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The 2009 assessment of the Northern Shrimp (*Pandalus borealis*, Kroyer) resource in NAFO Divisions 3LNO

by

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ABSTRACT:

This paper describes the 2009 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 2009) and biomass estimates (autumn 1996 – spring 2009) are updated within this report. Preliminary data indicate that 27,435 t of shrimp were taken against a 25 000 TAC in 2008 while 18 567 t were taken against a 30,000 t TAC by October 1, 2009.

The autumn 2008 3LNO biomass index was estimated to be 249,300 t, the second highest in the autumn time series, down from 275,700 t in 2007. The spring biomass index increased from 93,500 t in 2004 to 288,600 t in 2007, but has since decreased to 112,500 t in 2009, a decrease of 61.0% over two years.

Similarly, the autumn 3LNO fishable biomass index was estimated to be 204,600 t in 2008, the second highest in that time series, down from 230,800 t in 2008. The spring fishable biomass index increased from 83,300 t in 2004 to 280,900 t in 2007, but has since decreased to 97,600 t in 2009, a decrease of 65.2% over two years. It is important to note that indices derived from spring surveys are thought to be less precise because the confidence intervals may be broad relative to confidence intervals around the respective autumn indices.

Standardized catch rates for large Canadian vessels have been fluctuating around the long term mean since 2004 with the 2009 catch rate near term average and similar to the 2002 and 2004- 2008 catch rates. The Canadian small vessel standardized CPUE for 2008 was near the long term average and similar to the 2004, 2006 and 2007 catch rates.

This report provides a new method of using commercial catch and effort data to provide stratified estimates of biomass.

Additionally, this report addresses the September 2009 Fisheries Commission (FC) request to provide information on the effect of the following catch levels in 2011 of 24 000 t, 27 000 t and 30 000 t on the projected SSB.

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 of 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 Divisions 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 13,000 t TAC 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 2007 shrimp assessment, SC was asked to determine exploitation rates for various catch options assuming that the fishable biomass remains at the 2007 level. During May 2008, a special session of FC decided that the 2008 and 2009 quotas should be increased to 25,000 t and that the advice would be reviewed in September 2008.

Various TAC options, based upon exploitation of fishable biomass were presented to FC during September 2008. A TAC of 30 000 t was chosen for the 2009 management year.

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 2009.

The present document was produced for the October 2009 NAFO-ICES Pandalus Assessment Group (NIPAG) assessment meeting and therefore provides a full assessment of the Divs. 3LNO shrimp resource.

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; <65') 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 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, vessel (cfv) etc. The multiplicative model has the following logarithmic form:

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

Where: $CPUE_{\mathrm{ijkml}}$ 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} cfv;

T_m is the effect of m number of trawls;

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

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

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 2008 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.

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 captured in each CPUE model.

In addition to the normal CPUE models produced for this stock, attempts were made to create more direct indices of resource biomass. This is possible because positional data is provided within both the observer and logbook datasets allowing one to assign catch and effort data to strata (Fig 1) that were fished through the years. Once the assignment is complete and catch data have been standardized it is possible to use areal expansion calculations (Cochran, 1997) to determine biomass indices. The biomass indices were calculated using SAS code developed by D. Stansbury (pers. comm.).

The catch data were standardized by way of:

Small vessel formulae

Catch-per-unit-effort = catch / effort

Effort is in terms of hours towed.

Trawlable unit = average speed in Nmi/hr X (average wingspread in ft /6080.2 ft/Nmi) * 1 hr

Average speed = 2.2 Nmi / hr. as determined from observer data

Average wingspread 56 ft (H. Delouche, pers. comm.).

Large vessel standardization formulae

Single trawl data:

Catch per unit of effort = catch X ((average speed/speed) X (average footrope length/footrope length))/effort

Average speed = 2.6 Nmi/hr as determined from observer data

Average footrope length = 70 m as determined from observer data

Double trawl data:

Catch-per-unit-effort = (catch X ((2.5/speed)X(145/footrope length))/effort)/conversion factor to single trawl units

Conversion factor to single trawl units = 1.3 as determined from the catch rate model provided in this report.

Trawlable unit = 2.6 Nmi/hr X (103.5 ft/6080.2 ft/Nmi)*1 hr

Average speed was determined from the observer dataset while the average wingspread was provided by H. Delouche (pers. comm.).

The catch data and trawlable units for the respective fleets were used to estimate biomass and average catch within each strata using areal expansion methods described within Cochran (1997) and SAS code produced by D. Stansbury (pers. comm.).

Spatial distribution of the northern shrimp fishery

Logbook and observer catches were plotted using Surfer 8.0 (Golden Software 2002). The area fished each year was divided into 10 min. X 10 min. cells, catches were aggregated by cells, and aggregated catches were organized into a cumulative percent frequency (cpf). The cpf was used to determine the number of cells accounting for 95% of the catch each year (Swain and Morin 1996). Area occupied by cells accounted for changes in latitude by way of the following great circle distance formula using decimal degrees:

3963.0 * arccos[sin(lat1/57.2958) * sin(lat2/57.2958) + cos(lat1/57.2958) * cos(lat2/57.2958) * cos(lon2/57.2958 - lon1/57.2958)]

(online available at: http://www.meridianworlddata.com/Distance-Calculation.asp)

The area necessary to account for 95% of the catch was compared with the amount of area available within each SFA.

The amount of area trawled was estimated from speed in Nmi/hr, footgear breadth and time trawled using observer dataset information. The start position was the only positional information available for the assessment and was used to place the fishing set in a cell. The amount of area necessary to account for 95% of the trawled effort was then determined and compared with the amount of area available within each SFA as determined above.

The plots and quantification of spatial coverage were used in describing changes in fishing patterns and practices that might affect CPUE interpretations.

International observer and logbook information:

These data were made available by Contracting Parties that fish shrimp in Div. 3L NRA. They were used in CPUE calculations and catches 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, Iceland, Norway, Spain and Russia provided catch and effort data over a number of years making it possible to derive 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; Brodie and Stansbury 2007; 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*., 2007).

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. Total biomass, abundance and length frequency estimates were determined using OGive MAPping calculations (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. The population estimate of age 2 animals provided a recruitment index. Recruitment was also estimated as the population of males from the spring and autumn surveys with 10-17 mm and 12-17 mm carapace lengths respectively. These animals are thought to represent age 2 and 3 animals that enter the fishery during the next year. As in previous assessments, fishable biomass was plotted against recruitment to determine whether a recruitment – stock relationship exists. Since the shrimp are thought to recruit to the fishery at age three and the fishable biomass is defined as the biomass of males > 17 mm in carapace length + the female biomass. The fishable biomass index was determined by estimating the weight of fishable males + weight of females on a set by set basis and then estimating biomass using Ogmap calculations. The fishable biomass index was used in regression analyses, with various lags, against the recruitment indices to determine whether there was improvement in recruit – stock relationship. Such relationships 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.

All indices (biomass, abundance, fishable biomass, female biomass (SSB), recruitment) as well as population adjusted shrimp carapace length frequencies were calculated using Ogmap (Evans *et al.* 2000).

Survival, annual mortality and instantaneous mortality estimates were calculated from the modal analysis results. The survival of age 3+ males and total females was compared with the surviving female abundances. This was completed by combining 3 years of data in order to account for vagaries within the survey data and due to errors in aging by modal analysis. The survival estimates were then used to determine annual mortality (1-survival) and instantaneous mortality (Z=-ln(survival)).

OGive MAPping (ogmap):

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.

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 fishable biomass estimate – lower 95% confidence interval

inverse variance weighted average fishable biomass =

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

Catch rates were determined as the catches prescribed by Fisheries Commission divided by the inverse variance weighted average fishable biomass.

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 4 711, 10,697, 6 994, 13,099 and 13,464 t respectively (Table 1; Fig. 5). Catch data indicate that 14,384 t of shrimp were taken against a 13,000 t quota in 2005 while 25,801 t were taken against a 22,000 t TAC in 2006 and 23,855 t were taken against a 22,000 t TAC in 2007. Preliminary data indicate that 27,435 t of shrimp had been taken against a 25,000 t TAC in 2008 while 18,567 t were taken against a 30,000 t quota by October 2009. It is anticipated that the 2009 quota will be taken.

As per NAFO agreements, Canadian vessels took most of the catch during each year. Canadian catches increased from 4 050 t in 2000 to 21,187 t in 2008. The Canadian large and small vessel fleets took 15,302 t of shrimp by October 2009 from a quota of 24,900 t;. Catches by non Canadian nations increased from 661 t to 7 673 t by 2006, remaining near 6 000 t until 2008. Preliminary data indicate that by October 2009, 3 265 t had been taken against a non Canadian TAC of 5 100 t.

Canadian fleet

Since 2000, small (<=500 t; LOA<65') and large (>500 t) shrimp fishing vessels catches have been taken from a broad area (Figs. 6 - 8) from the northern border with 3K south east along the 200 – 500 m contours to the NRA border. The percent area occupied by the large vessel fishery and the resource as determined from spring survey data was less than 4% of the total available habitat of the entire time series while similar indices for the autumn survey and small vessel fisheries occupied less than 8% of the total available habitat. The small vessel spatial indices show a clear downward trend over the past two years (2007 and 2008).

The small vessel fleet fishes shrimp mainly during the spring and summer months, while seasonality of the large vessel fleet varied over time (Fig. 9).

Due to a lack of data (Fig. 6) it was not possible to model small vessel CPUE up to and including 2009. Small vessel CPUE (2000 – 2008) 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 (Table 2). The logbook dataset that was used in this analysis accounted for between 57.2% and 93.8% of the catch within any one year (Table 3). The final model explained 87.4% of the variance in the data and indicated that the annual, standardized catch rates increasing from near 350 kg/hr over 2000 – 2002 to 676 kg/hr 2005 with a gradual decrease to 502 kg/hr in 2007 remaining near that level in 2008. The 2007 catch rate index was similar to the 2008 index (529 kg/hr), the 2005 and 2006 indices was significantly higher than the 2008 value while all others were significantly lower (Tables 2 and 3; Fig. 10). No clear trends were found in the plots of residuals (Fig. 11).

Table 4 provides biomass indices determined from small vessel logbook catch and effort data. Indices increased from 37,900 t in 2001 to 203,200 t in 2007 and have since decreased to 61,400 t in 2009, a drop of 70% over a two year period. The mean catch per fishing set increased from 0.28 t / hr. in 2000 to 0.72 t/ hr. in 2006 but has since decreased to 0.43 t/ hr by 2009. Over this period, the number of strata fished by the small vessel fleet increased from 7 in 2001 to 16 in 2007 but has since decreased to 13 in 2008 and 10 in 2009 (Table 5). Table 5 clearly indicates that most of the small vessel commercial fishing is completed within 183 – 549 m depths. Locations of strata provided in this table are shown in figure 1, while figure 6 indicates the fishing set locations for the period 2005 – 2009. As indicated earlier, the 2009 values are preliminary because the fishery is ongoing.

Seasonality among the large vessel fleet has varied greatly over the years (Fig. 9); however, most of the data came from the winter and spring; therefore large vessel catch rates were analyzed by multiple regression using data collected from January – June of each year. The model was weighted by effort, for year, month, number of trawls and vessel effects (Table 6). The observer dataset used in this analysis accounted for between 33% and 94% of the catch within any one year (Table 7). The final model explained 68% of the variance in the catch rate data. Standardized catch rates for large Canadian vessels have been fluctuating around the long term mean since 2004 with the 2009 standardized catch rate index (2058 kg/hr; Tables 6 and 7; Fig. 10) slightly above the long term average (1840 kg/hr) but similar to the catch rates for 2002 and 2004 - 2008 indices (Tables 6 and 7; Fig. 10). There were no trends in the residuals around parameter estimates (Fig. 12).

Table 8 provides the biomass indices determined from large vessel observed catch and effort information. This table clearly shows that the large vessel fishery is restricted to few strata compared to the small vessel fishery as is confirmed in figures 7 and 9 and most of the catch is taken in 200 m – 550 m depth ranges; however, the indices do not follow an obvious pattern.

Analyses from the small and large vessel fisheries do not provide consistent signals. The small vessel fishery covers a larger portion of the resource (Table 5 and 9; Figs 6 - 8) whereas the large vessel fleet has always fished near the 200 Nmi limit and along the northern edge of 3L (Table 9; Figs. 7 and 8). For this reason, the small vessel fleet information may provide a better indicator of resource status than the large vessel fleet. The small vessel information may be providing an early warning that the fishery (Table 5; Figs 6 and 8) may be contracting. It is important to note that the biomass estimates from small vessel data has been decreasing over the past few years (Table 5).

International fleet

A standardized international fleet CPUE model is not presented here as the percent catch data accounted for in the international dataset ranged from 1 – 54% and in most years was less than 25% of that year's catch. Unstandardized international indices increased from 381 kg/hr in 2001 to 1 344 kg/hr in 2004 but decreased to 744 kg/hr in 2005 and remaining near that level until 2009 (Table 10; Fig. 13). The 2009 catch rate index was 671 kg/hr; however, the data accounted for only 20% of the total catch and was limited to data from only Estonia and Greenland. It is not clear how representative these commercial catch rates are of the international fishery in the 3L NRA.

Size composition

Relatively few length frequencies were collected by observers of small vessel fishing activities therefore it is not certain whether the length frequencies are representative of fleet activities (Fig. 14). The low number of length frequencies resulted in very jagged length distributions that could not be aged using modal analysis. However, it is noteworthy that the length frequencies for both non-ovigerous and ovigerous animals were broad for each year implying that more than one year class was evident within the catch.

On the other hand, 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, there were often two faint sub-peaks implying the presence of more than one year class. Given that the modes were usually near 17 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. Since 2000, catch rates had been maintained at over 200,000 animals per hour. The within year frequency weighted average carapace lengths for males ranged between 17.8 mm and 19.7 mm, while the weighted average carapace lengths for females ranged between 22.7 mm and 23.8 mm. There were no trends in the average size of either males or females.

Figure 16 presents the length frequencies from the 2006 - 2009 Estonian catches. As with the Canadian size compositions, this figure also shows a broad range in sizes of shrimp, probably from at least three year classes. Given the fact that the length frequencies are from only one nation and relatively few samples were taken each year, it is not clear whether they are representative of Non Canadian catches.

RESEARCH SURVEY DATA

Stock size

The autumn 2005 – 2008 and spring 2006 – 2009 research catches are concentrated within NAFO Div. 3L at depths between 200 and 500 m (Figs 17 and 18). The autumn 2008 biomass estimate for NAFO Divisions 3LNO was 249,300 t (95% confidence range = 195,800 – 301,800 t), the second highest biomass index in the autumn time series (Table 11; Figs. 17 and 19). Table 12 provides trends in the mean catch per research survey tow by stratum and year from autumn surveys. There are no obvious signs of contraction of the resource.

The spring 2009 survey biomass index was 112,500 t (95% confidence bounds = 62,850 – 167,500 t), a drop of approximately 61.0% since 2007 (Table 11; Figs 18 and 20). 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. Figure 18 clearly indicates that very few large catches were taken along the northern edge of 3L during the 2009, spring survey relative to previous autumn and spring surveys, which normally held high catches in this area. This decrease was not evident in the plot of point area accounting for 95% of the spring research survey catches (Fig. 8). Table 13 provides the trends in mean catch per research survey tow by stratum and year from spring surveys. While there are no obvious signs that the resource is contracting, the mean catches per tow for most strata are lower than in previous years.

A comparison between Tables 12 and 13 illustrates the fact that there appears to be a switch from deeper water in the spring (184 – 550 m) to shallower (93-366 m) with sporadic catches to 500 m in the autumn. This trend toward shallow water in the autumn and deeper water in the spring is also evident in figures 17 and 18.

Figure 21 indicates that there is a linear relationship (r^2 = 68%) between spring survey biomass and biomass determined from small vessel commercial catch data. Both sets of indices show an increase in biomass over the period 2000 – 2007 followed by a decline.

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

Over 92.7% of the total 3LNO biomass, from either spring or autumn surveys, was found within Division 3L, mostly within depths from 184 to 550 m. Over the study period, the area outside 200 Nmi accounted for between 11.2 and 32.6% of the estimated total 3LNO biomass (Tables 14 and 15; Figs. 17 and 18; Orr *et al.* 2007). During the autumn, the percent biomass within the NRA ranged between 12.1 and 21.0%. Three year running averages were estimated in order to smooth the peaks and troughs within the data. They indicate that 14.5 – 20.1% of the total 3LNO autumn biomass was within the NRA (Table 14). Over the period 1996 – 2008 the overall average autumn percent biomass within the NRA was 17.0%. During the spring, the percent biomass within the NRA ranged between 11.2 and 32.6% (three year running average ranged between 19.2 and 25.0%) (Table 15). Over the period 1999 – 2009 the average spring percent biomass with the NRA was 22.2%. It must be noted that variances around the spring indices are greater than around autumn indices (Table 11; Figs. 19 and 20).

In all surveys, Division 3N accounted for 0.2-8.1% of the total 3LNO biomass (Tables 14 and 15). Between 33.3 and 83.3% 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 1996 - spring 2009 surveys are presented in figures 22 and 23. Generally, modes increase in height as one moves from ages 1 – 3 indicating that modes become more overlapping and that shrimp catchability probably improves as they increase in size. Tables 16 and 17 provide the modal analysis and the estimated demographics from each survey. These time series provide 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 were low and a second period after 1999 during which abundances were 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 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 cohort appeared weak in 1999, but appeared strong over the next few years. Conversely, if an age 2 mode appeared strong, in any one year, that cohort remained strong throughout its history. Conversely weak year classes such as the 1995 and 1996 appeared weak as age 2 modes and remained weak throughout their history.

Modal length at age varies between years reflecting different growth rates for the different cohorts. However, there is some inter-annual consistency in modal positions and the relative strength of cohorts is maintained from one year to the next (Tables 16 and 17; Figs. 22 and 23).

Shrimp aged 2 - 4 dominated the male component of the length frequencies in autumn 2008 (2006, 2005 and 2004 year classes respectively) survey with carapace length frequency modes at 14.95 mm, 17.86 mm and 20.17 mm respectively (Table 16; Fig. 22). Likewise, abundance estimates from the spring 2009 survey were dominated by shrimp aged 2 - 4 (2007, 2006 and 2005 year classes respectively) with modes at 15.61 mm, 17.66 mm and 19.56 mm respectively. The 2005 year class first appears as the strongest year classes in the spring of 2007 as two year old animals. This year classes remains strong in the male distributions from the 2009 spring survey; however, the total abundance of animals in 2009 was much reduced in relation to the previous three surveys. The 2006 year class appears average throughout 2008 and 2009. Age 1 males, from the spring 2009 survey, were the most abundant age 1 group in that time series.

The autumn surveys showed an increase in biomass of male shrimp from 33,200 t (10 billion animals) in 1999 to 152,000 t (44 billion animals) in 2001, remaining at a high level there after (Table 18; Fig. 24). The autumn 2008 male survey biomass index was estimated to be 144,100 t (41 billion animals), the second highest in the autumn time series. The spring survey male biomass indices showed a general increasing trend from 29,400 t (9 billion animals) in 1999 to 91,100 t (26 billion animals) in 2003, dropped to 51,700 t (12 billion animals) the next year then increased to 111,900 t (31 billion animals) by 2007 after which biomass dropped by 52% to 53,500 t (16 billion animals) in 2009 (Table 19; Fig. 24).

Autumn and spring female biomass and abundance indices (transitionals and all females = SSB) followed trends similar to the respective male indices. The autumn female biomass generally increased from 5,800 t in 1996 (1 billion animals) to 128,000 t (16 billion animals) in 2007; the highest in the autumn time series. The 2008 male biomass index was 105,200 t (13 billion animals), the second highest in the time series. Spring female biomass indices increased from 32,500 t (5 billion animals) in 2001 to 74,400 t (12 billion animals) in 2004, decreased to 41,800 t (6 billion animals) in 2005, after which it increased to 176,700 t (23 billion animals) in 2007, the highest level in the time series. Spring female biomass decreased over the next two years by 67% to 59,000 t (8 billion animals) in 2009 (Tables 20 and 21; Fig. 25).

The autumn 3LNO fishable biomass index increased from 14,600 t in 1996 to 173,200 t remained near that level until 2007 at which time it had increased to 230,800 t, the highest in the time series. Fishable biomass decreased in 2008 to 204,600 t in 2008, the second highest in the time series. The spring fishable biomass index increased from 40,700 t in 1999 to 148,500 t in 2003, decreased to 83,300 t in 2004 after which fishable biomass increased to 280,900 t in 2007, but has since decreased to 188,200 t in 2008 with a further decrease to 97,600 t in 2009 (Table 22 and Fig. 26). The fishable biomass index decreased of 65.2% over 2 years.

Recruitment Index

Recruitment indices were determined using two methods:

1. age 2 abundance as determined from modal analysis of population adjusted length frequencies, and
2. the abundance of males 10-17 mm in carapace length from spring surveys and 12-17 mm carapace lengths in autumn.

from the autumn 1996-2008 and spring 1999 - 2009 survey time series. Due to the incomplete survey in autumn 2004, this value was excluded from the autumn time series. In terms of modal analysis, the autumn 98, 99, 04 - 06 year classes were strong, the 97, 00 and 01 year classes were average while the 94 - 96 and 03 year classes were the weakest recorded (Tables 16 and 23; Figs. 22 and 27). Even though the 04 – 06 year classes appear strong, there is a downward trend. Spring recruitment indices have been fluctuating around the mean with the 04 and 05 year classes being the strongest in the time series (Tables 17 and 23; Figs. 23 and 27). Similar to the autumn recruitment signal, there is a downward trend in abundances of age 2 animals from the 05-07 cohorts.

