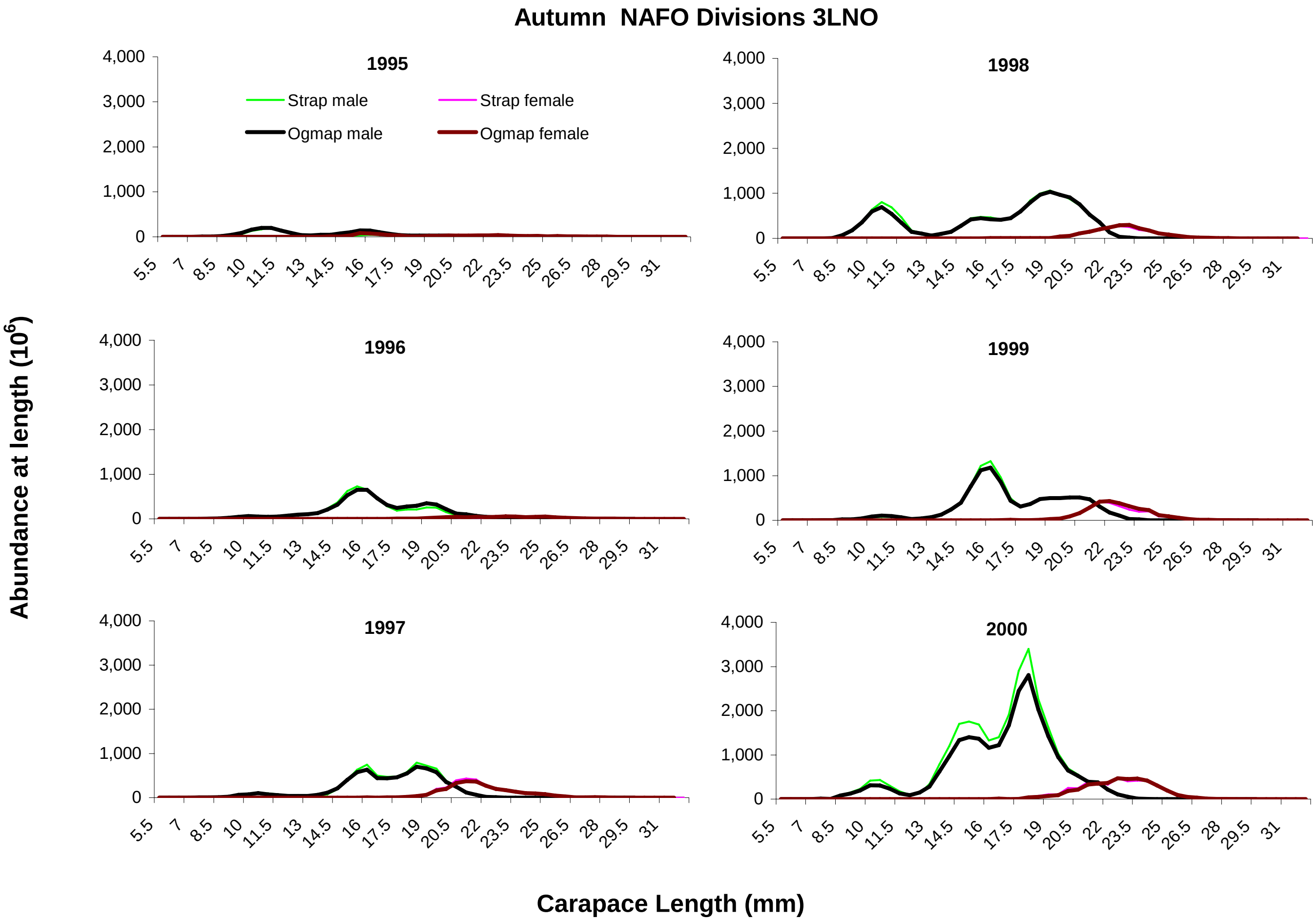


Figure 20. NAFO divisions 3LNO northern shrimp carapace length frequencies as calculated using stratified areal expansion and ogmap calculations. The data were obtained from annual autumn Canadian research bottom trawl surveys using a Campelen 1800 shrimp trawl. (Offshore strata only. Standard 15 min. tows.)