The size class method allows the direct calculation of confidence intervals, but will not allow the identification of age classes because each index probably consists of a combination of age 2 and 3 animals. The autumn 1996 – 1999 indices were the lowest in the time series, the 2000, 2002 and 2003 values were near the mean while the 2001 and 2005 – 2008 were the highest. Similarly, the spring indices followed an increasing trend between 1999 and 2003, the 2004 value was the lowest in this time series but since then the recruitment indices have gradually increased to a record level in 2008 with a decrease in recruitment to mean levels during 2009.

Figure 28 presents a series of regressions between fishable biomass with various lags versus abundances of age 2 males and males with 12-17 mm carapace lengths. These regressions were based upon autumn data. In both cases, highest correlation coefficient was achieved when the fishable biomass was lagged by one year after the recruitment index.

The regression of the fishable biomass versus abundance of 12-17 mm males, with a one year lag, resulted in a predictive model accounting for 87% of the variance in the data. This is higher than a fit of 60% achieved when fishable biomass was regressed against the age 2 abundance index. Increased fit from the recruitment index based upon size class rather than age should not be surprising because shrimp recruit to the fishery by size and not age. Animals recruiting to the fishery probably range from 2 – 3 years of age as is clearly illustrated from the modal analysis presented in figures 22 and 23 and the commercial length frequencies (Figs. 14-16).

This predictive relationship using the abundance of 12-17 mm carapace length males, lagged by 1 year may be written as follows:

Fishable biomass_{year+1}= 12.355 (autumn recruitment index_{year}) + 11.29

If the autumn 2008 recruitment index (14.8716 billion animals) is applied to this simple model then the predicted fishable biomass would be 195,028 t in autumn 2009. This would represent a drop in fishable biomass of 15% since 2007.

Exploitation Rate Indices

Exploitation rate indices were estimated using ratios of catch divided by the previous year's lower 95% confidence interval of the biomass estimate, spawning stock biomass and fishable biomass. In general, they all follow similar trajectories (Table 24). Overall, exploitation has been low even though catches have increased over time because the stock parameters also increased. Figure 29 presents the exploitation rate index determined as catch/ previous year's autumn fishable biomass. The 2008 exploitation rate index was 11.7% using Ogmap values. By October 2009, the 2009 exploitation rate index was 9.7%.

Mortality Estimates

The median survival, annual mortality and instantaneous mortality rates were 0.798, 0.202 and 0.225 respectively (Table 25). These values are reasonable as the survival from one year to the next is high enough to allow the present population to exist and are within the range of values presented in Shumway (1985) and Bergström (2000). It is important to note that last survival index, as determined from 2006-2008/2005-2007 abundances, is the lowest in the time series. This survival index is 0.69.

Precautionary Approach

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 30).

TAC:

Table 26 provides the exploitation rate index determinations for various TAC options. If the inverse variance weighted average fishable biomass is 173,886 t and TAC was 25,000, 27,000 or 30,000 t then the respective exploitation rate indices would be 14.4%, 15.5% and 17.25%.

Sources of Uncertainty in the Assessment

Several important strata, within NAFO Division 3L, were missed in the autumn 2004 Canadian multi-species survey therefore fishery independent indices could not be estimated for that year.

It was not possible to survey all of NAFO Divisions 3NO during the spring of 2006; therefore 3NO indices were estimated for that survey. Historically, at least 95.9% of the 3LNO shrimp biomass is found within Division 3L; therefore, the spring 2006 indices were for NAFO Division 3L only.

Attempts have been made to determine shrimp mortality rates; however, they have been based upon ratios over several cohorts. It is probable that mortality is dependent upon age therefore further work must be completed.

It was not possible to model CPUE for the international fleet fishing in the NRA because the percentage of the fishery captured in the catch rate data set was usually less than 25% for any one year. It is not clear whether this data is representative of fleet conditions.

There are ongoing questions about mis-reporting of catch between the 3L NRA and 3M international fisheries.

The shortness of the survey time series and lack of dynamic range, as well as modest catches in relation to biomass indices resulted in past failed attempts at modeling stock dynamics. The assessments are based upon evaluating various indices of stock conditions. There is no risk analysis for this resource because of the lack of limit reference points.

There is imperfect knowledge information on sustainable exploitation rates; however, there is evidence that they may differ widely between stocks. When setting TACs, ecosystem considerations should be taken into account because shrimp is an important forage species.

Resource Status

Canadian large (>500 t) fishing vessel catch rates have fluctuated around the long term mean since 2004 with the 2009 catch rate index slightly above the long term mean but similar to the 2002 and 2004 – 2008 catch rates. The Canadian small vessel standardized CPUE increased by 90% over the period 2001 – 2005 but has subsequently decreased to near the long term mean.

The area occupied by the resource, as determined by the multi-species survey and large vessel fleet had been increasing over time. The area occupied by the small vessel fleet had been increasing until 2006; however, there are clear signs that it has been decreasing over the past two years (2007 and 2008).

Regardless of whether the spatial indices have been increasing, the area occupied has never been higher than 8% of the available area. While the shrimp fishery may still have impacts upon some non target species, the chance of doing serious harm to the habitat is probably low because the foot print of the fishery is relatively low. However, it is still important to determine the actual impact of the fishery upon the ecosystem.

Unstandardized catch rates, from the non Canadian vessels, fluctuated along the long term mean over the short time series. Unstandardized international indices increased from 381 kg/hr in 2001 to 1 344 kg/hr in 2004 but decreased to the long term mean in 2005 and remaining near that level until 2009. As noted above, the percentage of the fishery captured in the catch rate data set was usually less than 25% for any one year. It is not clear whether this data is representative of fleet conditions.

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 1996 and 2001 and this index has since remained stabilize at a high level. The autumn 2008 biomass estimate for NAFO Divisions 3LNO was 249,300 t (95% confidence range = 195,800 – 301,800 t), the second highest biomass index in the autumn time series. At table of trends in the mean catch per research survey tow by stratum and year from autumn surveys indicated no obvious signs of contraction of the resource.

The spring 2009 survey biomass index was 112,500 t (95% confidence bounds = 62,850 – 167,500 t), a drop of approximately 61.0% since 2007. 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. Plots of research survey catches clearly indicated that very few large catches were taken along the northern edge of 3L during the 2009 spring survey, relative to previous autumn and spring surveys, which normally held high catches in this area. This decrease was not evident in the spatial index from spring research survey catches. Similarly, there were no obvious signs of contraction in the table of trends in mean catch per research survey tow by stratum and year from spring surveys. However, the mean catches per tow for most strata were lower than in previous years.

There was a linear relationship (r^2 = 68%) between spring survey biomass and biomass determined from small vessel commercial catch data. Both sets of indices show an increase in biomass over the period 2000 – 2007 followed by a decline.

Autumn and spring female biomass and abundance indices (transitionals and all females = SSB) followed trends similar to the total biomass indices. The autumn female biomass generally increased from 5,800 t in 1996 (1 billion animals) to 128,000 t (16 billion animals) in 2007; the highest in the autumn time series. The 2008 male biomass index was 105,200 t (13 billion animals), the second highest in the time series. Spring female biomass indices increased from 32,500 t (5 billion animals) in 2001 to 74,400 t (12 billion animals) in 2004, decreased to 41,800 t (6 billion animals) in 2005, after which it increased to 176,700 t (23 billion animals) in 2007, the highest level in the time series. Spring female biomass decreased over the next two years by 67% to 59,000 t (8 billion animals) in 2009.

The autumn 3LNO fishable biomass index increased from 14,600 t in 1996 to 173,200 t remained near that level until 2007 at which time it had increased to 230,800 t, the highest in the time series. Fishable biomass decreased in 2008 to 204,600 t in 2008, the second highest in the time series. The spring fishable biomass index increased from 40,700 t in 1999 to 148,500 t in 2003, decreased to 83,300 t in 2004 after which fishable biomass increased to 280,900 t in 2007, but has since decreased to 188,200 t in 2008 with a further decrease to 97,600 t in 2009. The fishable biomass index decreased of 65.2% over 2 years.

In terms of modal analysis, the autumn 98, 99, 04 - 06 year classes were strong, the 97, 00 and 01 year classes were average while the 94 - 96 and 03 year classes were the weakest recorded. Even though the 04 – 06 year classes are strong they are trending downward. Spring recruitment indices have been fluctuating around the mean with the 04 and 05 year classes being the strongest in the time series. Similar to the autumn recruitment signal, there is a downward trend in abundances of age 2 animals from the 05-07 cohorts.

Shrimp aged 2 - 4 dominated the male component of the length frequencies in autumn 2008 (2006, 2005 and 2004 year classes respectively) survey with carapace length frequency modes at 14.95 mm, 17.86 mm and 20.17 mm respectively. Likewise, abundance estimates from the spring 2009 survey were dominated by shrimp aged 2 - 4 (2007, 2006 and 2005 year classes respectively) with modes at 15.61 mm, 17.66 mm and 19.56 mm respectively. The 2005 year class first appears as the strongest year classes in the spring of 2007 as two year old animals. This year classes remains strong in the male distributions from the 2009 spring survey; however, the total abundance of animals in 2009 was much reduced in relation to the previous three surveys. The 2006 year class appears average throughout 2008 and 2009. Age 1 males, from the spring 2009 survey, were the most abundant age 1 group in that time series.

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 much of the history within the autumn time series. Due to the increase in fishable biomass, the exploitation rate index has remained low in spite of increased catches.

The predictive relationship between fishable biomass and the autumn survey abundance of 12-17 mm carapace length males, lagged by 1 year, was written as:

Fishable biomass$_{year+1}$= 12.355 (autumn recruitment index$_{year}$) + 11.29

If the autumn 2008 recruitment index (14.8716 billion animals) is applied to this simple model then the predicted fishable biomass would be 195,028 t in autumn 2009. This would represent a drop in fishable biomass of 15% since 2007.

The spring survey and small vessel biomass indices have been trending downward over the past three years, recruitment indices are trending downward, latest index of survival was the lowest in the time series and the predictive model between fishable biomass and recruitment projects a 15% drop in fishable biomass since 2007. It is important to note that these indices decreased at the same time. There was no lag between the decrease in recruitment and the decrease in spring biomass indices. This means that the declines seen in biomass are not simply due to poor recruitment. Poor recruitment will have an impact on future status of the stock but in this case there are other contributing factors. These should be taken as a warning that conditions may be changing in 3LNO northern shrimp resource. However, this is tempered by the fact that:

1. the autumn biomass indices are still at a high level
2. exploitation is still relatively low
3. the commercial and survey length frequencies are broad meaning that the resource is depending upon more than just two or three year classes. This will provide a buffer. and
4. indices derived from spring surveys are thought to be less precise because the confidence intervals may be broad relative to confidence intervals around the respective autumn indices.

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 the limit reference point regardless of whether it is B_{lim} or the proposed B_{Loss} (Figure 30).

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Table 1. Annual nominal catches (t) by country of northern shrimp (*Pandalus borealis*) caught in NAFO Div. 3L between 2000 and September 2009.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Canada	4,050[2]	4,984[2]	5,417[2]	10,701[2]	10,560[2]	11,109[2]	18,128[2]	18,312[2]	21,187[2]	15,302[2]	
Cuba		46[1]	70[1]	81[1]	145[3]	136[1]	239[1]	240[1]	207[3]	334[3]	
EU/Estonia	64[1]	2,264[4]	450[5]	299[6]	271[6]	569[6]	1,098[10]	1,453[10]	1,458[10]	623[10]	
European Union											
Faroe Islands	42[1]	2,052[4]	620[5]	25[1]	1,050[1]	1,055[1]	1,521[1]	1,798[1]	2,273[1]	757[3]	
France (SPM)	67[1]	67[1]	36[1]	144[1]				245[1]	278[1]		
Greenland	34[1]			671[1]	299[1]	311[1]	453[8]	455[8]	488[8]	533[8]	
Iceland	99[1]	55[7]	54[7]	133[7]	105[7]	140[1]	226[7]				
EU/Latvia	64[1]	67[1]	59[1]	144[1]	143[1]	144[1]	244[1]	310[1]	278[1]		
EU/Lithuania	67[1]	67[1]	67[1]	142[1]	144[1]	216[1]	486[1]	245[1]	182[1]		
Norway	77[1]	78[6]	70[6]	145[9]	165[9]	144[1]	272[9]	250[9]	345[1]	349[9]	
EU/Poland	40[1]	54[1]		145[1]	144[1]	129[1]	244[1]				
Portugal		61[5]									
Russia	67[1]	67[1]	67[1]		141[1]	146[1]	248[1]	112[1]	278[1]	335[3]	
EU/Spain	40[1]	699[4]		151[1]	140[1]	154[1]	305[6]	190[1]	183[1]		
Ukraine		57[1]		144[1]	145[1]		121[1]			334[3]	
USA		66[1]	57[1]	144[1]		136[1]	245[1]	245[1]	278[3]		
Estimated additional catch							2,000[5]				
GRAND TOTAL	4,711	10,697	6,994	13,099	13,464	14,384	25,801	23,855	27,435	18,567	
TAC (tons)	6,000	6,000	6,000	13,000	13,000	13,000	22,000	22,000	25,000	30,000	30,000

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. Estonian logbook dataset.

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 – 2008. (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	9	2000 2001 2002 2003 2004 2005 2006 2007 2008
month	5	5 6 8 9 99 Standardized to July
size_class	3	1 2 3

Number of Observations Read 104
Number of Observations Used 104

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	14	7714.586176	551.041870	43.93	<.0001
Error	89	1116.438651	12.544255		
Corrected Total	103	8831.024827			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.873578	56.35693	3.541787	6.284563

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	8	6146.547886	768.318486	61.25	<.0001
month	4	1099.880774	274.970193	21.92	<.0001
size_class	2	468.157516	234.078758	18.66	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	8	2692.266145	336.533268	26.83	<.0001
month	4	1221.354066	305.338517	24.34	<.0001
size_class	2	468.157516	234.078758	18.66	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		6.561455165 B	0.03208531	204.50	<.0001
yearf	2000	-0.388561053 B	0.05814021	-6.68	<.0001
yearf	2001	-0.395547261 B	0.06856788	-5.77	<.0001
yearf	2002	-0.379182410 B	0.06254809	-6.06	<.0001
yearf	2003	-0.273078819 B	0.05131563	-5.32	<.0001
yearf	2004	-0.137231344 B	0.04432723	-3.10	0.0026
yearf	2005	0.245307635 B	0.04812340	5.10	<.0001
yearf	2006	0.131269585 B	0.04120920	3.19	0.0020
yearf	2007	-0.052235518 B	0.03821895	-1.37	0.1751
yearf	2008	0.000000000 B	.	.	.

yearf	lncpue LSMEAN	95% Confidence Limits	
2000	5.882397	5.780511	5.984283
2001	5.875411	5.759407	5.991414
2002	5.891776	5.791393	5.992158
2003	5.997879	5.920347	6.075411
2004	6.133727	6.056441	6.211012
2005	6.516266	6.432492	6.600040
2006	6.402228	6.337524	6.466931
2007	6.218722	6.158081	6.279363
2008	6.270958	6.207402	6.334513

Table 3. Catch rate indices for Canadian small vessels (<=500 t; <65’) fishing northern shrimp (*Pandalus borealis*) in NAFO Division 3L, 2000 – 2008.

				UNSTANDARDIZED			STANDARDIZED		
YEAR	TAC[1] (t)	FLEET CATCH (t)	[2] PERCENT OF CATCH DATA CAPTURED IN MODEL	CPUE (KG/HR)	CPUE RELATIVE TO 2007	[3] EFFORT (HR)	CPUE RELATIVE TO 2007	MODELLED CPUE (KG/HR)	EFFORT (HRS)
1999		17							
2000	2,500	3,217	69.0%	384	0.600	8,388	0.678	359	8,969
2001	2,500	2,590	57.2%	345	0.540	7,508	0.673	356	7,272
2002	2,500	2,961	76.0%	342	0.536	8,648	0.684	362	8,178
2003	6,566	6,663	65.2%	407	0.637	16,363	0.761	403	16,551
2004	6,566	6,524	93.5%	550	0.861	11,868	0.872	461	14,147
2005	6,566	7,070	93.8%	778	1.217	9,090	1.278	676	10,458
2006	12,297	12,112	83.2%	658	1.029	18,419	1.140	603	20,080
2007	12,297	12,571	81.6%	581	0.909	21,643	0.949	502	25,039
2008	14,209	14,873	74.7%	639	1.000	23,282	1.000	529	28,116
2009	14,209	12,873	14.2%						

[1] 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. NAFO Division 3L annual Northern Shrimp biomass indices using area[1] expansion calculations with standardized small vessel (<500 t; <65' LOA) logbook catch information (2000 – 2009). The data were restricted to the April – October period of each year.

Year	Biomass (tons)			Mean t per Set	Commercial Sets
	Lower C.I.	Estimate	Upper C.I.		
2000	42,160	45,799	49,438	0.284	813
2001	9,830	37,904	65,978	0.382	574
2002	44,894	47,981	51,067	0.428	844
2003	56,299	59,884	63,469	0.460	1,283
2004	89,316	105,358	121,399	0.576	1,446
2005	86,063	99,516	112,968	0.703	1,261
2006	133,883	162,595	191,308	0.715	2,004
2007	140,402	203,159	265,916	0.644	2,193
2008	86,154	151,348	216,542	0.635	2,578
2009	54,653	61,433	68,212	0.432	1,392

Table 5. Trends in mean Northern Shrimp catch (t) per stratum and year using standardized small vessel (<500 t; <65'LOA) logbook catch information (2000 – 2009). (Green = <.5 t; .5<white<=1 t; 1<pink t; black no catch). The data were restricted to the April – October period of each year.

3LShrimp Mean wgt		year									
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		.	.	.	.	.	.	.	.	.	.
Max depth (m)	STRATUM										
91	371	.	.	.	.	.	.	.	0.41	.	.
183	348	.	.	.	.	.	.	0.88	0.42	0.43	.
	349	.	.	.	.	.	.	.	.	0.51	.
	364	.	.	.	.	.	.	.	0.95	.	.
	365	.	.	.	.	.	.	0.55	.	.	.
	370	.	.	.	.	.	0.65	0.64	0.52	.	.
	385	0.34	.	.	.	0.7	.	.	0.44	0.79	.
274	366	0.27	0.49	0.49	0.48	0.47	.	0.63	0.93	.	0.28
	369	0.26	0.11	.	.	0.53	0.74	0.53	0.54	0.39	0.47
	386	0.34	0.35	0.31	0.41	0.58	0.9	0.85	0.64	0.71	0.5
	389	.	.	.	0.36	0.48	0.9	1.02	0.64	0.94	0.6
366	345	0.13	.	0.38	0.5	0.66	0.37	0.78	0.74	0.71	0.44
	346	0.32	0.29	0.44	0.45	0.58	0.75	0.71	0.72	0.69	0.42
	368	0.28	0.6	0.32	0.5	0.52	0.74	0.55	0.61	0.36	0.39
	387	0.43	0.4	0.4	0.43	0.56	0.78	0.71	0.58	0.54	0.47
	388	.	.	.	.	.	.	.	.	1.54	.
549	731	.	.	.	.	.	.	.	1.23	0.58	.
	733	.	0.67	0.71	0.68	0.39	0.65	0.57	0.52	0.55	0.42
	735	0.11	.	0.47	0.55	.	0.95	0.51	0.67	.	.
731	734	.	.	.	.	0.37	.	.	.	.	0.3
	736	.	.	.	.	.	.	0.54	.	.	.
914	737	.	.	.	.	.	.	0.56	.	.	.
	741	.	.	.	0.15	.	.	.	.	.	.

Table 6. 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 – 2009. (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             10  2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
month             6  1 2 3 4 5 99
CFV              13
gear              2  66 99
                        Number of Observations Read         156
                        Number of Observations Used         156
Dependent Variable: lncpue
Weight: effort                                              Sum of
       Source                      DF         Squares     Mean Square    F Value    Pr > F
       Model                       27     1602.430193      59.349266      10.26    <.0001
       Error                      128      740.062554       5.781739
       Corrected Total            155     2342.492747
                       R-Square     Coeff Var      Root MSE    lncpue Mean
                       0.684071      32.18112      2.404525       7.471849
       Source                      DF       Type I SS     Mean Square    F Value    Pr > F
       year                         9     781.9115858      86.8790651      15.03    <.0001
       month                        5     310.0288993      62.0057799      10.72    <.0001
       CFV                         12     416.8190105      34.7349175       6.01    <.0001
       gear                         1      93.6706973      93.6706973      16.20    <.0001
       Source                      DF     Type III SS     Mean Square    F Value    Pr > F
       year                         9     426.4259393      47.3806599       8.19    <.0001
       month                        5     277.9357596      55.5871519       9.61    <.0001
       CFV                         12     362.5465750      30.2122146       5.23    <.0001
       gear                         1      93.6706973      93.6706973      16.20    <.0001
                                                          Standard
            Parameter               Estimate                 Error    t Value    Pr > |t|
            Intercept            6.714375423 B      0.21499595      31.23      <.0001
            year      2000      -0.831632950 B      0.15577182      -5.34      <.0001
            year      2001      -0.426152859 B      0.13777780      -3.09      0.0024
            year      2002       0.022231516 B      0.14378671       0.15      0.8774
            year      2003       0.370854855 B      0.14970796       2.48      0.0145
            year      2004      -0.119343577 B      0.13460009      -0.89      0.3769
            year      2005      -0.183747804 B      0.12358020      -1.49      0.1395
            year      2006      -0.189230752 B      0.11658782      -1.62      0.1070
            year      2007      -0.054362976 B      0.12696040      -0.43      0.6692
            year      2008      -0.121023223 B      0.11569911      -1.05      0.2975
            year      2009       0.000000000 B       .                .          .
                                     lncpue
                        year          LSMEAN      95% Confidence Limits
                        2000        6.798085       6.548498     7.047672
                        2001        7.203566       7.031715     7.375416
                        2002        7.651950       7.461898     7.842002
                        2003        8.000573       7.786194     8.214953
                        2004        7.510375       7.328180     7.692570
                        2005        7.445971       7.310110     7.581831
                        2006        7.440488       7.314238     7.566737
                        2007        7.575355       7.396507     7.754204
                        2008        7.508695       7.377537     7.639853
                        2009        7.629718       7.420416     7.839021
```

Table 7. Catch rate indices for **Canadian large vessels (>500 t)** fishing northern shrimp (*Pandalus borealis*) in NAFO Division 3L, 2000 – 2009.

YEAR	TAC	CATCH[1] (t)	PERCENT OF CATCH DATA CAPTURED IN MODEL[2]	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE RELATIVE TO 2008	UNSTANDARDIZED EFFORT[3] (HR)	STANDARDIZED CPUE RELATIVE TO 2008	STANDARDIZED MODELLED CPUE	STANDARDIZED EFFORT (HRS)
2000	1,686	833	47%	753	0.429	1,107	0.435	896	930
2001	2,500	2,394	79%	1,157	0.659	2,069	0.653	1,344	1,781
2002	2,500	2,456	94%	1,893	1.078	1,298	1.022	2,105	1,167
2003	4,267	4,038	59%	3,898	2.220	1,036	1.449	2,983	1,354
2004	4,267	4,036	45%	1,773	1.010	2,276	0.888	1,827	2,209
2005	4,277	4,039	82%	1,758	1.001	2,298	0.832	1,713	2,358
2006	5,273	6,016	61%	1,578	0.899	3,813	0.828	1,704	3,531
2007	5,907	5,743	33%	1,947	1.109	2,949	0.947	1,950	2,946
2008	6,568	6,314	75%	1,942	1.106	3,251	0.886	1,824	3,462
2009	6,022	2,287	55%	1,756	1.000	1,303	1.000	2,058	1,111

[1] 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 8. NAFO Division 3L annual Northern Shrimp biomass indices using areal expansion calculations with standardized large vessel (>500 t) observed catch information (2000 – 2009). The data were restricted to the first six months of each year.

Year	Biomass (tons) Lower C.I.	Biomass (tons) Estimate	Biomass (tons) Upper C.I.	Mean t per Set	Commercial Sets
2000	69,904	95,342	120,780	0.681	271
2001	56,952	80,625	104,297	0.382	434
2002	83,442	121,212	158,983	2.473	504
2003	130,692	166,901	203,111	4.122	357
2004	67,919	95,338	122,757	1.945	381
2005	96,355	108,953	121,551	2.012	598
2006	-181,359	134,734	450,827	1.721	582
2007	86,203	101,031	115,860	2.062	328
2008	168,182	193,808	219,433	2.296	669
2009	60,645	77,639	94,632	1.584	199

Table 9. Trends in mean Northern Shrimp catch (t) per stratum and year using standardized large vessel (>500 t) observed catch information (2000 – 2009). (Green = <1.33 t; 1.33<white<=2.66 t; 2.66<pink t; black no catch). The data were restricted to the first six months of each year.

3LShrimp Mean wgt		year									
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		.	.	.	.	.	.	.	.	.	.
Max depth (m)	STRATUM										
274	366	0.73	0.61	.	.	.	.	.	.	.	.
	369	.	.	.	.	.	.	1.48	.	1.97	.
	386	0.99	1.02	2.48	.	1.06	1.31	1.66	1.86	1.68	1.18
366	345	0.34	.	.	.	.	.	.	.	.	.
	346	0.69	.	.	.	.	.	.	.	.	.
	368	0.57	1.03	.	3.46	.	.	1.27	.	3.39	.
	387	1.07	1.23	2.06	3.87	2.14	2.35	1.77	2.13	2.28	1.93
549	733	0.43	1.06	3.1	5.76	3.51	2.66	2.59	2.37	3.2	1.91
	735	.	.	.	2.79	.	.	.	.	2.83	.
731	734	.	.	.	.	.	2.67	.	.	.	.

Table 10. Unstandardized catch rate indices for non Canadian large vessels fishing northern shrimp in NAFO Div. 3L NRA over the period 2000 – 2009. Indices included data from Iceland, Greenland, Estonia, Spain and Norway.

YEAR	TAC	CATCH (t)	PERCENT OF CATCH CAPTURED IN MODEL DATASET	UNSTANDARDIZED CPUE (KG/HR)	CPUE RELATIVE TO 2008	EFFORT (HR)
2000	1,000	661	21	746	1.111	886
2001	1,000	5,713	1	381	0.567	15,012
2002	1,000	1,577	4	650	0.967	2,428
2003	2,167	2,398	54	771	1.149	3,110
2004	2,167	2,904	18	1,344	2.002	2,160
2005	2,167	3,275	21	744	1.108	4,400
2006	3,675	7,673	22	677	1.008	11,337
2007	3,675	5,543	42	727	1.082	7,628
2008	3,815	6,248	37	632	0.941	9,888
2009	5100	3,265	20	671	1.000	4,863

Table 11. 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, 1996 – 2009. Previous estimates made use of preliminary data. The estimates presented here were determined using finalized datasets. Direction and percent change in relation to previous estimates are provided within the brackets. (Offshore strata only with standard 15 min. tows).