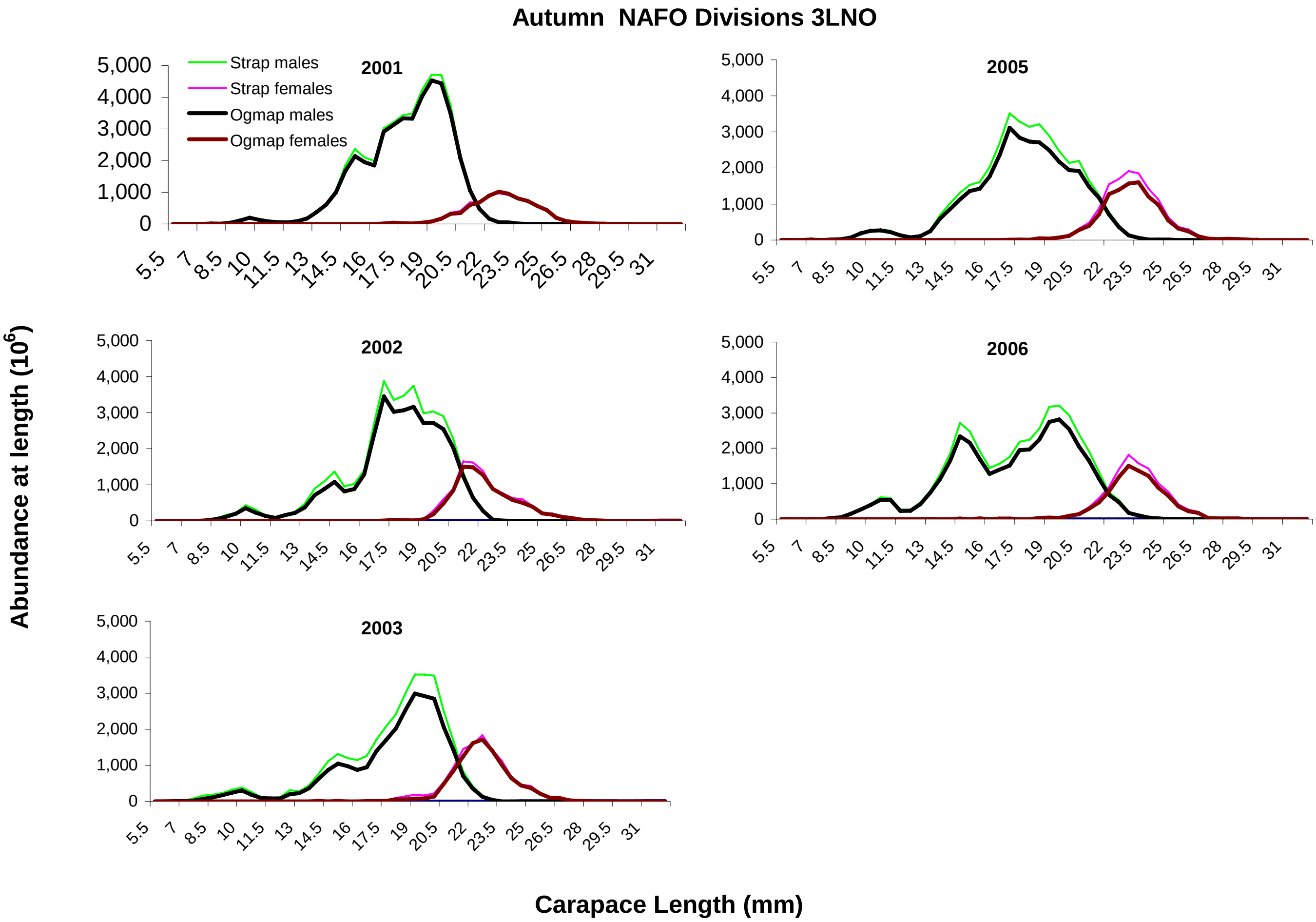


Figure 20. (Continued) NAFO divisions 3LNO northern shrimp carapace length frequencies as calculated using stratified areal expansion and ogmap calculations. The data were obtained from annual autumn Canadian research bottom trawl surveys using a Campelen 1800 shrimp trawl. (Offshore strata only. Standard 15 min. tows.)