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.

Year	Biomass (tons)			Abundance (numbers x 10^6)			Survey Sets
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	
1996	20,150	24,700 (0%)	35,010	5,342	6,580 (+.12%)	9,390	304
1997	32,410	44,000 (0%)	61,940	7,550	9,917 (+0.06)	13,870	318
1998	48,320	60,700 (0%)	76,650	11,950	14,980 (+.03%)	19,130	347
1999	43,160	54,900 (0%)	72,400	10,620	12,997 (+.03%)	16,520	313
2000	83,990	107,000 (0%)	139,200	20,890	27,901 (+.01%)	35,830	337
2001	155,300	215,500 (+0.05%)	259,600	36,890	51,732 (0%)	62,040	362
2002	135,500	191,700 (0%)	239,500	31,110	44,475 (0%)	54,760	365
2003	144,000	191,000 (+.11%)	243,400	30,470	39,669 (+0.48%)	49,590	316
2004		???			???		
2005	177,500	222,600 (-0.49%)	264,600	35,490	45,083 (-0.41%)	53,730	333
2006	172,900	215,400 (0%)	252,000	36,450	47,034 (-0.04%)	55,700	312
2007	214,600	275,700 (+0.22%)	349,800	43,620	56,852 (+0.81)	71,460	361
2008	195,800	249,300	301,800	40,740	53,252	65,020	256

Area compared each year = 272,766.3 sq. km.

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. 18). The 1996 estimates are for Div. 3L only since at least 90% of the shrimp biomass and abundance is found within that division.

Year	Biomass (tons)			Abundance (numbers x 10^6)			Survey Sets
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	
1999	26,990	49,400 (0%)	76,190	6,564	11,418 (0%)	17,300	313
2000	65,710	113,300 (0%)	176,700	13,150	21357 (0%)	31,590	298
2001	52,680	82,500 (0%)	117,100	12,250	19,718 (+0.02%)	28,540	300
2002	87,390	133,800 (0%)	204,700	20,730	31,263 (0%)	47,660	304
2003	117,200	169,600 (0%)	222,600	26,370	38,967 (-.08%)	53,790	300
2004	40,960	93,500 (0%)	169,100	8,172	17,999 (0%)	31,890	296
2005	85,630	133,400 (0%)	183,500	16,800	25,553 (+ 0.05%)	34,860	289
2006	107,400	177,200 (-1.23%)	246,300	21,260	34,086 (-1.49%)	46,340	195
2007	190,200	288,600 (0%)	379,200	35,340	54,306 (0%)	72,790	295
2008	170,800	223,200 (-3.96%)	277,200	35,150	45997.2 (-4.58%)	55,980	273
2009	62,850	112,500	167,500	14,430	24,447	35,180	299

Table 12. Trends in mean Northern Shrimp catch (kg/15 min tow) per stratum and year using autumn Canadian research bottom trawl multi-species survey data (1996 - 2008). (Green = <33 kg; 33 kg<white<=66 kg; 66 kg<pink t; black no catch).

Fall3L3N3O Shrimp Mean wgt		YEAR												
		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
		.	.	.	.	.	.	.	.	.	.	.	.	.
Max depth (m)	STRATUM	0	0	0	0	0	0	0	0	0	0	0	0	0
55	375													
	376	0	0	0	0	0	0	0	0	0	0	0	0	0
91	330	0	0	0	0	0	0	0	0	0.01	0	0	0	0
	331	0.01	0	0	0	0	0	0	0	0.01	0	0	0	0
	338	0	0.01	0.01	0	0	0	0.01	0.01	0.01	0	0	0	0
	340	0	0	0	0	0	0	0.01	0	0.01	0	0	0	0
	350	0	0	0.01	0	0	0.01	0.1	0.13	0.01	0.01	0.02	0.03	0.01
	351	0.01	0	0.03	0	0.01	0.01	0.12	0	0.01	0.02	0	0	0
	352	0	0	0	0	0	0	0.01	0	0	0	0	0	0
	353	0.01	0	0.02	0	0	0	0	0	0.02	0	0	0	0
	360	0.03	0.01	0	0	0	0	0	0	0	0	0	0	0
	361	0	0	0	0	0	0	0	0	0	0	0	0	0
	362	0	0.01	0	0	0.01	0.03	0.06	0.07	0	0	0	0.01	0
	363	0	0.01	0.01	0	0.03	0.07	0.07	2.38	0	0	0	0.02	0.01
	371	0	0.01	0	0	0.04	0.03	0.06	0.14	0	0.02	0.03	0.1	0.09
	372	0.01	0.03	0.02	0	0.02	0.02	0.29	0.46	0.02	0	0	0.05	0.2
	373	0	0.01	0.02	0	0	0	0.18	0.05	0.01	0.02	0.01	0	0
	374	0	0	0.01	0	0	0	0.02	0.17	0	0	0.01	0	0
	383	0	0	0.05	0.01	0.08	0.03	1.16	0.11	0.06	0.01	0.05	0.01	0
	384	0.01	0.01	0	0.01	0.07	0.03	2.97	0.23	0.04	0	0.05	0.04	0.06
183	328	0.25	0.41	0.07	0.18	0.05	0.06	0.13	0.33	0.18	0.11	0.03	0.1	0.02
	329	0	0.01	0.01	0	0	0	0.01	0.03	0.02	0	0	0.03	0.01
	332	0.01	0	0.02	0	0	0	0	0.11	0.04	0.01	0	0	0
	337	0	0.01	0.03	0	0	0	0.01	0.09	0.04	0.04	0	0	0
	339	0	0.02	0.01	.	0	0	0.02	0.02	0.02	0	0	0	0
	341	0.35	0.18	0.02	0.08	0.12	0.09	0.22	0.25	0.17	0.01	0.08	0.76	0.08
	342	0.01	0	0.29	0.05	5.18	0.04	0.41	0.56	0.01	0	0	0	0.2
	343	0.01	0.01	0.06	0.02	0.07	0.05	0.07	0.06	0.24	0.31	0	0.79	0.12
	348	0.06	0.06	0.18	0.94	1.16	1.4	2.17	0.63	17.07	20.63	7.35	30.55	34.46
	349	0.01	0.02	0.05	0.04	0.1	0.13	1.5	0.96	0.13	0.12	0.61	1.04	0.02
	354	0.02	0.07	0.07	0.02	0	0.01	0.3	0	0.06	0.78	0.08	0	0
	359	0	0	0	0	0.01	0.01	0.03	0.01	0.01	0.17	0	0	0.01
	364	0.01	0.11	0.03	0.01	0.29	0.46	0.76	0.22	0.06	1.81	0.04	1	0.48
	365	0.02	0.69	1.17	0.41	.	22.16	22.29	0.65	.	66.53	140.1	25.54	61.32
	370	0.01	0.3	3.68	0.69	0.43	15.54	0.67	0.54	.	0.06	30.93	1.51	15.76
	377	0.15	2.97	8.13	0.01	0.34	0.06	0	33.18	0.66	3.33	0	0	0
	382	0	0.01	0	0.01	0.05	0.08	20.55	0.3	0.07	0.07	0.04	0.49	0.16
	385	0.03	4.26	0.59	3.69	6.01	12.46	10.5	13.47	16.55	24.33	58.32	92.97	108.4
	390	0	0.05	0.03	0.05	0.7	11.5	16.19	36.48	6.19	11.76	22.8	12.03	95.12
274	333	.	0.07	0.73	0.01	0.16	0.13	0	0.2	0.62	0.5	0.02	0.2	0.55
	336	0.04	0.03	0.23	0.01	0.01	0.01	0.02	0.64	0.63	0	0.16	0	0.01
	344	0.12	0.45	12.31	21.84	13.75	8.49	32.52	8.98	63.65	66.52	52.12	189.6	202.7
	347	0.31	0.17	33.63	10.73	51.12	72.45	59.04	12.08	151	95.32	98.24	159	97.88
	355	0	0.12	1.05	0.05	0.01	0.09	1.67	0.6	0.83	0.2	0.5	0.08	0
	358	0.87	0.05	1.23	0.09	0.29	5.25	3.42	8.35	3.62	0.6	0.05	0	0
	366	2.74	58.07	26.53	37.51	118.3	123.8	132.2	112.2	.	168.3	220.7	53.63	142.4
	369	1.29	13.07	44.81	27.94	23.78	76.89	47.47	156	.	203.2	112.8	156.7	158.2
	378	1.3	9.55	17.31	0.41	0.78	5.44	68.11	4.77	27.28	0.87	14.27	0.04	0.05
	381	26.98	4.55	98.48	3.47	1.47	0.9	1.66	50.2	0.35	1.09	7.9	1.58	0.49
	386	2.11	64.47	41.46	54.66	42.72	105.7	174.2	159.2	.	149.8	223.7	273	229.6
	389	16.66	13.53	57.42	83.55	208.3	269.3	284.9	165.8	88.48	102.4	210.5	227.3	334.2
	391	9.46	5.7	4.02	5.95	88.03	8.54	2.56	189.4	54.45	50.06	18	430.9	11.26
366	334	.	0.02	0.04	0	0	0	0.05	0.04	0.08	0	0	0	0
	335	0	0	0	0	0	0	0	0	0	0.01	0	0	0
	345	9.66	28.44	47.37	20.76	87.04	85.21	151.7	80.64	95.4	129.7	89.14	169.5	78.74
	346	55.7	44.18	27.66	41.98	49.25	149.6	282.7	237.6	87.11	278.3	98.99	41.18	99.9
	356	0	0	0	0.01	0	0.14	0.13	0.1	0.03	0	0	0.01	0
	357	0	0.25	0.48	.	0.04	0	4.93	9.24	0.18	8.23	0.72	0.89	0.02
	368	25.13	9.87	7.3	2.06	0.56	346.6	9.33	207.4	.	227.5	44.62	13.43	5.51
	379	7.06	0.05	0.08	0.08	1.24	25.97	27.26	14.44	39.82	2	2.45	1.45	13.7
	380	2.03	1.93	4.08	5.21	2.19	1.09	6.04	0.6	5	0.82	4.43	0	1.23
	387	22.72	40.41	68.32	37.09	114	415.7	112.9	424.5	.	219.3	104.6	216.2	93.65
	388	30.19	39.96	28.04	10.75	81.68	257	136	70.73	78.28	167	36.92	197.1	40.39
	392	15.21	3.45	8.77	5.76	18.19	15.03	2.07	41.43	39.58	32.6	26.3	38.5	0.06
549	717	.	0.01	0.01	0.01	0	0	0.04	0.03	0	0	0	0	0.08
	719	0	0	0	0	0	0	0	0	0	0	0	0	0
	721	0.02	0	0	0.03	0.01	0.09	0.26	0.02	0.01	0	0.18	0.09	0.15
	723	0	0	0.85	0.07	0.08	0.03	1.82	0.17	0.01	0.7	0.26	0.07	0.01
	725	0.11	0.63	0.05	3.38	4.52	0.61	0.78	0.75	.	0.63	0.06	0.15	0.56
	727	24.57	0.31	0.2	0.33	0.73	0.78	0.53	0.22	0.02	0	1.32	0.12	1.26
	729	0.13	0.06	0.01	1.85	0.02	22.11	0	0.54	0.04	0.03	0.27	0	0
	731	.	0.49	0.35	0.45	3.55	2.9	24.37	0	50.57	4.09	6.71	4.13	0.83
	733	3.09	2.48	0.18	0.96	0	3.54	0.06	0	3.36	0.47	0.04	1.6	10.19
	735	0.04	4.15	0.05	1.42	2.99	0.19	0.31	3.69	.	1.43	2.76	0.01	1.58
731	718	.	0	0	0	0	0	0	0.04	0	0	.	0	0
	720	0	.	0	0	0	0	0	0.05	0.02	0	0	0	0
	722	0	0.01	0	0.13	0.03	0	0	0.1	0	0	0	0	0
	724	0	0.01	0.01	0.01	0.62	0.17	0.59	.	0.02	0	0.05	0	0
	726	0.06	0.02	8.62	0.1	0.36	3.45	0.31	0.06	0.09	0.23	0	0	0
	728	0	0.05	0.25	0.46	0.1	0.12	0.09	0.16	0	0	0.72	0	0
	730	0.04	0.02	0	0	0	0.04	0	0	0	1.18	0.02	0	0
	732	0	0.01	0	0.02	0	0.07	0.27	0	0.04	0.12	0	0	0.72
	734	0	0.02	0	0.01	0	0.04	0.26	0	.	0.03	0	0.03	0
	736	0	0.3	0.09	0.08	1.05	0.49	0	0.72	.	0.05	0.07	0	0.04
914	737	0	0	0	0	0.02	0.01	0	0.01	.	0.04	0	0	.
	741	0	0	0	0	0	0	0.01	0.65	.	.	0	0	.
	745	0	0.01	0	0	0.01	0.19	0	0.15	.	.	0	0	.
	748	0	0.02	0.01	0	0.03	0.12	0	0.03	.	.	0	0.01	.
	752	.	.	0	.	0.02	0	0	.	.	.	.	0	.
	756	.	.	0	.	1.04	0.63	0.37	.	.	0.35	.	0	.
	760	.	.	0	.	0.04	0	0.07	.	.	0	.	0	.
	764	.	.	0	.	0.01	0	0	.	.	0	.	0	.
	768	.	.	0	.	0	0	0	.	.	0	.	0	.
	772	.	.	0	.	0	.	0	0	.	0	.	0	.

Table 13. Trends in mean Northern Shrimp catch (kg/15 min tow) per stratum and year using spring Canadian research bottom trawl multi-species survey data (1999 - 2009). (Green = <33 kg; 33 kg<white<=66 kg; 66 kg<pink t; black no catch).

Spring3L3N3O Shrimp Mean wgt		YEAR										
		1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		.	.	.	.	.	.	.	.	.	.	.
Max depth (m)	STRATUM	0	0	0	0	0	0	0	0	0	0	0
55	375											
	376	0	0	0	0.02	0	0	0	0	0	0	0
91	330	0	0	0	0	0.01	0	0	0	0	0	0.01
	331	0	0	0.01	0	0.01	0	0	.	0	0	0
	338	0	0	0	0	0.01	0	0	0	0	0	0
	340	0	0	0	0.01	0.01	0.04	0	0	0	0	0
	350	0	0	0	0	0.02	0	0	0	0.01	0.01	0
	351	0	0	0	0	0.01	0	0	0	0	0	0
	352	0	0	0	0.01	0.01	0	0	0	0	0	0
	353	0	0	0	0	0	0	0	0	0	0	0
	360	0	0	0	0	0	0	0	0	0	0	0
	361	0	0	0	0	0	0	0	0	0	0	0
	362	0	0	0	0	0	0	0	0	0.01	0	0
	363	0	0	0	0	0.02	0	0	0	0	0.07	0
	371	0	0	0	0	0	0	0	0	0	0	0
	372	0	0	0	0	0	0	0	0	0	0	0.01
	373	0.01	0	0	0.01	0	0	0	.	0.01	0	0.01
	374	0	0	0	0	0	0	0	0	0	0	0
	383	0	0	0.01	0	0	0.01	0	.	0	0	0
	384	0.01	0	0	0.02	0	0	0	0	0	0	0
183	328	0	0.06	0	0.01	0.04	0.1	0.07	0.04	0.03	.	0.01
	329	0	0	0.02	0	0.05	0.01	0	.	0	0	0.02
	332	0.06	0	0	0	0.05	0.22	0.12	.	0	0	0
	337	0	0	0	0.01	1.02	0	0.08	.	0	0	0
	339	0.02	0	0.09	0.01	0.09	0.39	0.04	0	0	0	0
	341	0.01	0.02	0.01	0.01	0.02	0.2	0	0	0.01	0.02	0.01
	342	0.04	0.01	0	0.09	0.02	0.06	0.01	0	0.11	0	0.08
	343	0.04	0	0.08	0	0.03	0.06	0.03	0.01	0.11	0.02	0.08
	348	0.02	0.08	0.02	0.03	0.04	0.03	0.05	0.04	0.11	0.42	0.06
	349	0.03	0.01	0	0.01	0.02	0.03	0	0.03	0	0.01	0.01
	354	0	0	0	0	0	0	0.2	.	0.1	0	0
	359	0.01	0	0.01	0	0.01	0	0	.	0	0	0
	364	0	0.01	0.02	0.03	0.02	0	0	0	0	0	0
	365	0	0.01	0.06	0.02	0.04	0	0.02	0.18	0	9.07	0.1
	370	0	0	0	0	0	0	0	0	0	0	0
	377	6.84	0	0	0	0.01	0.09	0.04	.	0	0	0
	382	0	0.01	0	0.02	0.02	0	0.04	.	0	0	0
	385	0	0	0.02	0.06	0	0.03	0	0	0.09	130.4	0.01
	390	0.01	0.01	0.01	0.01	0	0.04	0.11	0	0	0	0.02
274	333	0.22	0.01	0.02	0.24	0.13	0.12	2.85	.	0.02	0.01	0.02
	336	0.34	0.4	0.07	0.01	0.16	0	0	.	0	0.42	0
	344	0.16	0.05	0.24	0.81	4.11	0.06	13.98	4.28	0.81	16.57	0.65
	347	0.11	0	9.05	0.93	0.17	0.86	49.41	20.99	53.62	43.42	92.85
	355	0	0	0.02	0	0.18	0.61	0.63	.	0.01	0.02	0
	358	0.24	0	0	0.01	0.28	6.06	0.1	.	0	0	0
	366	3.85	93.34	59.22	179.1	36.98	1.95	66.49	17.68	32.17	51.94	8.25
	369	0.05	11.21	0	22.86	275.6	2.6	144.6	32.18	115.6	32.94	113.8
	378	8.4	1.71	0.11	3.35	58.53	0.06	0.19	.	0	0	0.04
	381	1.94	10.65	0.09	4.13	0.94	13.73	1.07	.	0.64	3.02	0.81
	386	15.7	60.75	12.05	0.23	3.39	13.29	29.49	183.6	92.55	162.9	0.04
	389	84.13	283.7	8.31	43.38	129.9	9.9	125.7	445.8	262.7	202.5	101.2
	391	0.01	0	2.46	0	78.51	0.99	3.08	2.5	949.8	26.45	526.8
366	334	0.56	1.84	0	0.01	0.07	3.29	0	.	0	0	0
	335	0.05	0.36	0	0	0.02	0	0.01	.	0.01	0	0
	345	30.77	67.13	159.7	49.94	193.1	92.71	163	204.1	386.9	388.5	94.93
	346	104.7	121.9	164	213.8	117.1	86.54	292.2	60.97	443	187.6	41.56
	356	0	0	0	0	0	0.04	0	.	0.04	0	0
	357	30.19	0.02	0.11	0	4.66	5.31	0.01	.	0.01	0	0
	368	76.56	202.9	21.46	70.57	320.1	109.7	15.52	67.53	61.86	50.97	7.68
	379	10.59	117.6	0.23	6.95	93.12	0.69	6.84	.	0	0.88	0
	380	2.88	3.37	2.17	237.6	3.43	0.01	2.04	.	8.47	0.11	1.15
	387	126.6	13.18	189	352.9	380	516.2	137.3	221.6	85.21	220.6	25.39
	388	64.25	258.7	170.8	581	158.9	69.91	53.33	175.1	242.4	21.56	272.8
	392	3.27	7.67	36.3	0.67	50.02	6.29	34.63	8.24	4.44	0.62	3.78
549	717	0.1	0.02	0	0.24	0.12	0	0	.	0	0	0.01
	719	0	0.01	0	0.97	0	0.01	0	.	0.03	0	0
	721	0	0.1	0.16	0.51	0.01	0.12	0	.	0.12	0	0.03
	723	0	0.03	0	0.6	0.02	0	0	.	0.58	0.04	0
	725	0	0.58	0.18	0	0.02	0.03	13.8	.	1.9	0.04	0.19
	727	3.13	1.31	0.03	0.26	0.03	16.5	5.59	.	2.06	0.76	0
	729	0	0.27	0.58	0.08	12.41	0.1	4.25	11.39	0.03	5.92	0
	731	3.5	14.55	21.69	3.54	143.9	0.69	18.46	25.43	47.65	6.4	2.11
	733	1.72	6.18	2.56	3.15	39.37	0.17	1.82	2.68	13.13	0.87	14.42
	735	0.49	3.25	0.42	1	0.08	0.04	1.75	1.71	0.41	4.69	1.94
731	718	0	0	0	0	0	0	0	.	0	0	0
	720	0	0.01	0	0	0.03	0	0	.	0	0	0
	722	0	0.48	0	0.01	0.02	0	0	.	0	0	0
	724	0	0	0	0	0	0.03	0	.	0.08	.	0
	726	0	0	0	0.11	0	0	0	.	0.62	0	0
	728	0.01	0.03	0	1.41	0	0.04	0.16	.	0	0	0
	730	0	0.04	0	0.02	0.05	0.01	0	0	0	0	0
	732	2.39	1.37	0.35	3.27	0.29	0	0	0.07	0	0	0.68
	734	0.11	0	2.35	0.21	0.03	0	0	0.04	0.09	.	0
	736	0.11	0.1	0.29	0.25	0.38	0	0	0	0.11	0.62	0

Table 14. NAFO Divisions 3LNO *Pandalus borealis* biomass estimates for entire divisions and outside the 200 Nmi limit. Shrimp were collected during the 1996 – 2008 **autumn** Canadian multi-species surveys using a Campelen 1800 shrimp trawl (standard 15 min tows). All indices were estimated using Ogmap calculations.

			Entire Division		Outside 200 Nmi limit			
Season	Year	Division	Biomass 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	1996	3L	22,900	92.71	4,000	85.11	17.47	
Autumn	1997	3L	43,400	98.64	5,500	91.67	12.67	
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	97.02	35,600	91.75	19.21	19.02
Autumn	2004	3L	???	???	???	???	???	???
Autumn	2005	3L	221,200	99.37	26,200	97.40	11.84	???
Autumn	2006	3L	213,700	99.21	27,100	96.44	12.68	???
Autumn	2007	3L	271,500	98.48	49,700	98.42	18.31	14.28
Autumn	2008	3L	246,200	98.76	32,900	97.92	13.36	14.78
Autumn	1996	3N	2,000	8.10	700	14.89	35.00	
Autumn	1997	3N	700	1.59	500	8.33	71.43	
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	8.25	68.09	70.39
Autumn	2004	3N	2,600	???	2,100	???	???	???
Autumn	2005	3N	1000	0.45	700	2.60	70.00	
Autumn	2006	3N	1,500	0.70	1000	3.56	66.67	
Autumn	2007	3N	1,300	0.47	800	1.58	61.54	66.07
Autumn	2008	3N	1,300	0.52	700	2.08	53.85	60.68
Autumn	1996	3O	0	0.00	0	0.00	0.00	
Autumn	1997	3O	0	0.00	0	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	
Autumn	2006	3O	0	0.00	0	0.00	0.00	
Autumn	2007	3O	0	0.00	0	0.00	0.00	0.00
Autumn	2008	3O	0	0.00	0	0.00	0.00	0.00
	all divisions							
Autumn	1996		24,700	101	4,700	100	19.03	
Autumn	1997		44,000	100	6,000	100	13.64	
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		191,000	100	38,800	100	20.31	19.90
Autumn	2004		???		???		???	???
Autumn	2005		222,600	100	26,900	100	12.08	
Autumn	2006		215,400	100	28,100	100	13.05	
Autumn	2007		275,700	99	50,500	100	18.32	14.48
Autumn	2008		249,300	99	33,600	100	13.48	14.95

Table 15. NAFO Divisions 3LNO *Pandalus borealis* biomass estimates for entire divisions and outside the 200 Nmi limit. Shrimp were collected during the 1999 – 2009 **spring** Canadian multi-species surveys using a Campelen 1800 shrimp trawl (standard 15 min tows). Please note that strata deeper than 93 m were not surveyed in 3NO during spring 2006. Historically more than 97% of the shrimp have been attributed to strata within 3L therefore the spring 2006 estimates are for 3L. All indices were estimated using Ogmap 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	47,500	96.15	10,200	86.44	21.47	
Spring	2000	3L	108,700	95.94	23,800	87.18	21.90	
Spring	2001	3L	82,700	100.24	11,400	99.13	13.78	19.05
Spring	2002	3L	128,100	95.74	34,300	91.47	26.78	20.82
Spring	2003	3L	165,400	97.52	29,900	86.92	18.08	19.55
Spring	2004	3L	92,000	98.40	23,700	97.13	25.76	23.54
Spring	2005	3L	133,200	99.85	14,200	94.67	10.66	18.17
Spring	2006	3L	177,200	???	41,600	???	23.48	19.97
Spring	2007	3L	282,100	97.75	78,200	97.02	27.72	20.62
Spring	2008	3L	222,600	99.73	31,600	99.06	14.20	21.80