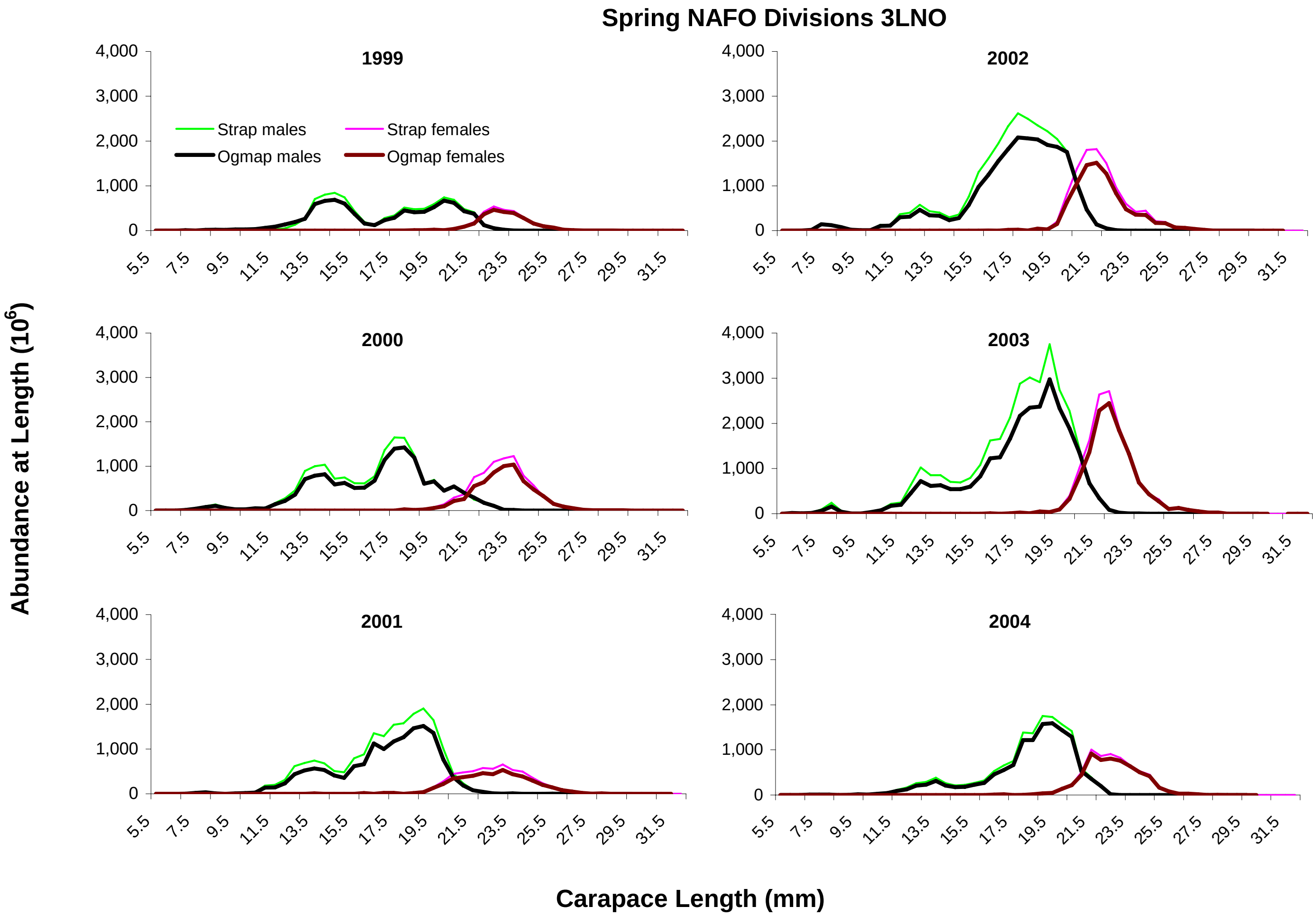


Figure 21. NAFO divisions 3LNO northern shrimp carapace length frequencies as calculated using stratified areal expansion and ogmap calculations. The data were obtained from annual spring Canadian research bottom trawl surveys using a Campelen 1800 shrimp trawl. (Offshore strata only. Standard 15 min. tows.)

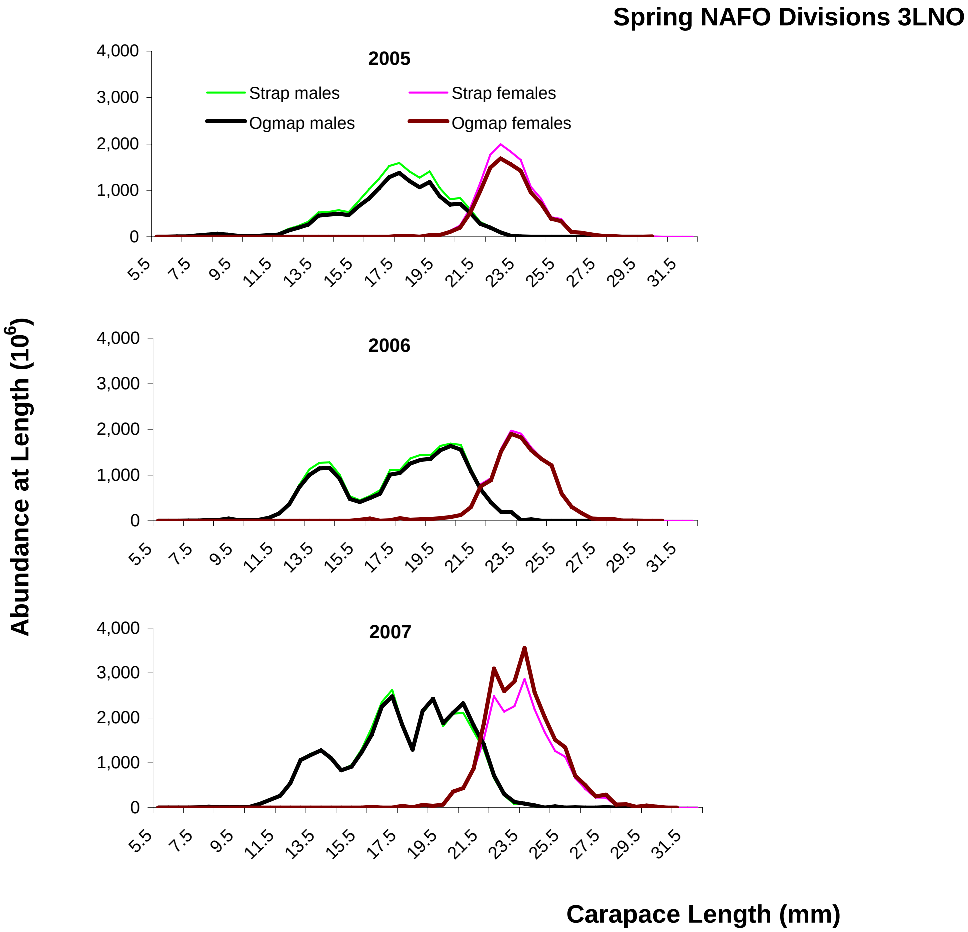


Figure 21. (Continued) NAFO divisions 3LNO northern shrimp carapace length frequencies as calculated using stratified areal expansion and ogmap calculations. The data were obtained from annual spring Canadian research bottom trawl surveys using a Campelen 1800 shrimp trawl. (Offshore strata only. Standard 15 min. tows.)