Spring	2009	3L	110,200	97.96	36,200	98.64	32.85	24.92
Spring	1999	3N	2,100	4.25	1,600	13.56	76.19	
Spring	2000	3N	4,700	4.15	3,500	12.82	74.47	
Spring	2001	3N	300	0.36	100	0.87	33.33	61.33
Spring	2002	3N	5,800	4.33	3,200	8.53	55.17	54.32
Spring	2003	3N	5,400	3.18	4,500	13.08	83.33	57.28
Spring	2004	3N	1,200	1.28	700	2.87	58.33	65.61
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	
Spring	2008	3N	500	0.22	300	0.94	60.00	
Spring	2009	3N	700	0.62	500	1.36	71.43	69.62
Spring	1999	3O	100	0.20	0	0.00	0.00	
Spring	2000	3O	100	0.09	0	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	0.21	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
Spring	2008	3O	0	0.00	0	0.00	0.00	0.00
Spring	2009	3O	0	0.00	0	0.00	0.00	0.00
	all divisions							
Spring	1999		49,400	100.61	11,800	100.00	23.89	
Spring	2000		113,300	100.18	27,300	100.00	24.10	
Spring	2001		82,500	100.61	11,500	100.00	13.94	20.64
Spring	2002		133,800	100.15	37,500	100.00	28.03	22.02
Spring	2003		169,600	100.83	34,400	100.00	20.28	20.75
Spring	2004		93,500	99.89	24,400	100.00	26.10	24.80
Spring	2005		133,400	100.97	15,000	100.00	11.24	19.21
Spring	2006		???	???	???	???	???	
Spring	2007		288,600	98.82	80,600	100.00	27.93	
Spring	2008		223,200	99.96	31,900	100.00	14.29	
Spring	2009		112,500	98.58	36,700	100.00	32.62	24.95

Table 16. 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 using OGMap calculations.

Mean Carapace Length (Standard Error)

	Age			
Year	1	2	3	4
1996	11.19 (.076)	15.92 (.036)	19.32 (.070)	21.44 (.404)
1997	11.01 (.063)	16.11 (.067)	18.83 (.317)	20.01 (1.289)
1998	10.74 (.018)	15.91 (.115)	18.90 (.172)	20.68 (.226)
1999	11.09 (.067)	15.99 (.020)	18.98 (.047)	20.89 (.042)
2000	10.49 (.029)	15.23 (.033)	18.16 (.021)	20.55 (.122)
2001	10.17 (.043)	15.03 (.023)	17.37 (.031)	19.60 (.015)
2002	10.44 (.032)	14.49 (.021)	17.65 (.014)	20.06 (.014)
2003	10.11 (.034)	15.10 (.031)	18.02 (.065)	19.95 (.030)
2004	Incomplete survey			
2005	10.63 (.028)	14.61 (.075)	17.83 (.052)	20.86 (.095)
2006	10.67 (.019)	14.84 (.019)	17.88 (.123)	19.97 (.029)
2007	11.27 (.040)	15.21 (.023)	17.87 (.023)	20.66 (.017)
2008	10.24 (.031)	14.95 (.026)	17.86 (.027)	20.17 (.024)

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

	Age				
Year	1	2	3	4	Total
1996	.073 (.004)	.630 (.011)	.220 (.036)	.077 (.032)	1.000
1997	.069 (.003)	.425 (.020)	.331 (.301)	.174 (.289)	0.999
1998	.234 (.004)	.212 (.016)	.335 (.079)	.220 (.068)	1.001
1999	.055 (.002)	.546 (.007)	.150 (.011)	.249 (.009)	1.000
2000	.061 (.002)	.342 (.007)	.460 (.015)	.137 (.011)	1.000
2001	.016 (.001)	.184 (.004)	.308 (.005)	.492 (.006)	1.000
2002	.035 (.010)	.133 (.002)	.468 (.004)	.364 (.004)	1.000
2003	.047 (.001)	.178 (.004)	.247 (.012)	.528 (.013)	1.000
2004	Incomplete survey				
2005	.039 (.001)	.097 (.012)	.637 (.036)	.227 (.025)	1.000
2006	.059 (.001)	.296 (.004)	.161 (.011)	.484 (.013)	1.000
2007	.035 (.001)	.239 (.004)	.401 (.004)	.325 (.004)	1.000
2008	.048 (.001)	.195 (.003)	.434 (.005)	.323 (.006)	1.000

Distributional Sigmas (Standard Error and constraints)

	Age			
Year	1	2	3	4
1996	1.165 (Fixed)	1.234 (.032)	0.794 (.072)	1.249 (.237)
1977	1.150 (.050)	1.043 (.043)	.843 (.167)	1.004 (.305)
1998	0.89 (.014)	1.20 (.068)	0.948 (.128)	0.892 (.068)
1999	1.23 (.054)	.975 (.017)	.699 (.052)	.997 fixed
2000	0.90 (.023)	1.11 (.024)	0.84 (.023)	1.20 (.057)
2001	0.99 (.007) Sigmas Eq.			
2002	0.97 (.006) Sigmas Eq.			

2003	1.123 (.012) Sigmas Eq.			
2004	Incomplete survey			
2005	0.86 (.022)	0.85 (.044)	1.50 (.086)	1.10 (.036)
2006	0.80 (CV=.075)	1.11 (CV=.075)	1.34 (CV=.075)	1.49 (CV=.075)
2007	1.106 (.008) Sigmas Eq.			
2008	1.149 (.010) Sigmas Eq.			

Population at Age Estimates (10^6)

	Male Ages					All females	Total
Year	0	1	2	3	4		
1996	0	436	3,740	1,360	455	661	6,570
1997	3	497	3,036	2,366	1,246	2,710	9,858
1998	0	3,006	2,717	4,298	2,819	2,132	14,973
1999	2	556	5,451	1,503	2,538	3,001	12,999
2000	3	1,465	8,080	10,257	3,268	4,250	27,922
2001	4	700	8,016	13,396	21,458	8,135	51,709
2002	0	1,234	4,633	16,322	12,679	9,596	44,464
2003	0	1,354	5,129	7,111	15,235	10,796	39,625
2004	Incomplete survey						
2005	7	1,331	3,281	21,574	7,685	11,126	46,046
2006	0	2,283	11,338	6,037	17,752	9,634	47,043
2007	0	1,449	9,803	16,423	13,305	15,774	56,754
2008	0	2,105	7,867	17,497	13,161	12,558	53,203

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 using OGMap calculations.

Mean Carapace Length (Standard Error)

Year	Age					
	0	1	2	3	4	5
1999		12.43 (.454)	14.63 (.055)	18.15 (.069)	20.51 (.053)	
2000		8.73 (.044)	14.22 (.034)	18.00 (.024)	20.74 (.070)	
2001		8.39 (.131)	13.45 (.027)	16.82 (.008)	19.13 (.024)	
2002		8.27 (.061)	12.85 (.029)	16.97 (.021)	19.43 (.018)	
2003		8.37 (.065)	13.09 (.003)	16.01 (.091)	17.96 (.086)	19.69 (.040)
2004		8.55 (.288)	13.66 (.094)	17.13 (.299)	18.47 (.090)	19.96 (.026)
2005		8.93 9.078)	14.10 (.052)	17.07 (.130)	18.69 (.212)	20.59 (.088)
2006		9.57 (.148)	13.84 (.019)	17.53 (.189)	18.83 (.412)	20.52 (.054)
2007		9.37 (.157)	13.48 (.018)	16.89 (.025)	19.46 (.063)	21.08 (.041)
2008		8.85 (.072)	13.39 (.032)	16.14 (.036)	18.46 (.038)	20.78 (.038)
2009		11.87 (.056)	15.61 (.162)	17.66 (.094)	19.56 (.148)	22.80 (.063)

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

Year	Age						
	0	1	2	3	4	5	Total
1999		.067 (.024)	.389 (.026)	.165 (.015)	.379 (.014)		1.000
2000		.023 (.001)	.353 (.006)	.454 (.012)	.170 (.008)		1.000
2001		.006 (.001)	.201 (.004)	.294 (.008)	.499 (.009)		1.000
2002		.018 (.001)	.100 (.002)	.399 (.006)	.482 (.006)		.999
2003		.013 (.001)	.131 (.003)	.137 (.010)	.304 (.013)	.415 (.017)	1.000
2004		.004 (.001)	.129 (.007)	.150 (.050)	.119 (.051)	.598 (.014)	1.000
2005		.017 (.001)	.162 (.006)	.352 (.042)	.272 (.037)	.197 (.020)	1.000
2006		.005 (.001)	.303 (.004)	.188 (.052)	.147 (.043)	.357 (.025)	1.000
2007		.003 (.000)	.196 (.003)	.325 (.005)	.255 (.010)	.221 (.011)	1.000
2008		.011 (.001)	.140 (.003)	.336 (.006)	.372 (.006)	.141 (.005)	1.000
2009		.110 (.004)	.227 (.034)	.213 (.071)	.442 (.050)	.008 (.002)	1.000

Distributional Sigmas (Standard Error and constraints)

Year	Age					
	0	1	2	3	4	5
1999		1.130 (.186)	.912 (.040)	.769 (.059)	.998 (.031)	
2000		.708 (.036)	1.317 (.026)	.917 (.026)	1.023 (.038)	
2001	1.063 (.012) Sigmas Eq.					
2002	1.064 (.009) Sigmas Eq.					
2003	1.011 (.015) Sigmas Eq.					
2004		1.086 (.220)	1.314 (.070)	.888 (.192)	.540 (.096)	1.00 (Fixed)
2005	1.094 (.025) Sigmas Eq.					
2006	1.029 (.014) Sigmas Eq.					
2007	1.028 (.010) Sigmas Eq.					
2008	1.054 (.013) Sigmas Eq.					
2009		1.083 (.037)	1.032 (.108)	.768 (.113)	1.156 (.076)	.246 (.058)

Table 17 (Continued)

Population at Age Estimates (10^6)

Year	Male Ages						Females	Total
	0	1	2	3	4	5		
1999	57	631	3,354	1,423	3,282	0	2,654	11,401
2000	0	334	5,216	6,702	2,523	13	6,559	21,347
2001	0	93	3,014	4,414	7,515	18	4,646	19,698
2002	0	416	2,258	8,976	10,848	0	8,749	31,247
2003	0	340	3,472	3,633	8,038	10,989	12,482	38,955
2004	0	47	1,587	1,846	1,468	7,349	5,689	17,986
2005	0	251	2,399	5,213	4,035	2,922	10,750	25,570
2006	4	132	6,288	3,896	3,049	7,631	13,104	34,104
2007	0	92	6,593	10939	8,599	7,474	25,215	58,912
2008	16	362	4,066	9,742	10,775	4,115	16,895	45,972
2009	0	1,770	3,643	3,409	7,094	125	8,415	24,456

Table 18. Male biomass/ abundance indices estimated using Ogmap calculations from Canadian **autumn** research bottom trawl survey data, 1996 – 2008. Please note that there was an incomplete survey during 2004 therefore there are no values for that survey.

Year	Biomass (tons)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	14,780	18,900	26,570	4,672	5,907	8,381
1997	18,950	24,800	34,320	5,638	7,197	9,976
1998	31,450	42,500	55,470	10,010	12,846	16,430
1999	25,170	33,200	42,670	7,911	9,997	12,590
2000	53,880	74,500	96,250	16,690	23,652	30,980
2001	101,100	152,000	187,100	30,240	43,594	52,930
2002	82,410	122,300	149,800	23,870	34,880	42,660
2003	79,860	108,200	138,200	21,800	28,855	36,150
2004						
2005	100,200	127,900	151,400	26,190	33,936	40,510
2006	101,200	132,800	155,000	27,690	37,397	44,990
2007	110,800	147,700	189,200	30,230	41,072	52,350
2008	107,200	144,100	185,600	29,720	40,681	51,870

Table 19. Male biomass/ abundance indices estimated using Ogmap calculations from Canadian **spring** research bottom trawl survey data, 1999 – 2009. 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.

Year	Biomass (tons)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1999	13,570	29,400	48,810	4,604	8,756	13,970
2000	25,740	46,900	73,670	8,880	14,796	21,490
2001	27,550	50,000	74,350	8,606	15,069	22,410
2002	47,440	79,200	129,400	14,170	22,506	34,940
2003	58,580	91,100	127,500	16,520	26,487	39,200
2004	19,110	51,700	102,500	5,257	12,306	22,710
2005	32,930	52,600	72,550	9,603	14,808	20,360
2006	43,520	76,000	103,900	12,890	20,992	28,490
2007	70,820	111,900	155,900	19,870	31,335	42,850
2008	68,560	94,600	118,900	21,170	29,099	36,890
2009	30,030	53,500	76,440	8,891	16,039	23,450

Table 20. Female biomass/ abundance indices estimated using Ogmap calculations from Canadian **autumn** research bottom trawl survey data, 1996 – 2008. Please note that there was an incomplete survey during 2004 therefore there are no values for that survey.

Year	Biomass (tons)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	4,401	5,800	10,300	519	661	1,159
1997	13,040	19,200	28,440	1,801	2,720	4,032
1998	14,670	18,200	24,190	1,762	2,134	2,844
1999	17,560	21,700	30,830	2,445	3,000	4,173
2000	24,340	32,600	46,250	3,229	4,249	5,925
2001	41,990	63,500	85,860	5,645	8,138	10,920
2002	49,550	69,500	93,800	6,802	9,595	13,030
2003	59,860	82,800	111,500	7,892	10,814	14,440
2004						
2005	69,790	94,800	121,700	8,336	11,147	14,340
2006	62,820	82,600	107,900	7,305	9,637	12,680
2007	94,070	128,000	168,500	11,890	15,781	20,650
2008	76,720	105,200	138,500	9,221	12,571	16,760

Table 21. Female biomass/ abundance indices estimated using Ogmap calculations from Canadian **spring** research bottom trawl survey data, 1999 – 2009. 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.

Year	Biomass (tons)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1999	11,610	20,000	29,550	1,517	2,655	3,956
2000	28,540	50,300	78,820	3,722	6,562	10,130
2001	23,130	32,500	43,870	3,231	4,648	6,361
2002	38,730	54,600	80,140	6,209	8,757	12,890
2003	58,350	74,400	101,300	9,096	12,479	16,060
2004	21,240	41,800	67,320	2,931	5,692	9,094
2005	51,000	80,800	111,800	6,679	10,745	15,090
2006	59,150	101,200	143,400	7,692	13,093	18,400
2007	110,900	176,700	241,100	14,370	22,970	31,550
2008	91,920	128,600	160,500	12,140	16,899	20,940
2009	30,300	59,000	97,490	4,391	8,408	13,600

Table 22. Fishable biomass (t) indices (total weight of all females + weight of all males with carapace lengths => 17.5 mm) as determined using ogmap calculations from autumn and spring Canadian multi-species bottom trawl survey data, 1996 – 2009. Previous estimates made use of preliminary data. The estimates presented here were determined using finalized datasets. Direction and percent change in relation to previous estimates are provided within the brackets.

Year	Spring			Autumn		
	Lower 95% C.I.	Estimate (t)	Upper 95% C.I.	Lower 95% C.I.	Estimate (t)	Upper 95% C.I.
1996				12,390	14,600 (0%)	22,790
1997				23,670	34,100 (0%)	48,900
1998				36,080	48,300 (0%)	63,770
1999	20,590	40,700 (0%)	64,080	32,230	41,000 (0%)	56,470
2000	42,080	80,900 (0%)	133,300	61,970	79,100 (0%)	105,200
2001	42,750	66,300 (0%)	93,630	123,400	173,200 (+0.06%)	217,600
2002	71,350	110,600 (-1.60%)	172,700	111,000	157,000 (0%)	198,700
2003	106,300	148,500 (0%)	193,100	123,700	167,300 (+0.6%)	217,300
2004	35,000	83,300 (+.012%)	152,900		???	
2005	73,190	116,100 (+0.09%)	161,200	143,500	180,700 (+.11%)	216,600
2006	91,250	158,300 (+0.06%)	218,900	138,300	173,100 (0%)	205,500
2007	183,500	280,900 (+8.79%)	415,300	176,500	230,800 (-5.02%)	297,200
2008	137,600	188,200 (+.22%)	237,500	157,400	204,600	251,300
2009	53,190	97,600	151,500			

Table 23. Recruitment indices as determined using ogmap calculations from autumn and spring Canadian multi-species bottom trawl survey data, autumn1996– spring 2009.

(i) Age 2 abundance from modal analysis of population adjusted length frequencies. Please note that the table presents survey year. The cohort year is survey year -2.

Survey Year	Recruitment indices		Cohort Year
	Spring	Autumn	
1996		3,740	1994
1997		3,036	1995
1998		2,717	1996
1999	3,354	5,451	1997
2000	5,216	8,080	1998
2001	3,014	8,016	1999
2002	2,258	4,633	2000
2003	3,472	5,129	2001
2004	1,587		2002
2005	2,399	3,281	2003
2006	6,288	11,338	2004
2007	6,593	9,803	2005
2008	4,066	7,867	2006
2009	3,643		2007

(ii) Abundances of males from spring (10 – 17 mm carapace lengths) and autumn (12-17 mm carapace lengths).

Year	Spring			Autumn		
	10 - 17 mm carapace lf			12 - 17 mm carapace lf		
	Lower 95% C.I.	Abundance (10^6)	Upper 95% C.I.	Lower 95% C.I.	Abundance (10^6)	Upper 95% C.I.
1996				2,641	3,515	4,934
1997				2,429	2,986	4,020
1998				2,226	2,936	3,813
1999	2,230	4,248	6,804	3,967	5,261	6,570
2000	4,424	7,207	9,827	6,965	10,266	13,640
2001	3,823	6,784	10,390	11,480	15,877	18,640
2002	5,409	8,668	13,950	8,261	12,253	14,840
2003	4,690	9,596	17,240	5,676	7,614	9,379
2004	1,866	2,935	4,332			
2005	4,073	6,392	8,994	9,088	12,513	16,010
2006	5,723	8,576	12,090	9,994	14,566	19,350
2007	8,022	13,840	19,470	11,770	16,758	22,800
2008	9,886	14,830	19,580	9,999	14,872	20,470
2009	3,141	6,950	11,460			

Table 24. Exploitation rate indices for NAFO Divisions 3LNO as determined using Canadian autumn survey and total catch data over the period 1997 -2009. Ogmap methods were used in determining stock size indices. The fishery was still ongoing at the time of this analysis therefore it is expected that the exploitation rate index will be higher once all of the catch for 2009 has been accounted for.

Year	Catch (t)	Lower 95% CL of biomass index (t)	Spawning Stock biomass (SSB) (t)	Fishable biomass (t)
1996		20,150	5,800	14,600
1997	485	32,410	19,200	34,100
1998	626	48,320	18,200	48,300
1999	795	43,160	21,700	41,000
2000	4,711	83,990	32,600	79,100
2001	10,697	155,300	63,500	173,200
2002	6,994	135,500	69,500	157,000
2003	13,099	144,000	82,800	167,300
2004	13,464			
2005	14,384	177,500	94,800	180,700
2006	23,802	172,900	82,600	173,100
2007	23,855	214,600	128,000	230,800
2008	27,069	195,800	105,200	204,600
2009	19,886			

Year	Catch / lower CL biomass	Catch/SSB	Catch/fishable biomass
1997	0.024	0.084	0.033
1998	0.019	0.033	0.018
1999	0.016	0.044	0.016
2000	0.109	0.217	0.115
2001	0.127	0.328	0.135
2002	0.045	0.110	0.040
2003	0.097	0.188	0.083
2004	0.094	0.163	0.080
2005			
2006	0.134	0.251	0.132
2007	0.138	0.289	0.138
2008	0.126	0.211	0.117
2009	0.102	0.189	0.097