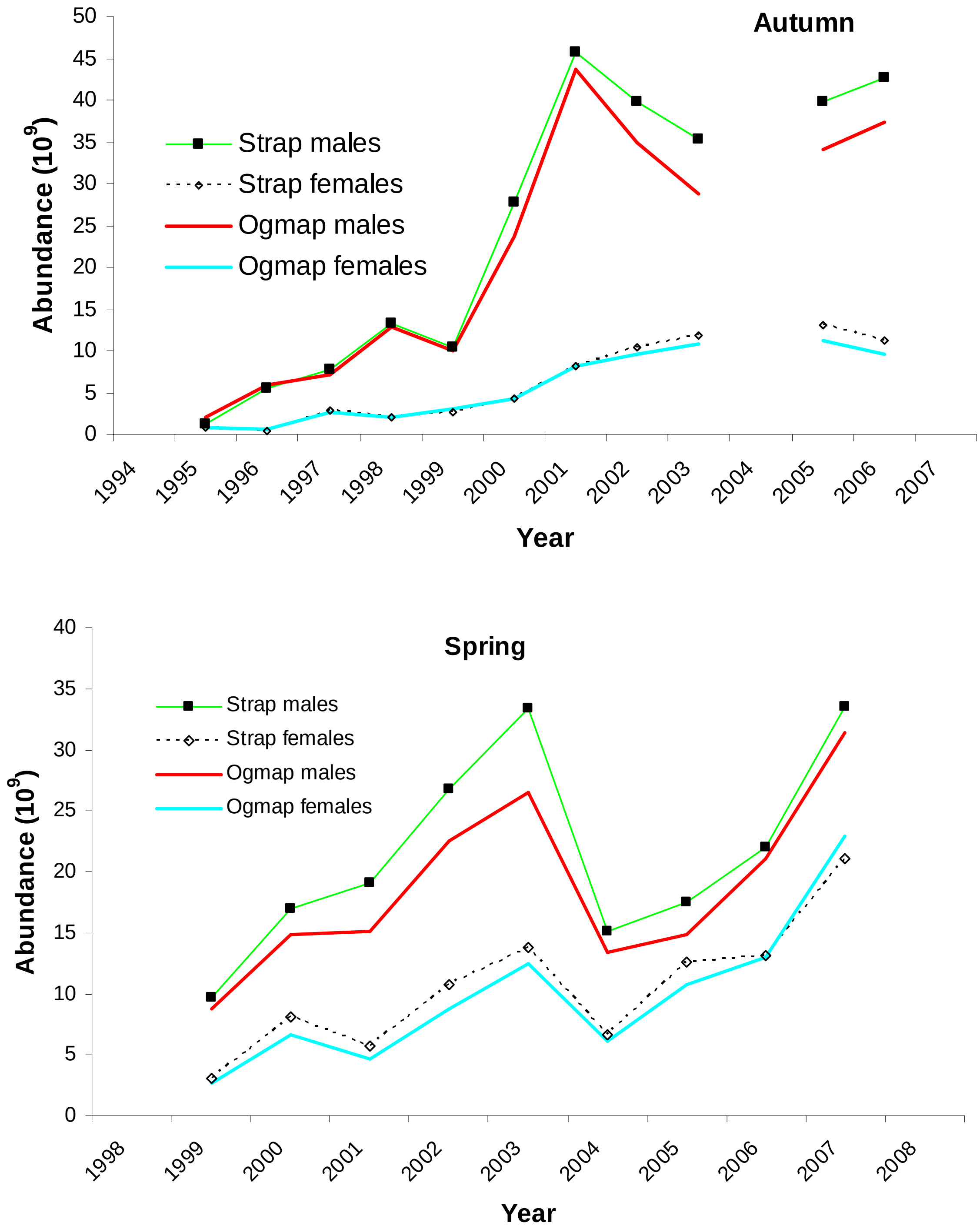


Figure 22. Abundance of male and female shrimp within Div. 3LNO as estimated from Canadian multi-species survey data using areal expansion and Ogmap calculations.

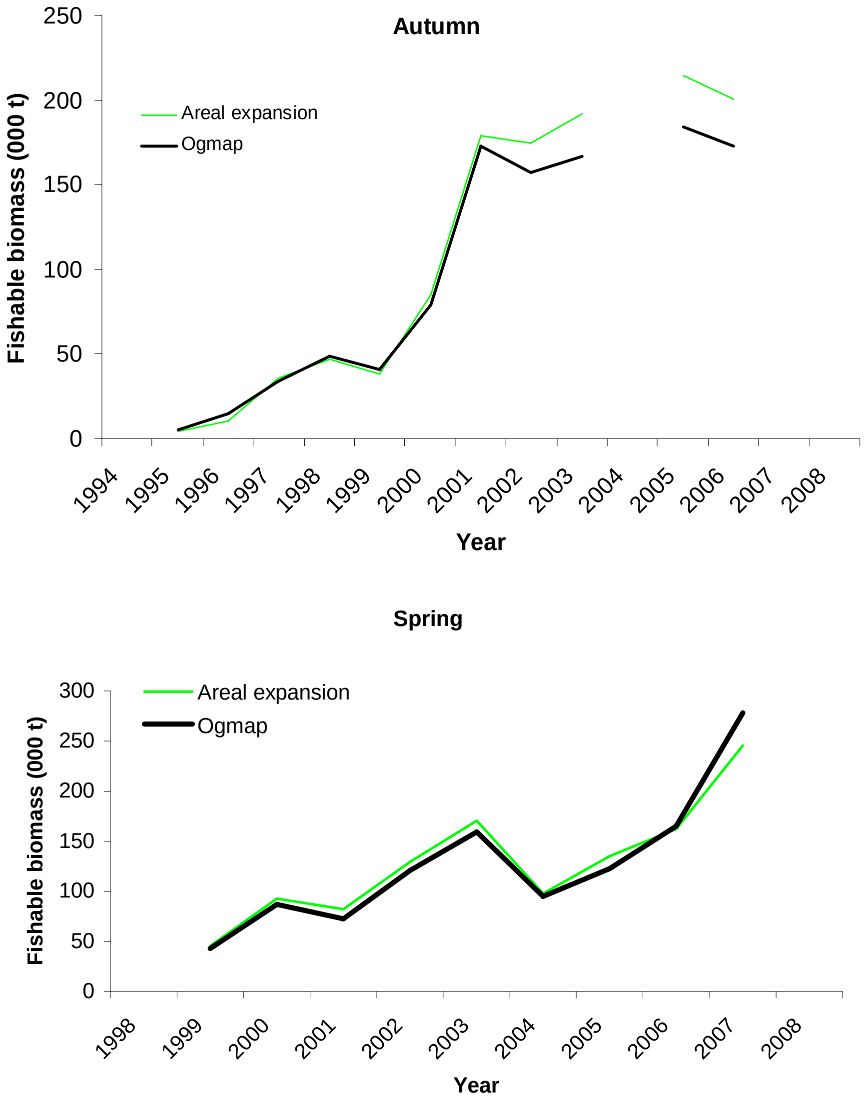


Figure 23. NAFO Div. 3LNO fishable biomass as determined from annual Canadian autumn and spring multi-species research bottom trawl survey data, 1995 – 2007 using areal expansion and Ogmap calculations.

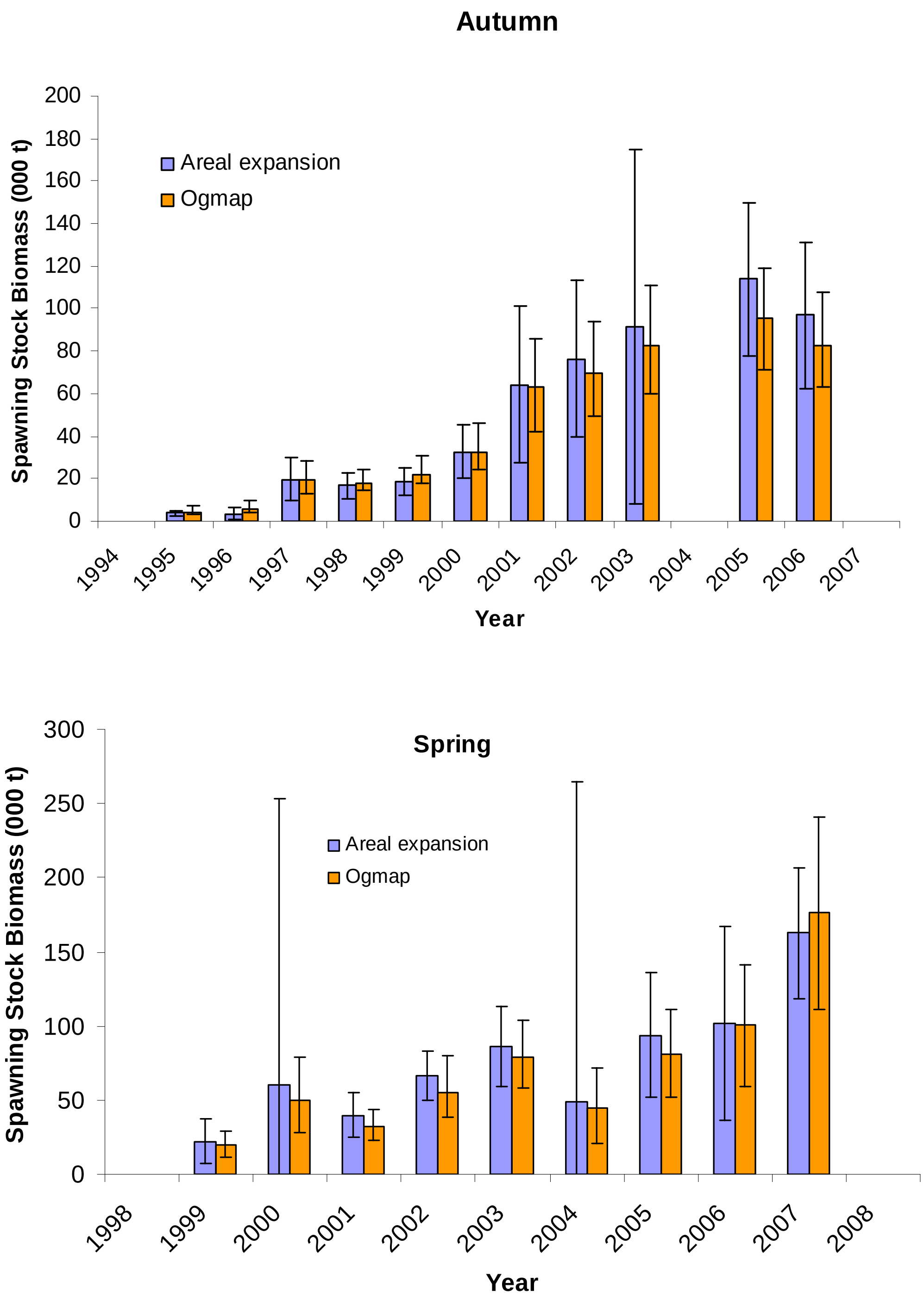


Figure 24. NAFO Div. 3LNO spawning stock biomass as determined from annual Canadian autumn and spring multi-species research bottom trawl survey data, 1995 – 2007 using areal expansion and Ogmap calculations.

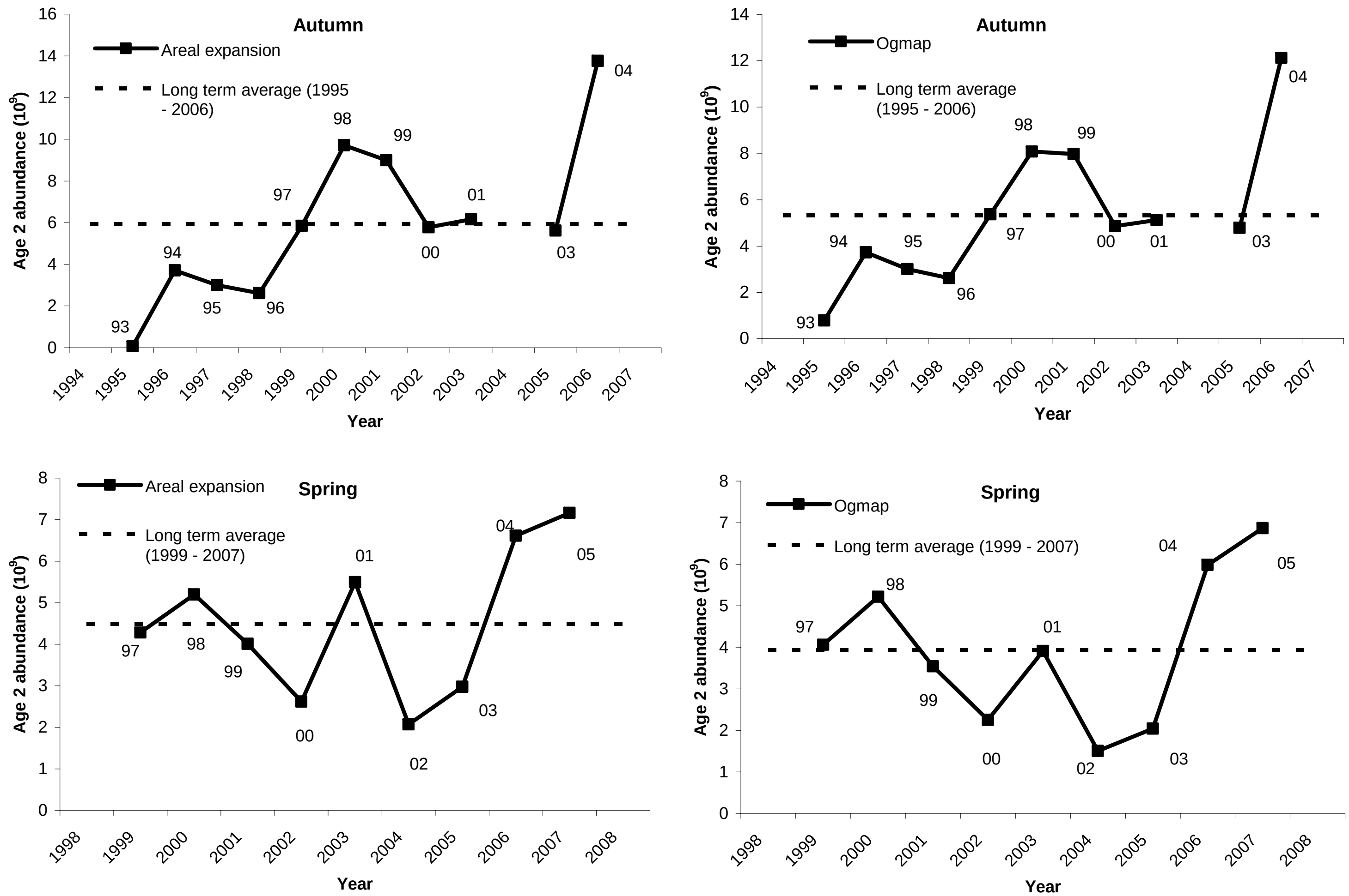
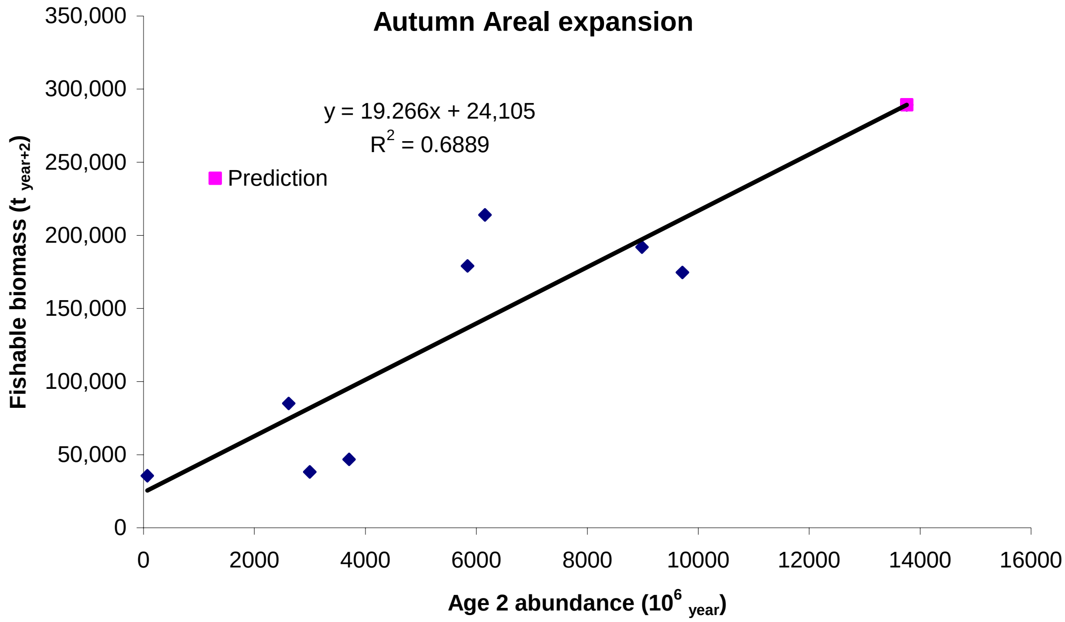


Figure 25. Autumn and spring recruitment indices (age 2 abundance) as determined from Mix analysis of Canadian research bottom trawl data using areal expansion and Ogmap calculations.



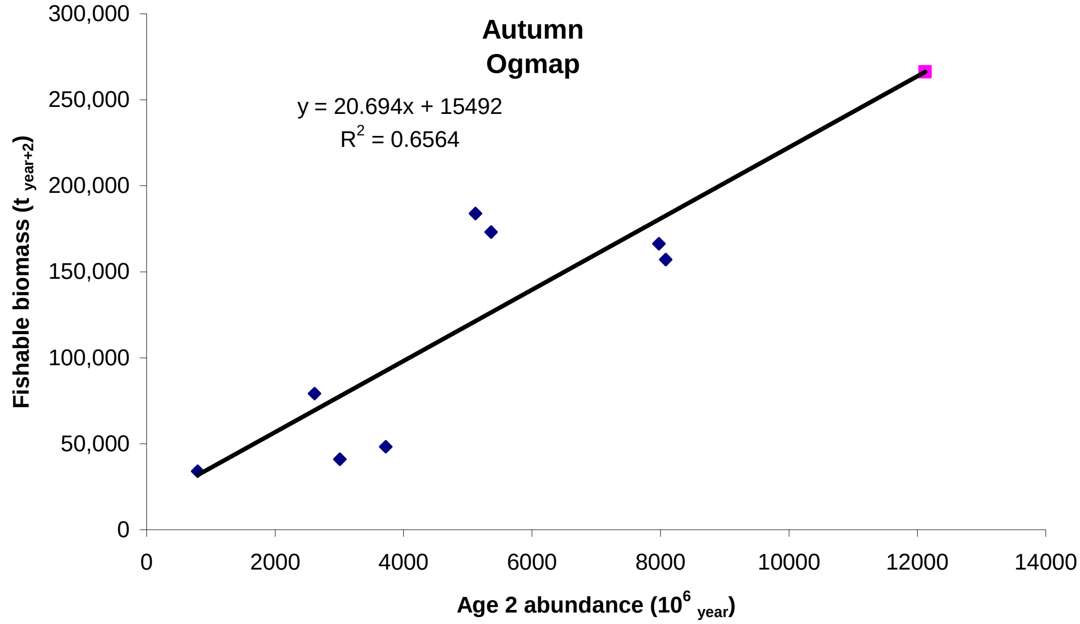


Figure 26. Regression of fishable biomass with a 2 year lag against recruitment indices age abundance) using Canadian autumn survey data as determined using areal expansion and Ogmap calculations.

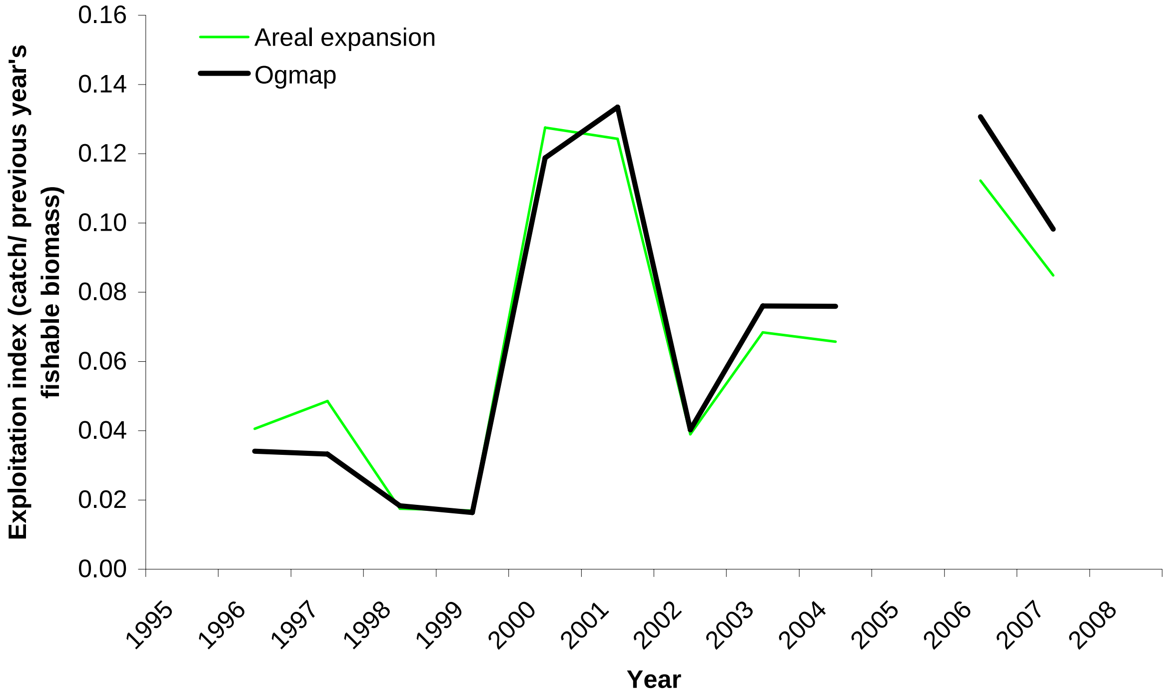
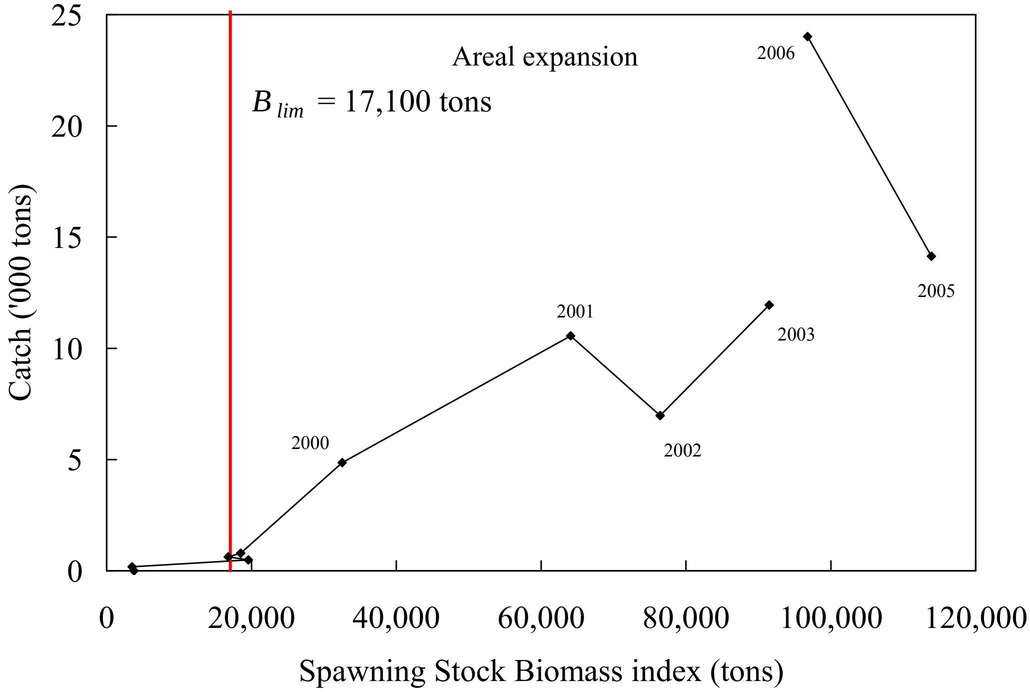


Figure 27. Trends in exploitation as derived by catch divided by the previous year's autumn fishable biomass index as derived using areal expansion and Ogmap calculations.



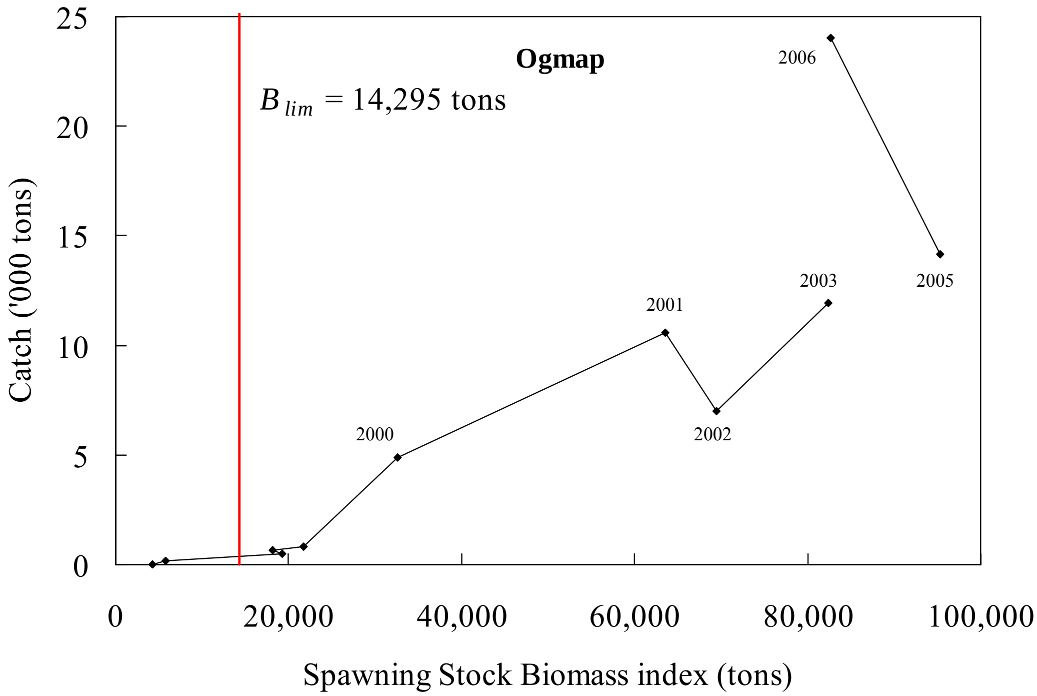


Figure 28. Catch plotted against female biomass index from the Canadian autumn multi-species survey data as derived using areal expansion and Ogmap calculations. Line denoting B_{lim} is drawn where the female biomass is 85% lower than the maximum point (2005 value).