Table 25. Survival, annual mortality and instantaneous mortality rate indices for Northern Shrimp (*Pandalus borealis)* within NAFO Divisions 3LNO. Indices were calculated by combining 3 years of data in order to account for vagaries within the survey data and due to aging by modal analysis. The survival, S, in the light green box is the female abundance shaded orange divided by the sum of the age 3+ shrimp shaded blue. Median survival, annual mortality, and instantaneous mortality rates were 0.798, 0.202 and 0.225 respectively.

Year	Age 3+males and total female abundance (millions; year = t)	Age 4+males and total female abundance (millions; year = t)	Survival rate = Total age 4 males + female abundance $_{(t+1)}$/ age 3+ males + female$_{(t)}$ abundance	Annual mortality rate = 1-survival	Instantaneous mortality rate = Z=-ln(survival)
1996	2,476	1,116			
1997	6,322	3,956			
1998	9,249	4,951	0.8005	0.1995	0.2226
1999	7,042	5,539	0.7964	0.2036	0.2277
2000	17,775	7,518	1.2520	-0.2520	-0.2247
2001	42,989	29,593	0.8758	0.1242	0.1326
2002	38,597	22,275	0.7840	0.2160	0.2433
2003	33,142	26,031			
2004					
2005	40,385	18,811			
2006	33,423	27,386			
2007	45,502	29,079	0.6888	0.3112	0.3728
2008	43,216	25,719			

Table 26. 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 exploitation indices using the numbers presented in the tables below; however, the derived values should be similar.

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

Survey	Fishable biomass (t)	Fishable biomass – lower 95% C.I.= measure of variance	Fishable biomass/ (measure of variance^2)	1/measure of variance^2	Variance weighting factor
Autumn 2007	230,800	54,300	1.400E-4	3.39E-10	0.201
Spring 2008	188,200	50,600	3.120E-5	3.91E-10	0.232
Autumn 2008	204,600	47,200	1.07E-4	4.49E-10	0.266
Spring 2009	97,600	44,410	7.31E-5	5.07E-10	0.301
Grand total			3.5061E-4	1.686E-09	1.00

Inverse variance weighted average fishable biomass = 3.5061E-4 / 1.686E-09 = 173,886 t

Inverse variance weighted average fishable biomass (t)	TAC options (t)		
173,886	25,000	27,000	30,000
Exploitation rates (TAC/fishable biomass) expressed percents	14.38%	15.53%	17.25%

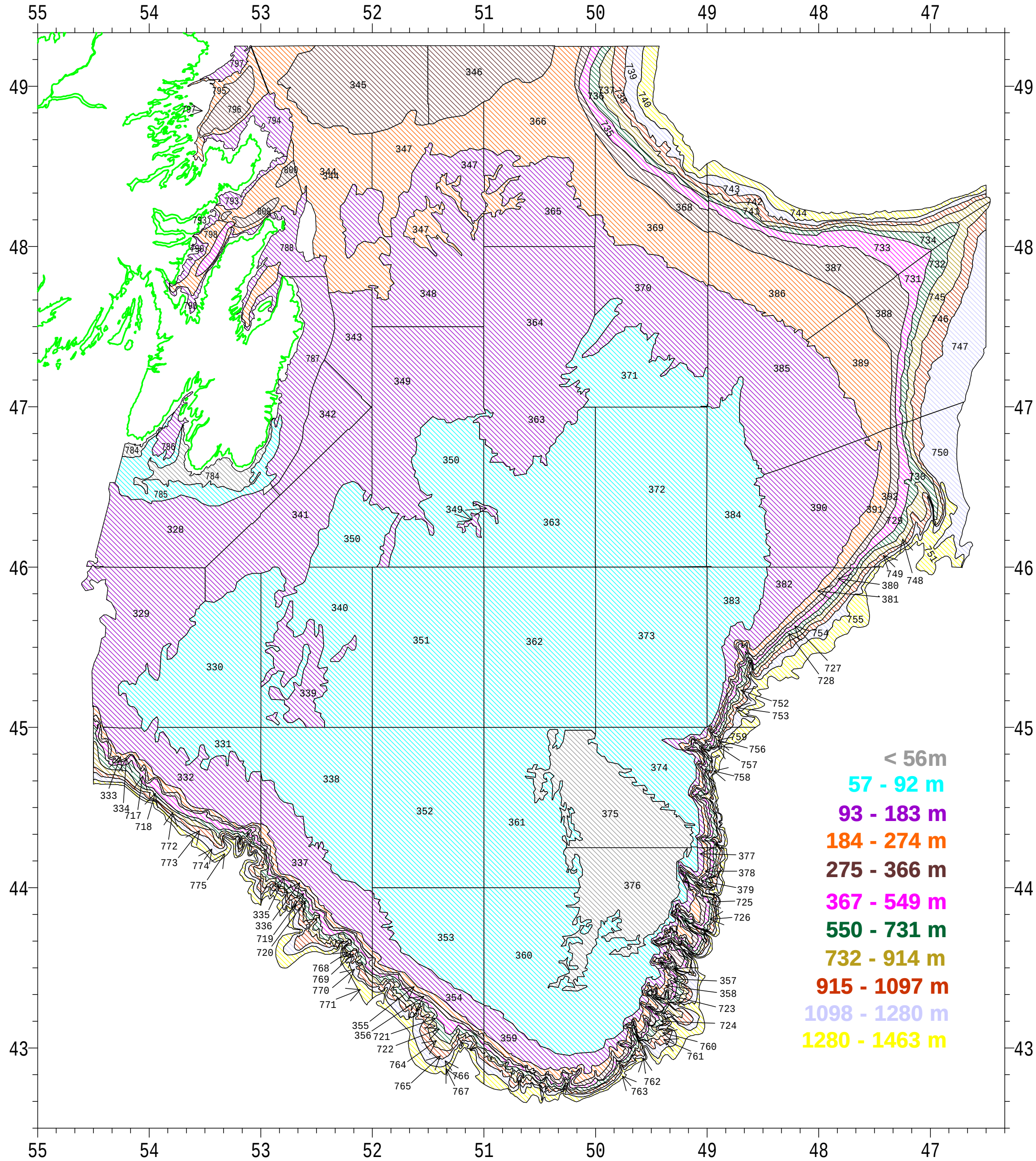


Figure 1. The NAFO Divisions 3LNO stratification scheme used in the Canadian multi-species research bottom trawl survey set allocation (G. Cossitt).

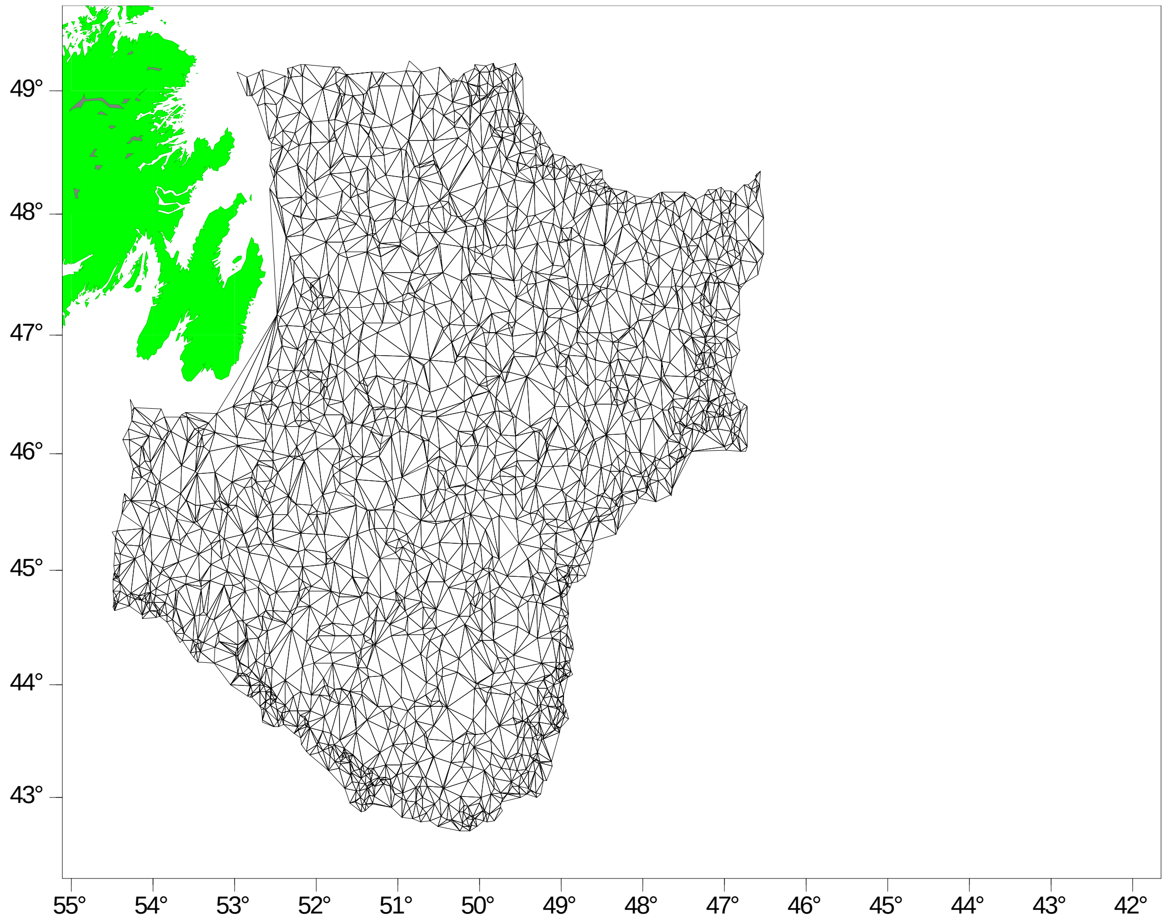


Figure 2. NAFO Divisions 3LNO – offshore Delauney triangulation used to derive the 3LNO biomass, abundance, fishable biomass, female biomass indices as well as population adjusted length frequencies using Ogmap.

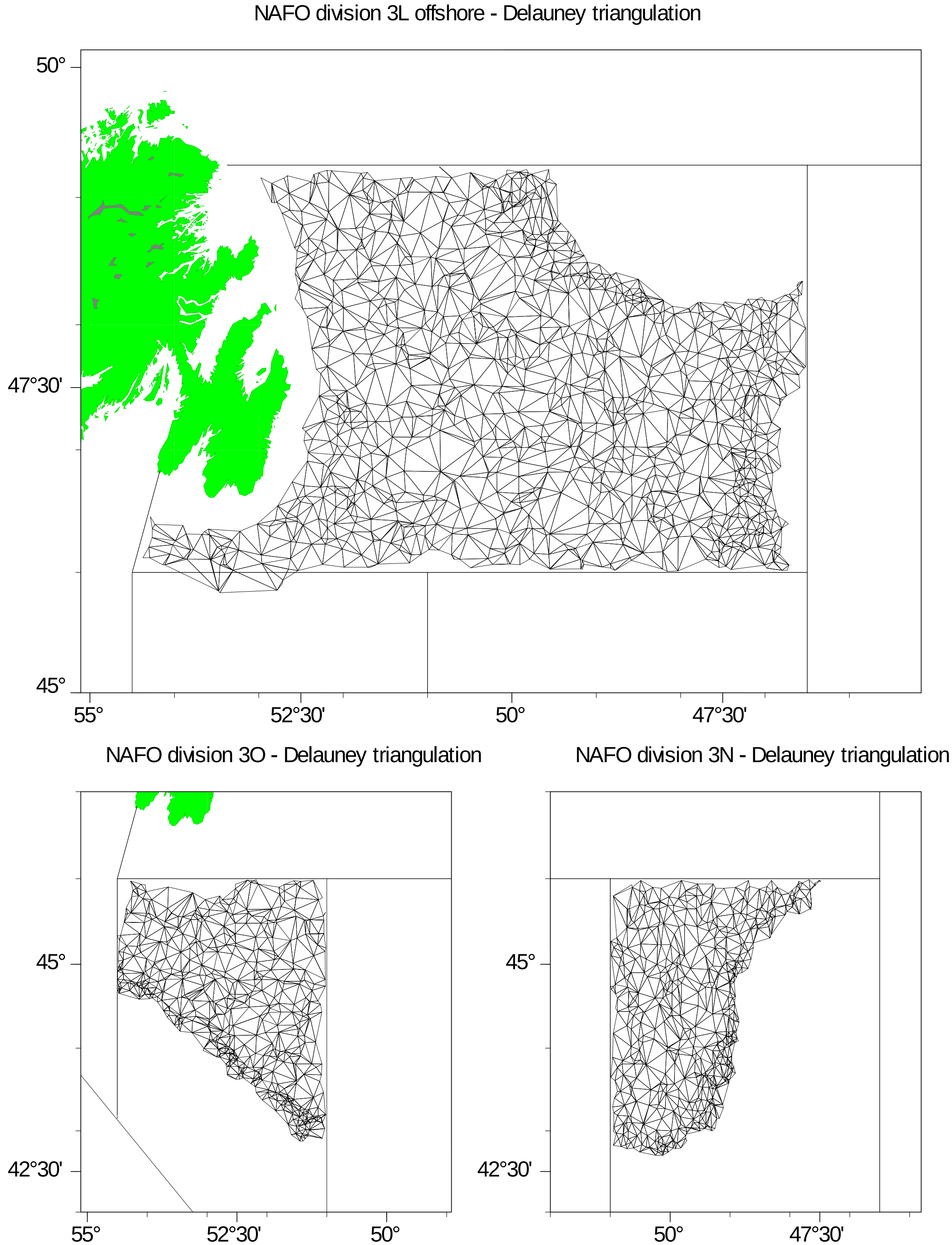


Figure 3. The Delauney triangulation used to derive within NAFO division ogmap biomass and abundance indices.

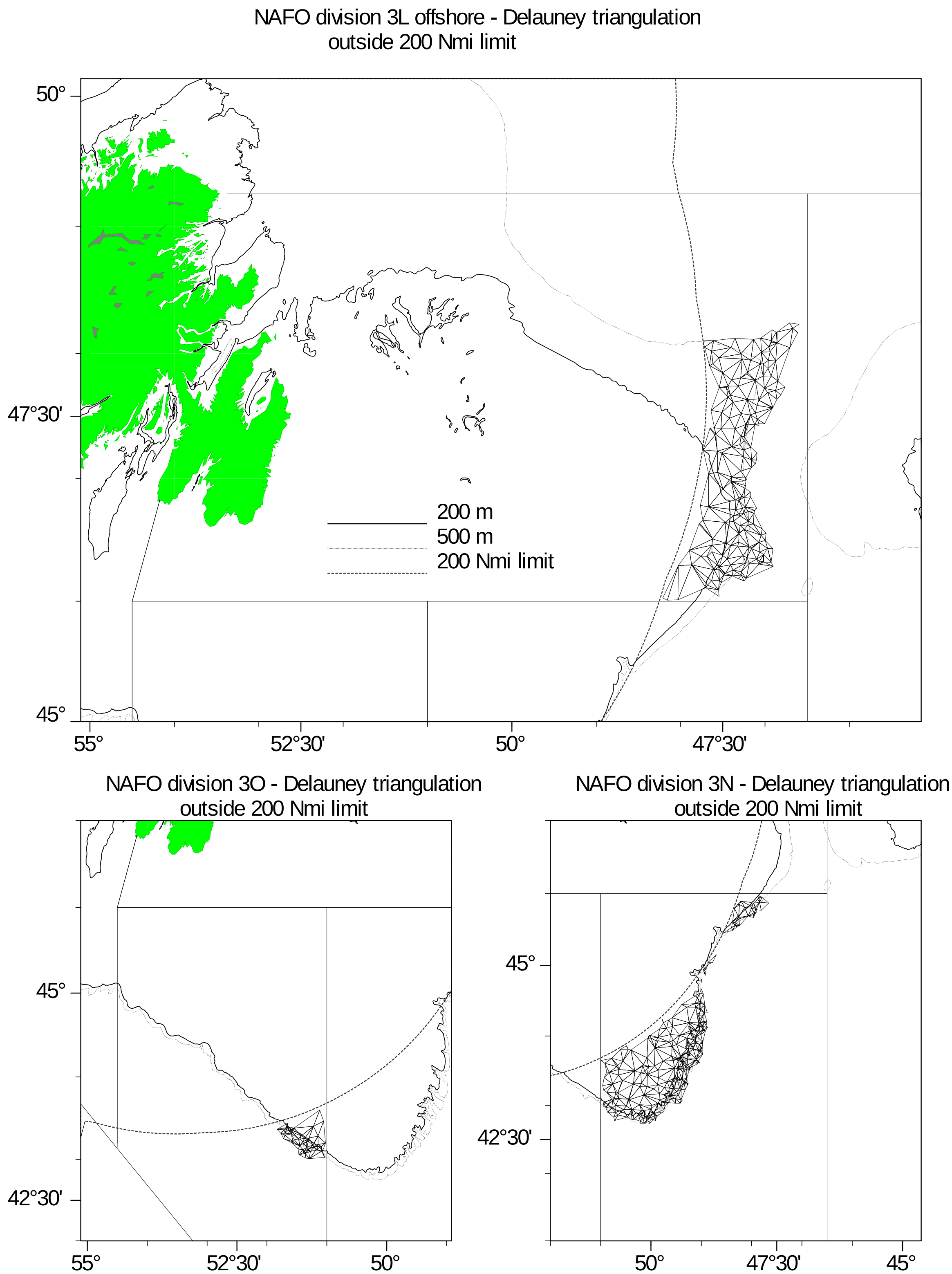


Figure 4. The Delauney triangulation used to derive the outside 200 Nmi limit ogmap biomass and abundance indices.

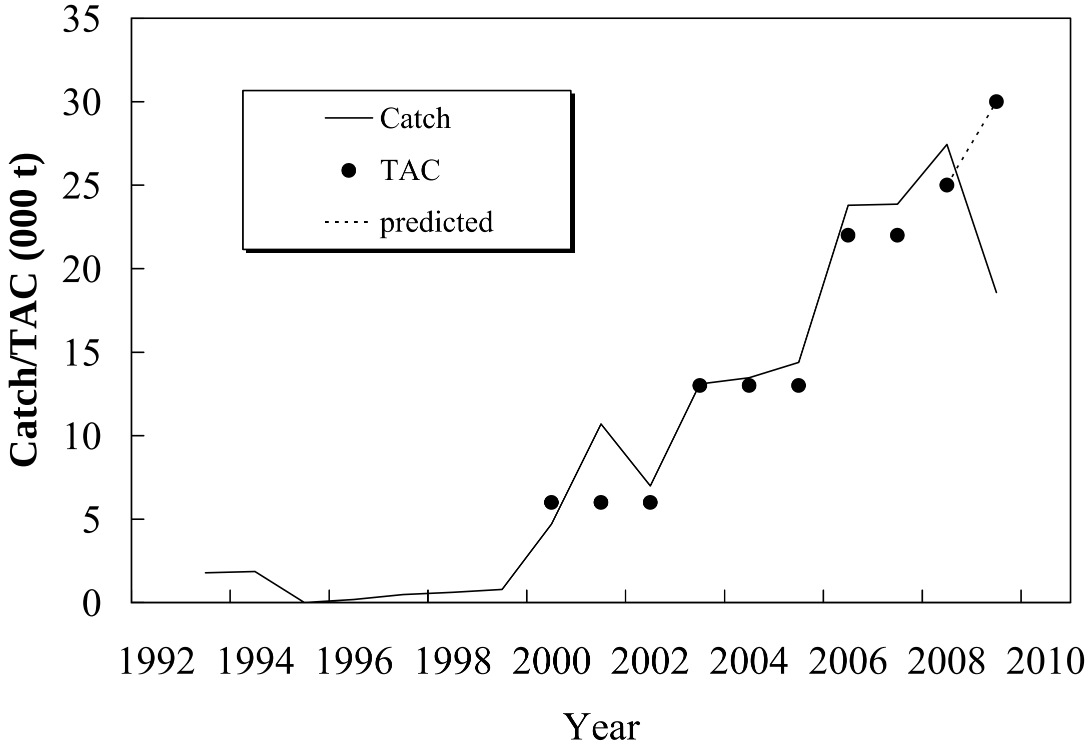


Figure 5. Trends in NAFO Division 3L northern shrimp (*Pandalus borealis*) catch and TAC over the period 1993 – 2009.

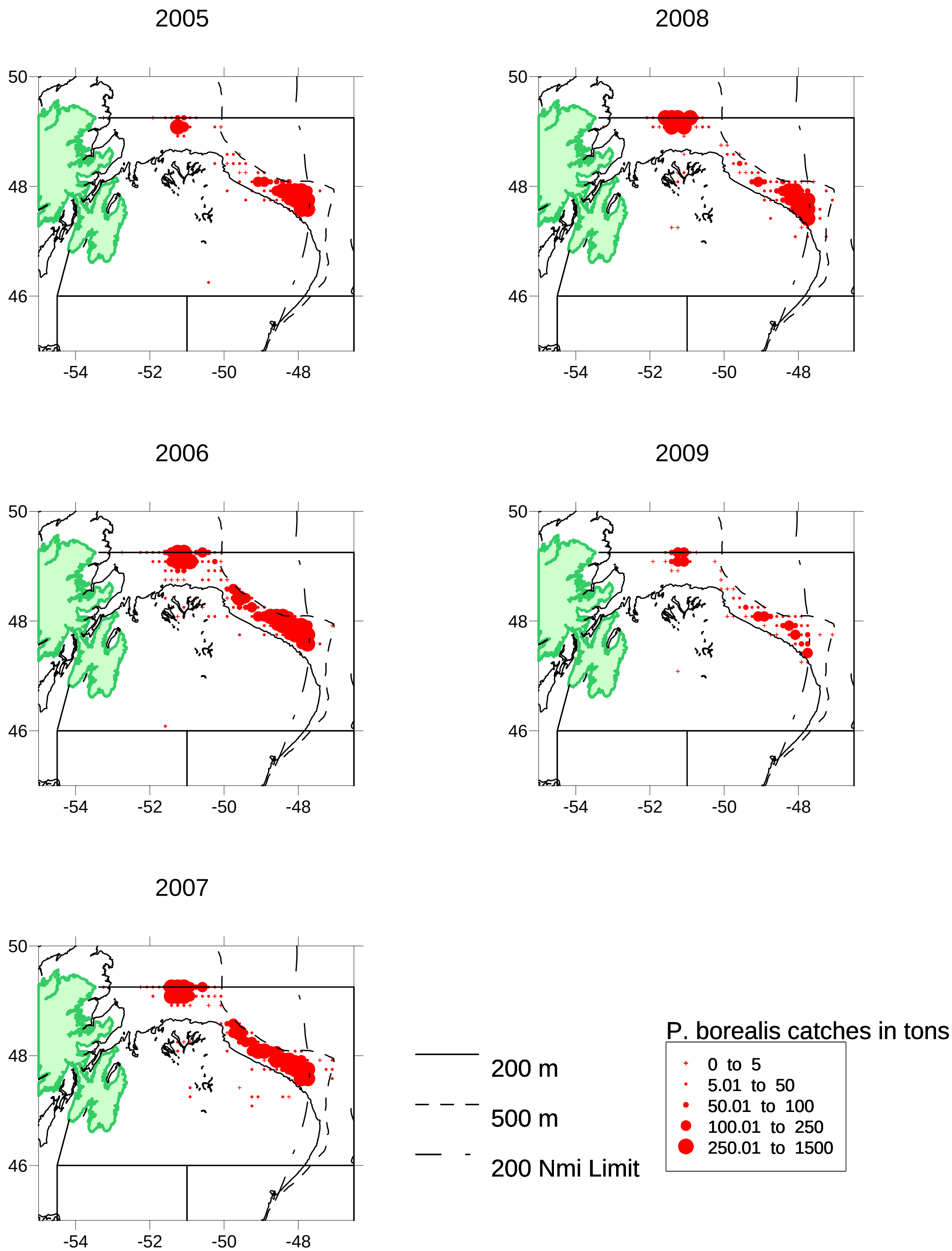


Figure 6. Distribution of **Canadian small vessel (<= 500 t)** shrimp catches in NAFO Division 3L, 2005 – 2009. (Logbook data aggregated into 10 min X 10 min cells).

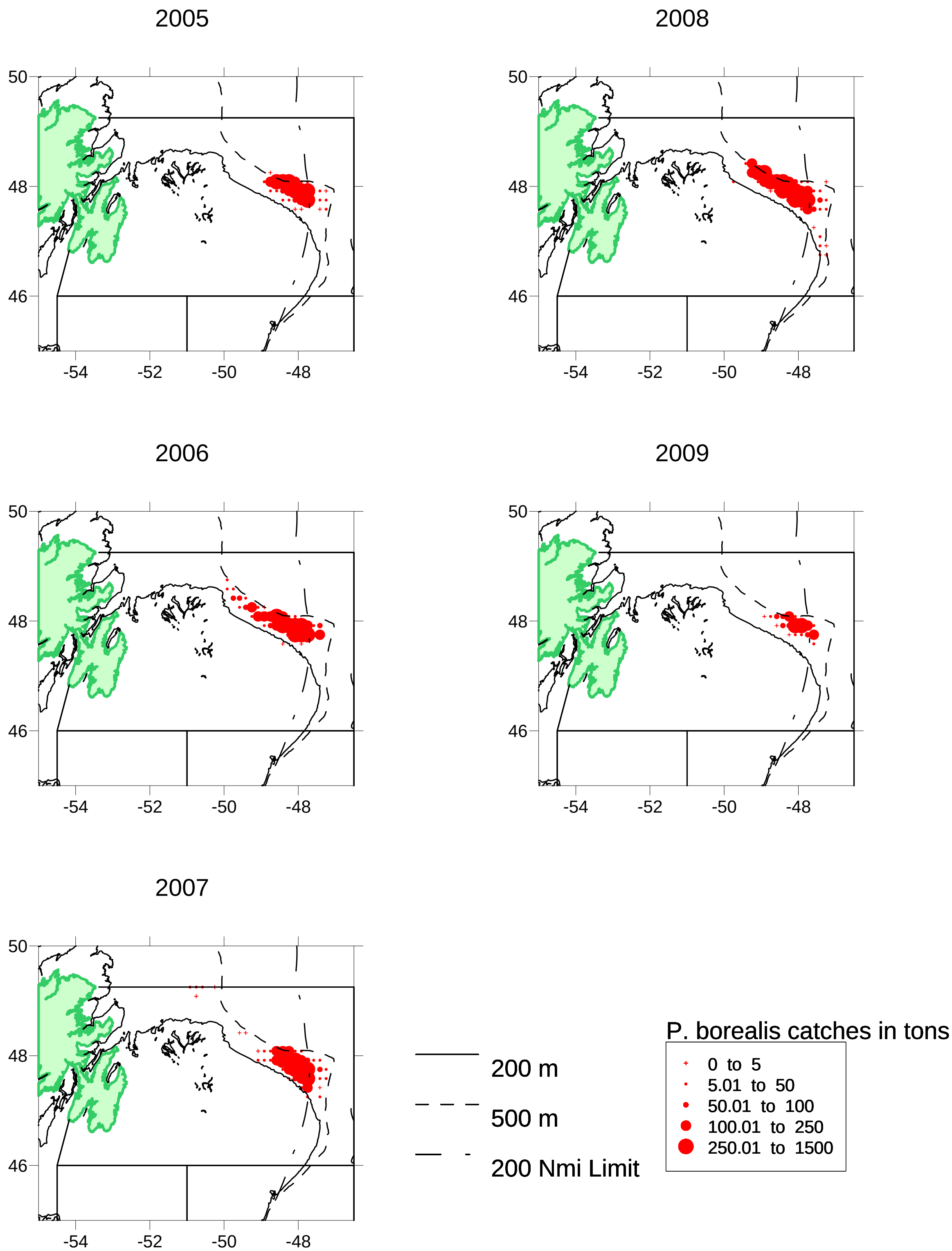


Figure 7. Distribution of **Canadian large vessel (>500 t)** shrimp catches in NAFO Division 3L, 2005 – 2009. (Observer data aggregated into 10 min X 10 min cells).

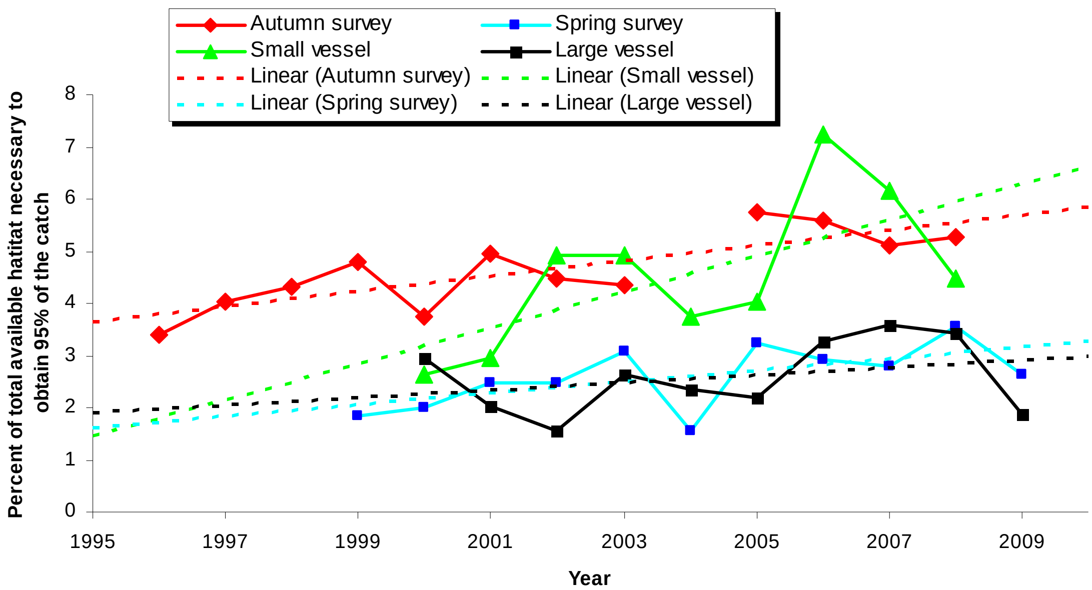


Figure 8. Trends in percent area occupied by the northern shrimp (*Pandalus borealis*) resource as well as large and small vessel shrimp fisheries in relation to total area available within NAFO Divisions 3LNO.

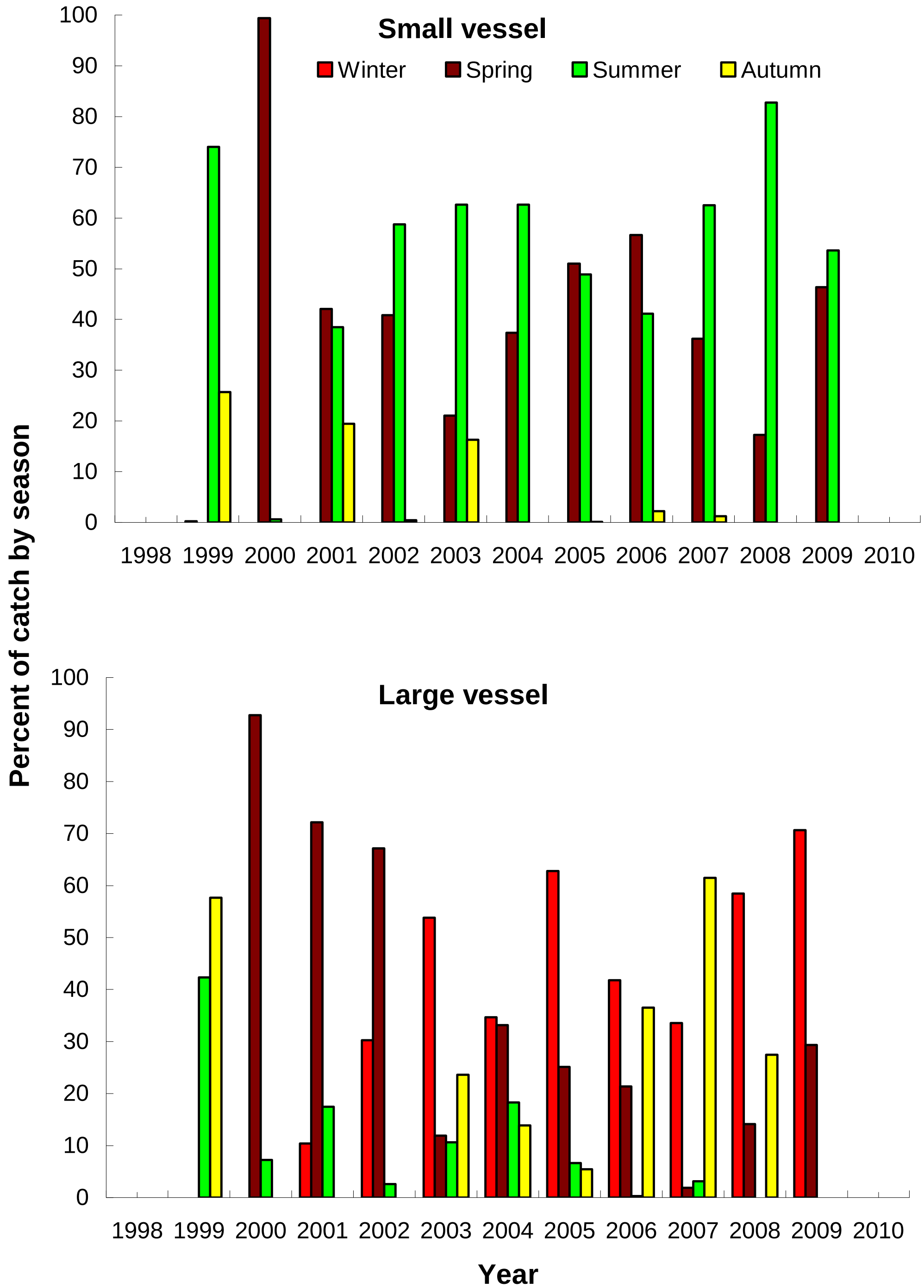


Figure 9. Seasonality of the large and small vessel northern shrimp (*Pandalus borealis*) fishery in NAFO Division 3L over the period 2000 – 2009. Please note that the 2009 values are preliminary with data up to the end of August 2009.

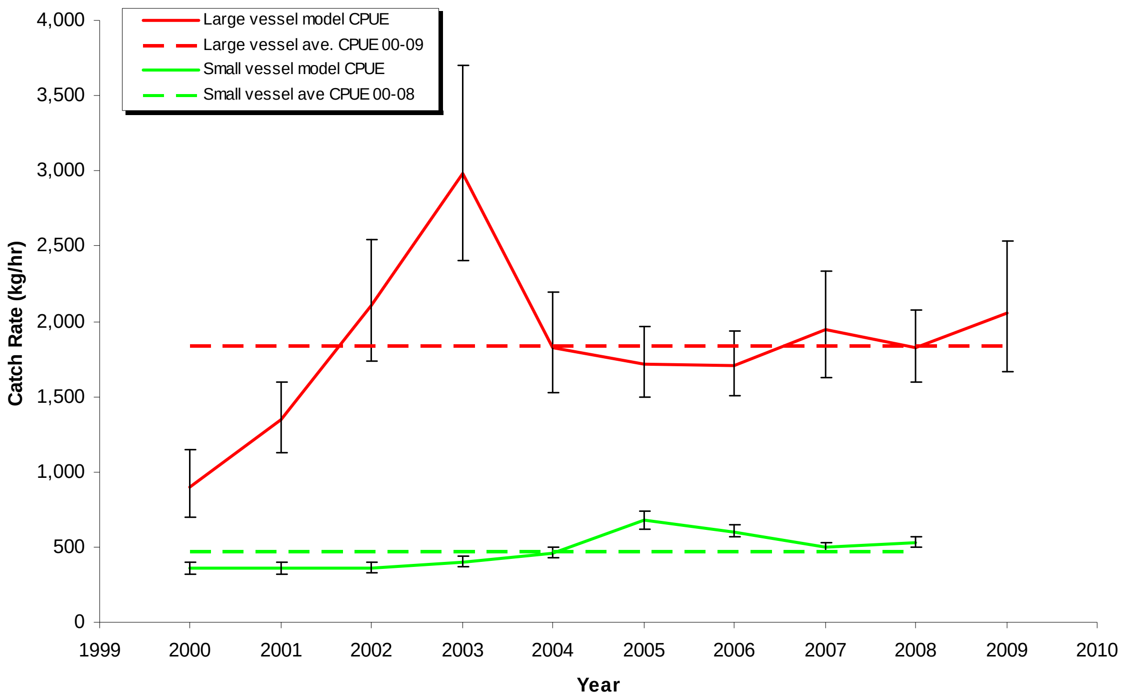


Figure 10. Model catch rates for Canadian large (>500 t) (2000 – 2008) and small (<=500 t; <65') (2000 – 2008) vessels fishing for shrimp in NAFO Div. 3L. Bars present 95% confidence intervals.

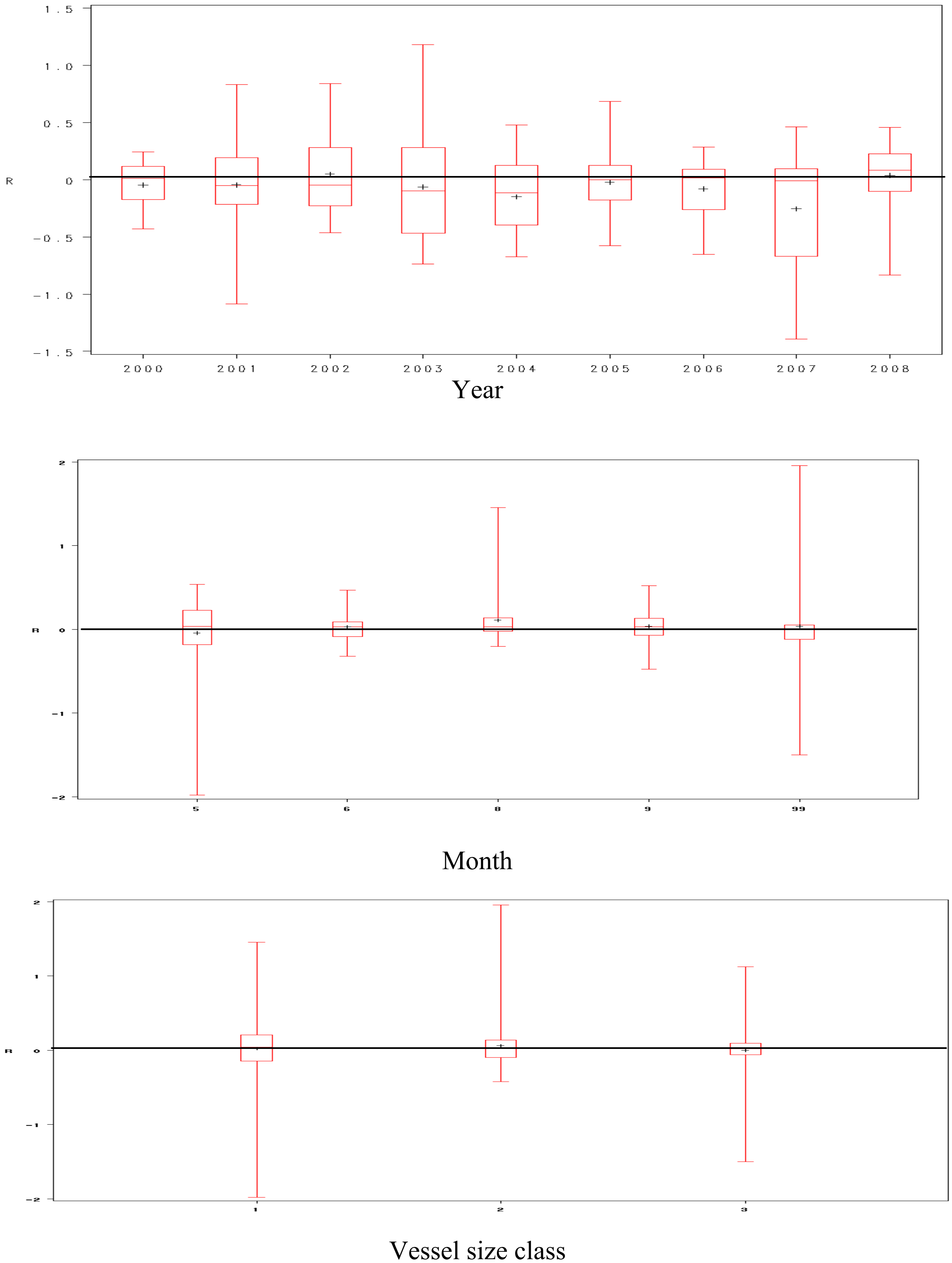


Figure 11. Distribution of residuals around estimated values for parameters used to model **Canadian small vessel** Div. 3L shrimp catch rates, 2000 – 2008.

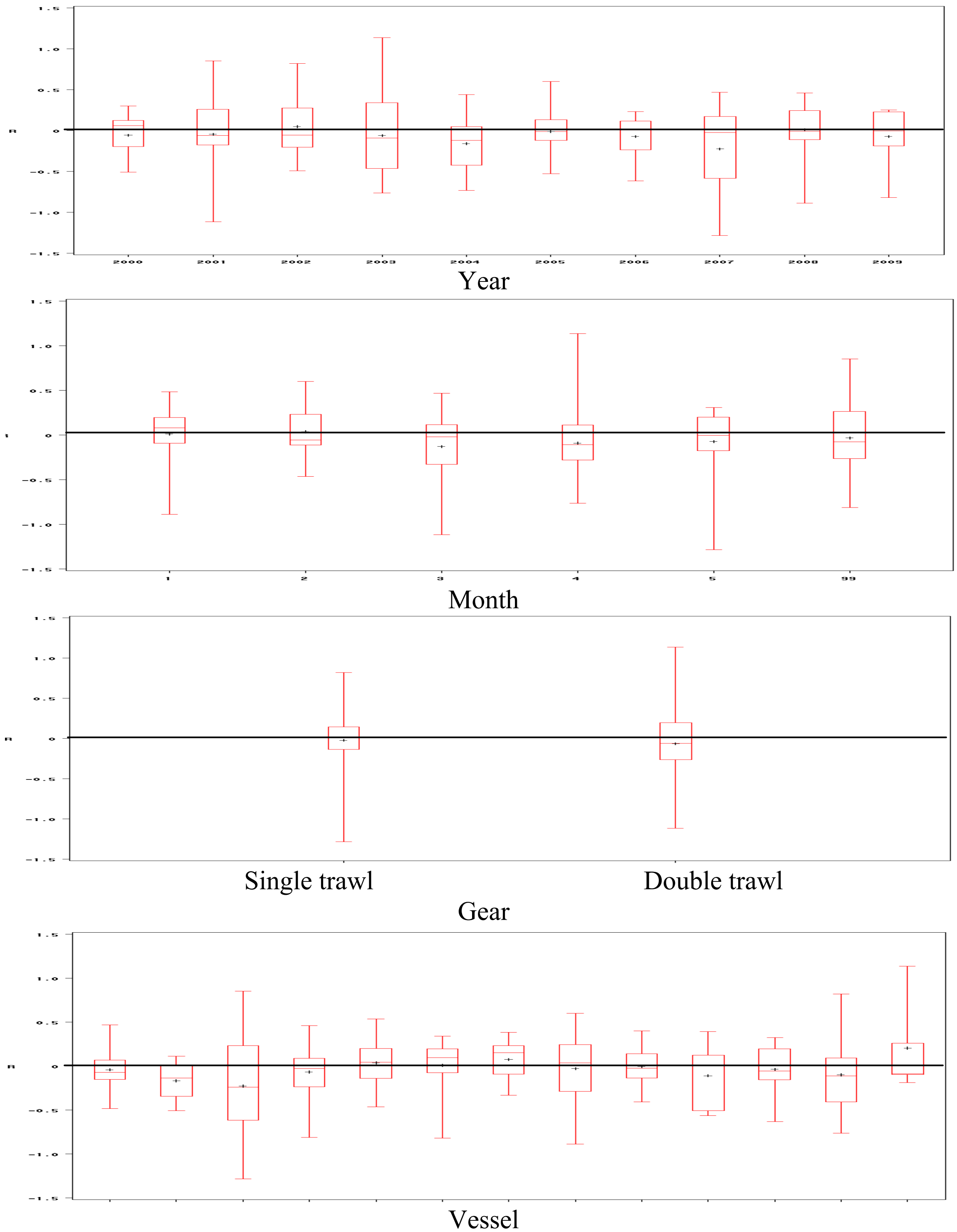


Figure 12. Distribution of residuals around estimated values for parameters used to model **Canadian large vessel** Div. 3L shrimp catch rates, 2000 –2009.

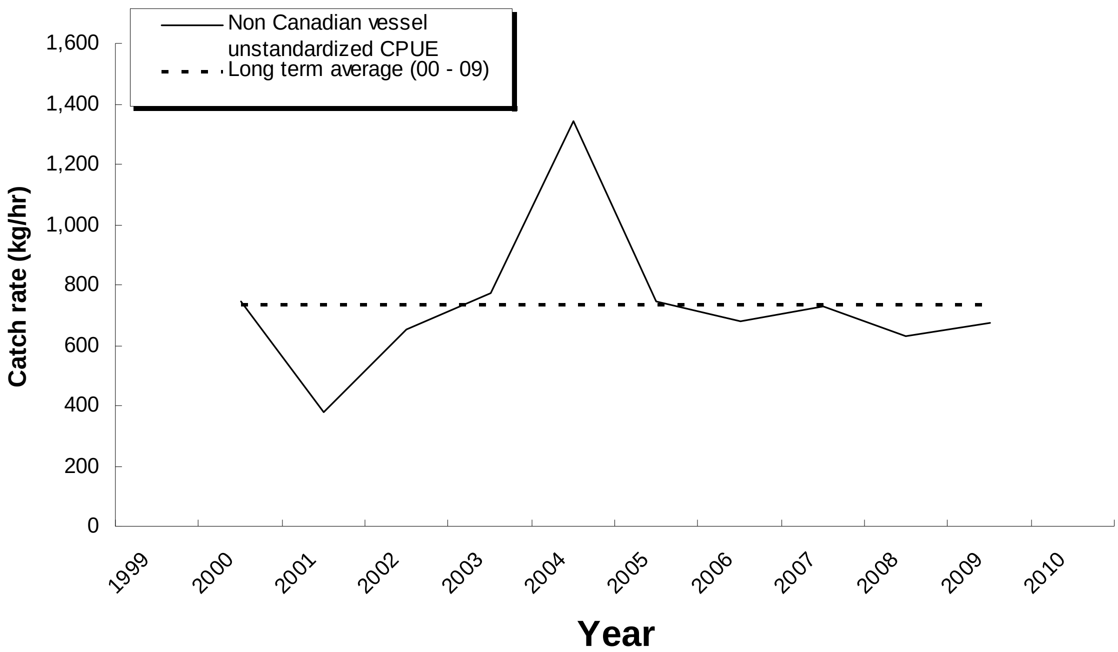


Figure 13. Unstandardized catch rates for **non-Canadian vessels** fishing for northern shrimp (*Pandalus borealis*) within the NAFO Division 3L NRA over the period 2000 – 2009.

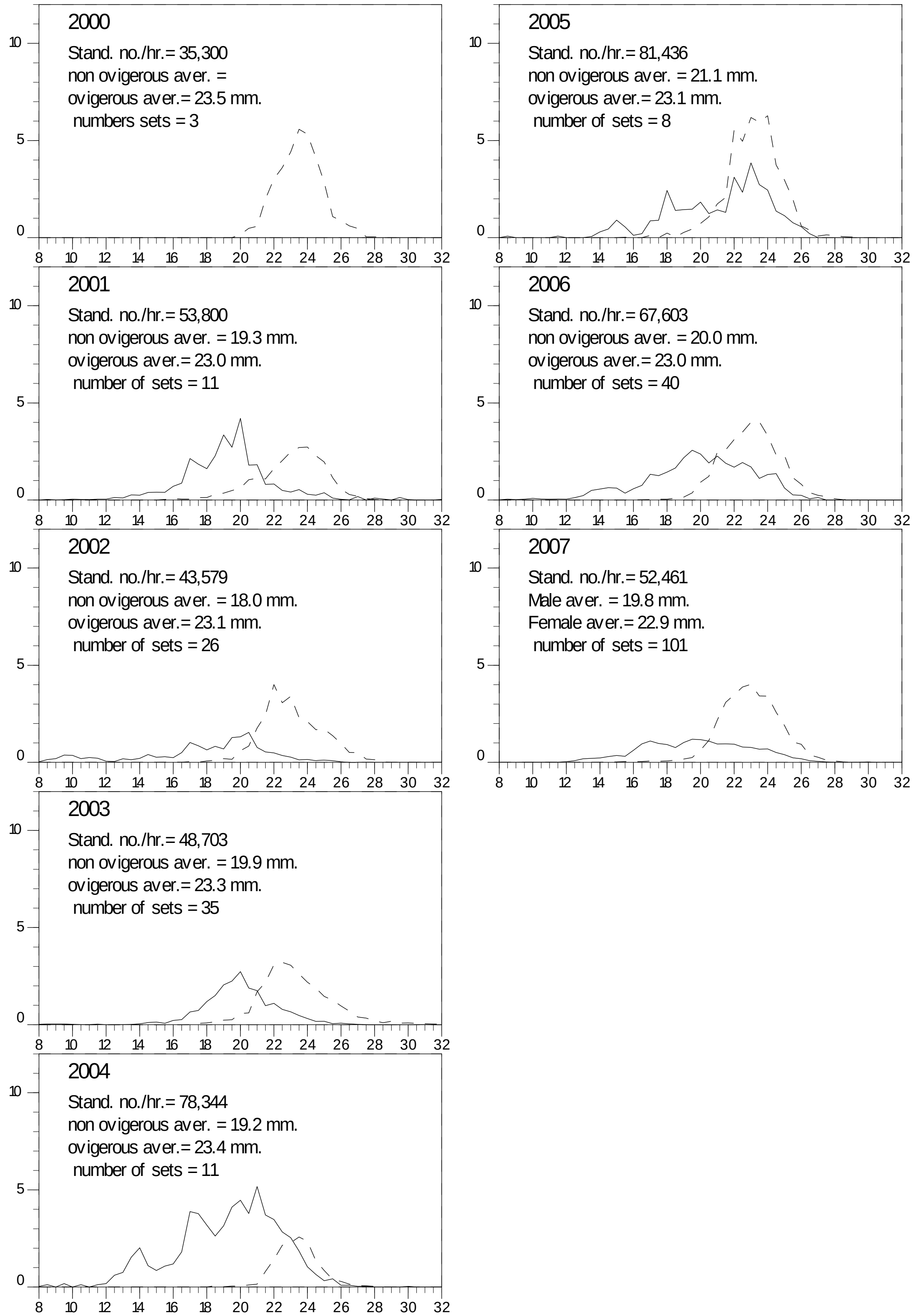


Figure 14. Observed northern shrimp (*Pandalus borealis*) length frequencies from the **Canadian small vessel (<= 500 t; <65')** fleet fishing shrimp in NAFO Div. 3L over the period 2001 – 2007. No observed shrimp length frequencies were available for 2008 and 2009.

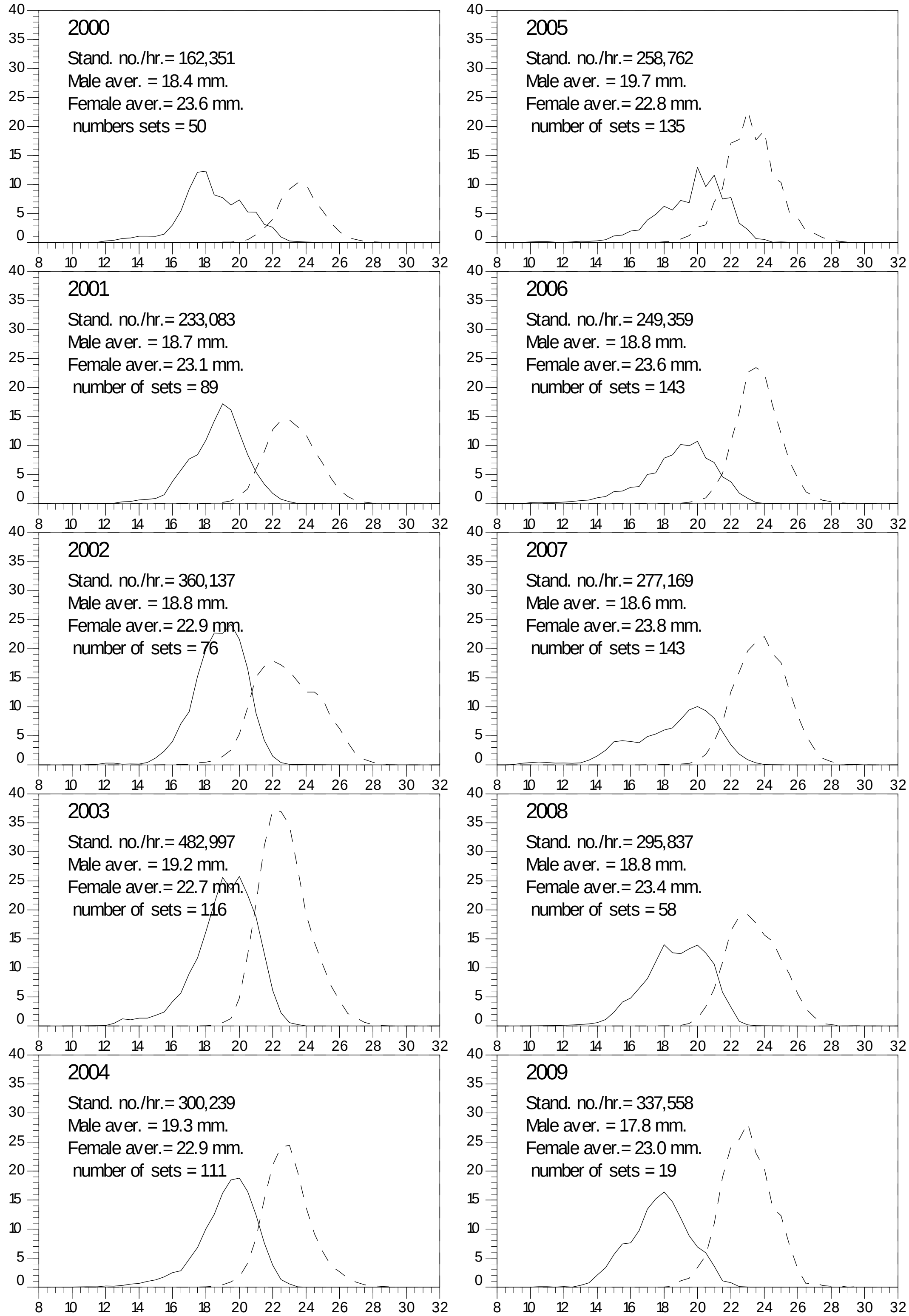


Figure 15. Observed northern shrimp (*Pandalus borealis*) length frequencies from the **Canadian large vessel (>500 t)** fleet fishing shrimp in NAFO Div. 3L over the period 2000 – 2009.

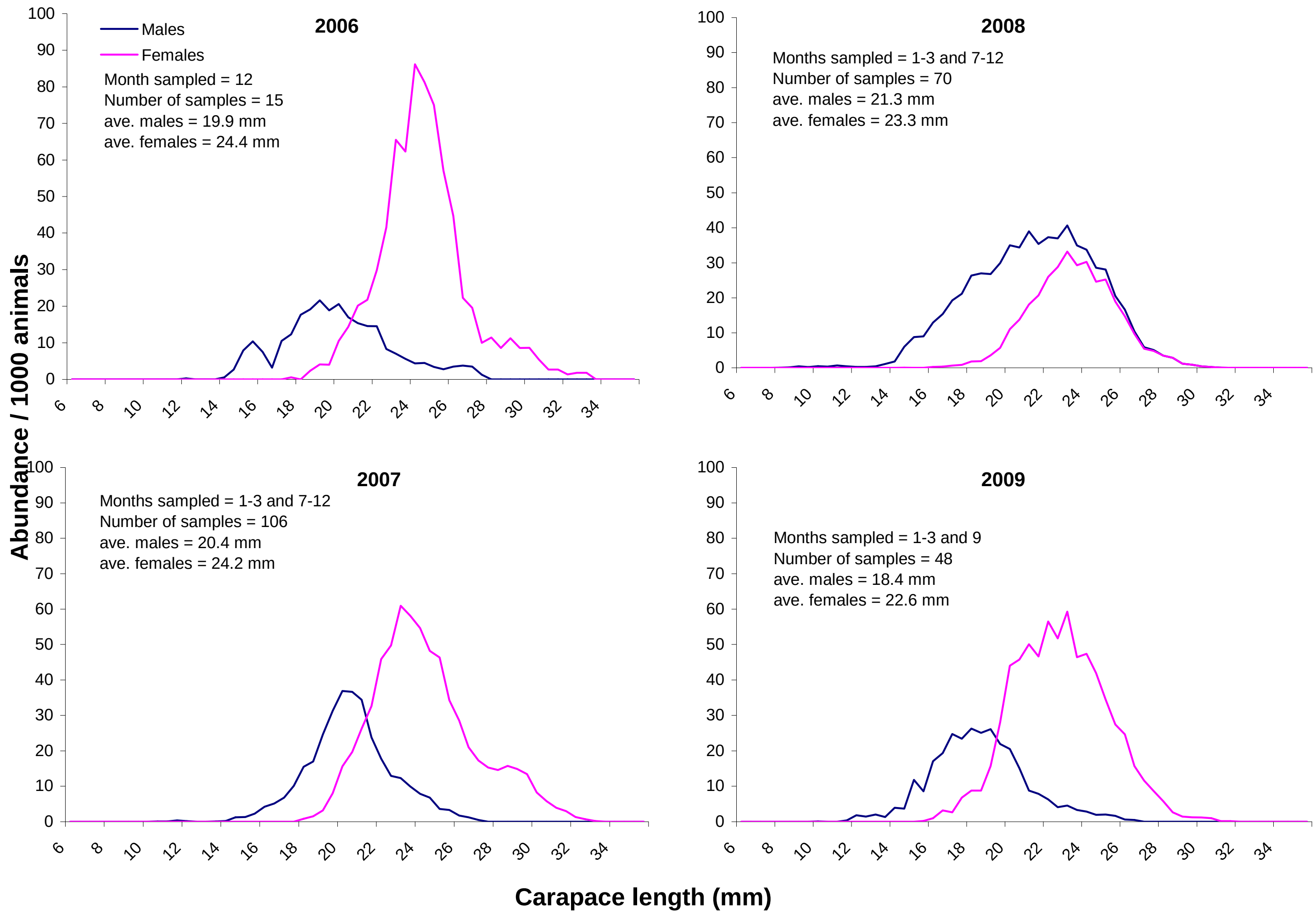


Figure 16. Observed length frequencies from the **Estonian** northern shrimp fishery in NAFO Div. 3L NRA over the period 2006 – 2009.

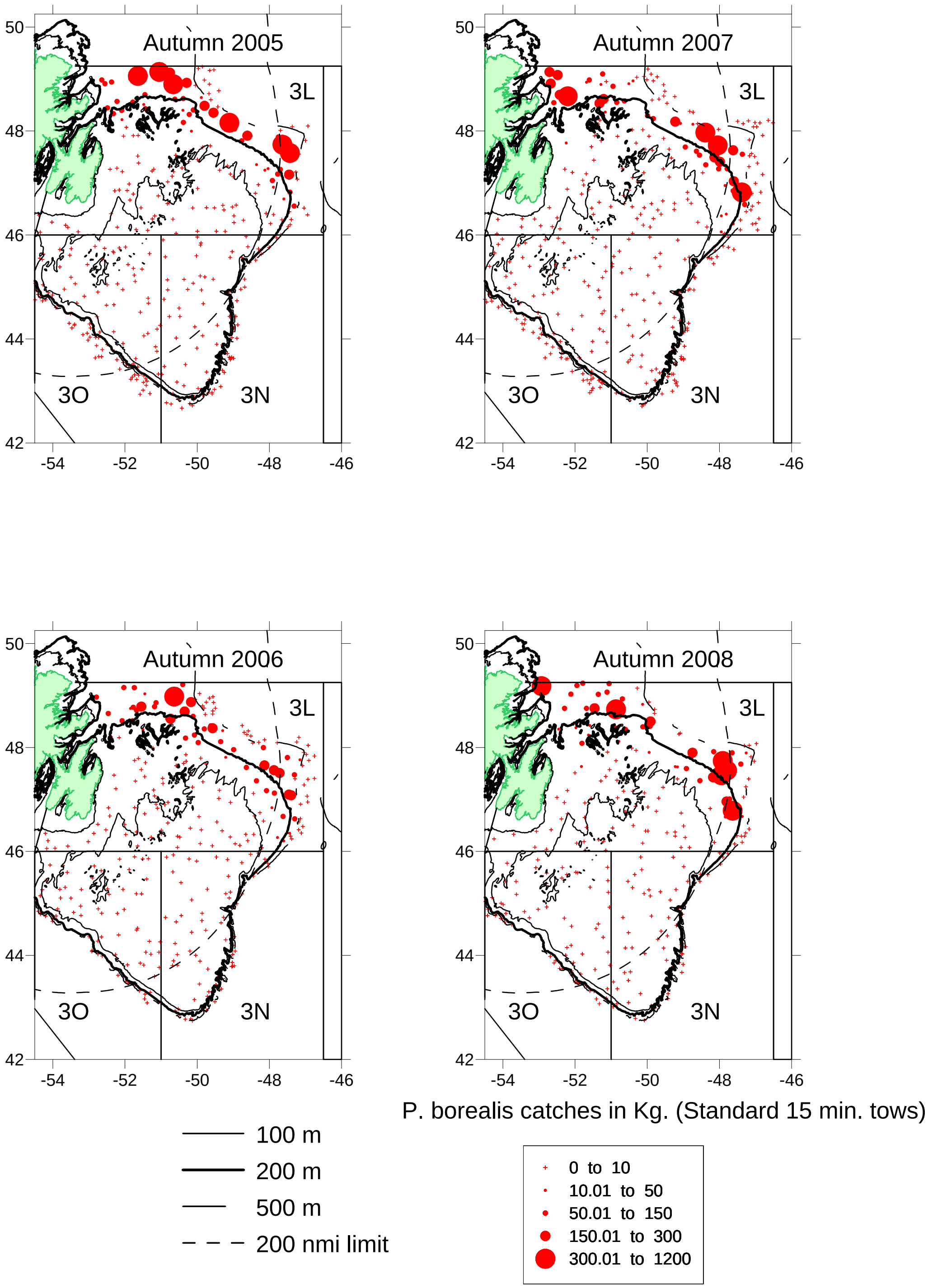


Figure 17. Distribution of NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) catches kg/tow) as obtained from **autumn** research bottom trawl surveys conducted over the period 2006-2008.

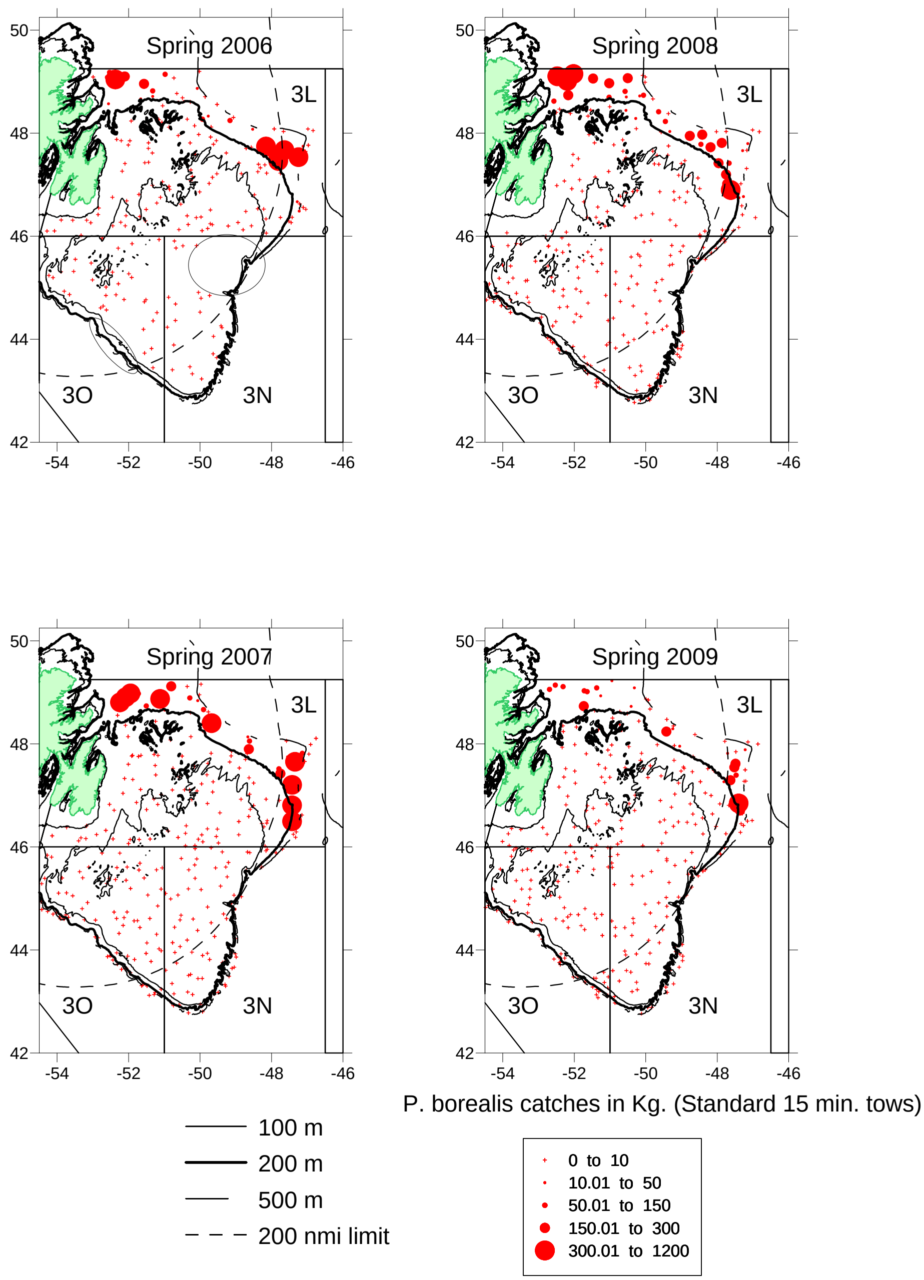


Figure 18. Distribution of NAFO Div. 3LNO northern shrimp (*Pandalus borealis*) catches kg/tow) as obtained from **spring** research bottom trawl surveys conducted over the period 2006-2009. Ellipses in upper left panel indicates area not surveyed during spring 2006.

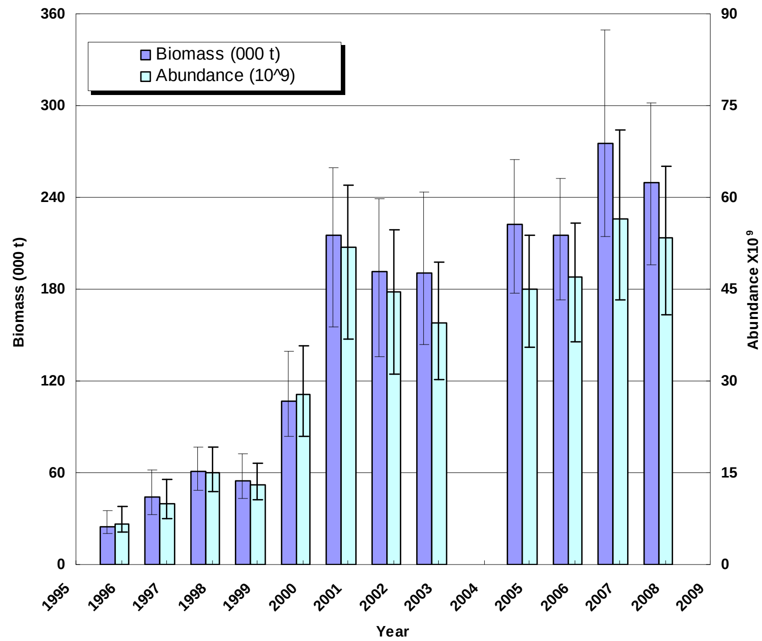


Figure 19. **Autumn** northern shrimp (*Pandalus borealis*) abundance and biomass estimates within NAFO Div. 3LNO. Data were from Canadian multi-species bottom trawl surveys using a Campelen 1800 trawl.(Standard 15 min. tows.). Bars present 95% confidence intervals.

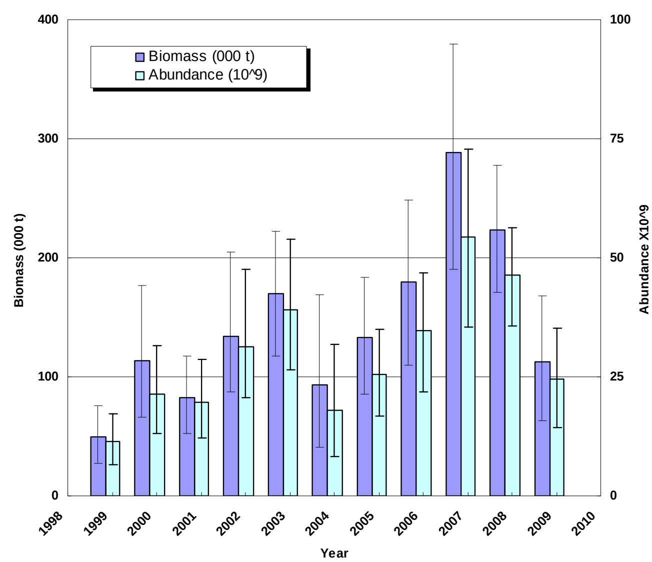
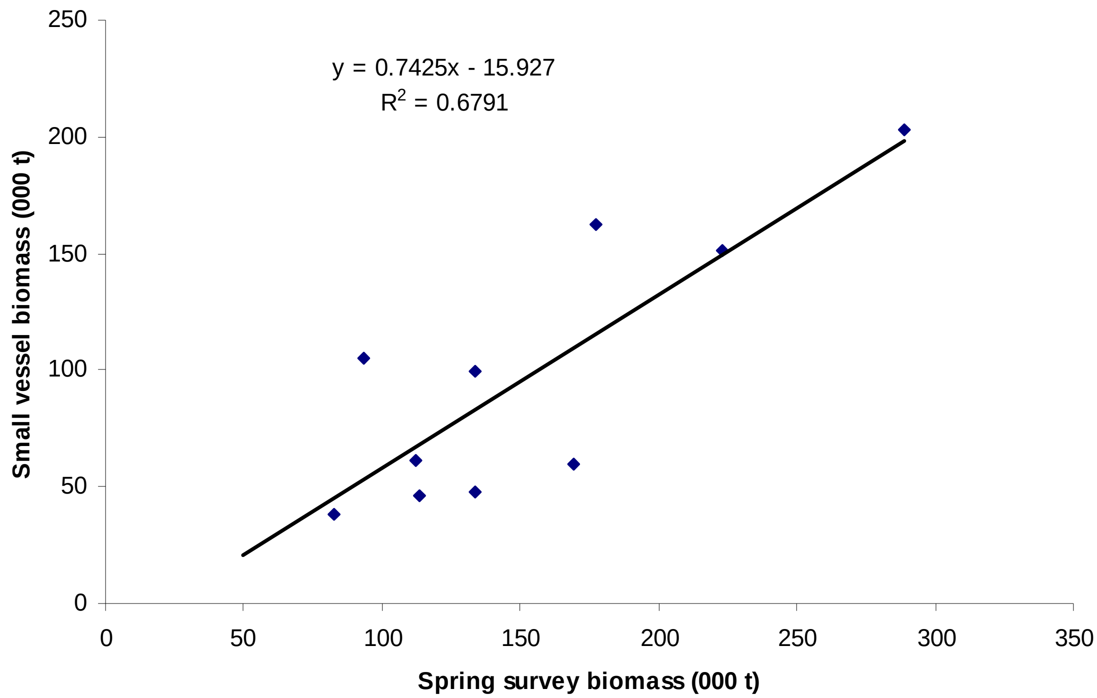


Figure 20. **Spring** northern shrimp (*Pandalus borealis*) abundance and biomass estimates within NAFO Div. 3LNO. Please note that due to operational problems, it was not possible to survey all of Div. 3NO during spring 2006. The indices for 2006 are for Div. 3L only. Data were from Canadian multi-species bottom trawl surveys using a Campelen 1800 trawl. (Standard 15 min. tows.). Bars present 95% confidence intervals.



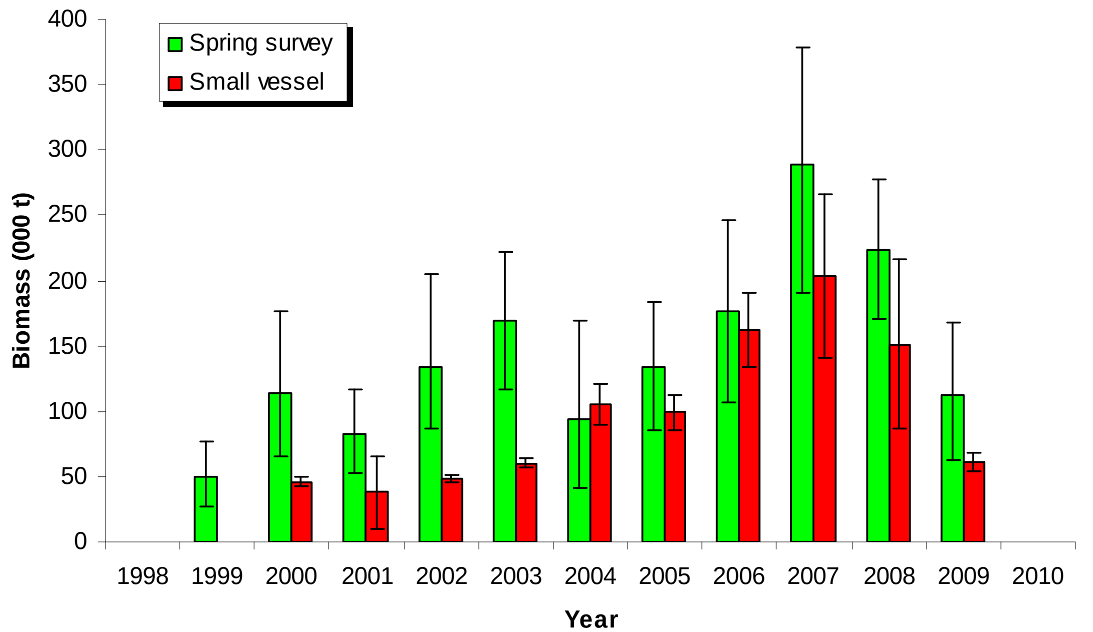


Figure 21. The relationship between Northern Shrimp biomass (000 t) determined from stratified areal expansion analyses of small vessel commercial catch data and biomass (000 t) determined Ogmap analyses of Canadian spring multi-species datasets.

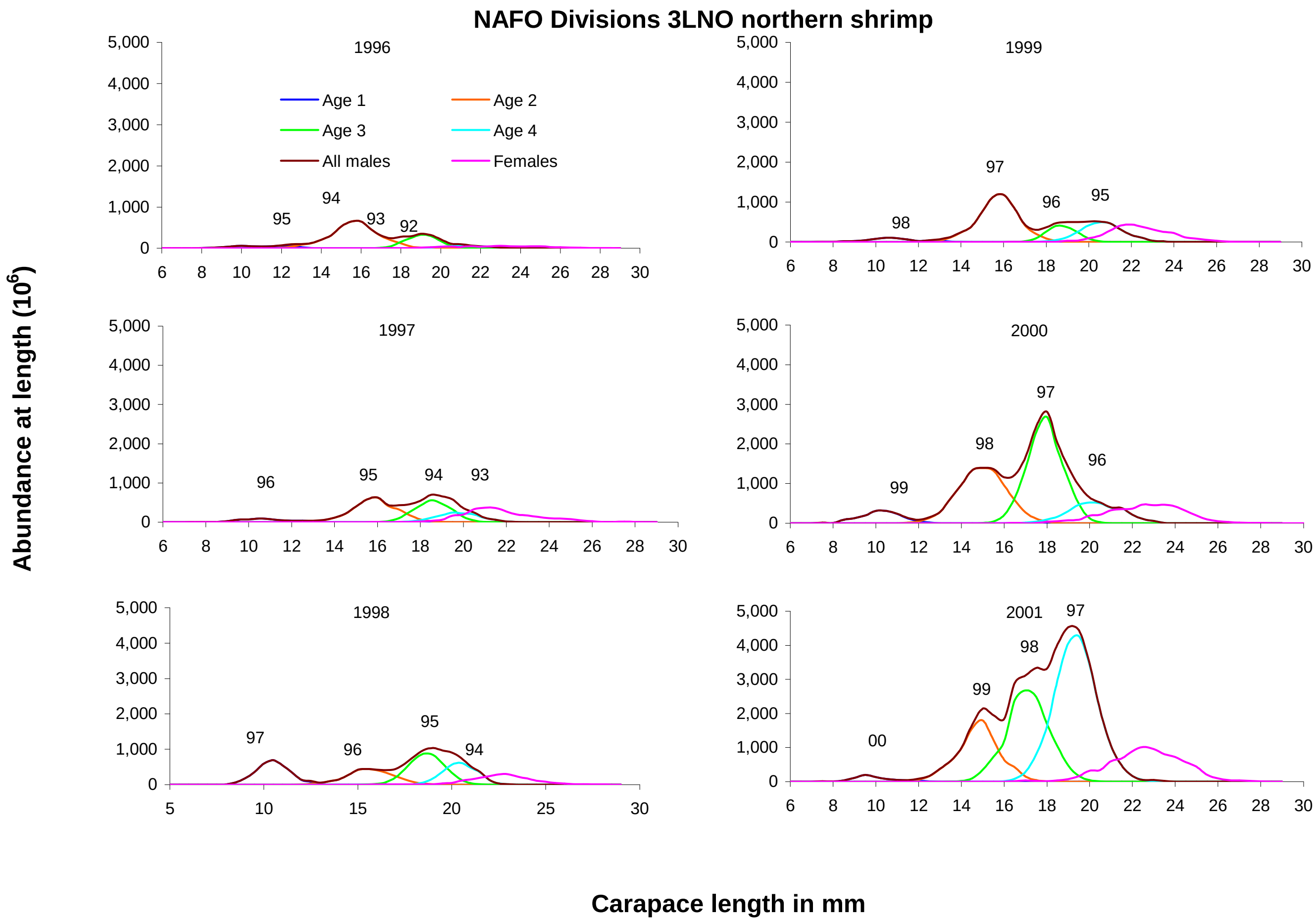


Figure 22. NAFO divisions 3LNO northern shrimp carapace length frequencies as calculated using ogmap calculations. The data were obtained from annual **autumn** Canadian research bottom trawl surveys using a Campelen 1800 shrimp trawl. Offshore strata only. Standard 15 min. tows.). The numbers within each plot indicate year classes as determined using Mix 3.01 (Pitcher and MacDonald, 1993).

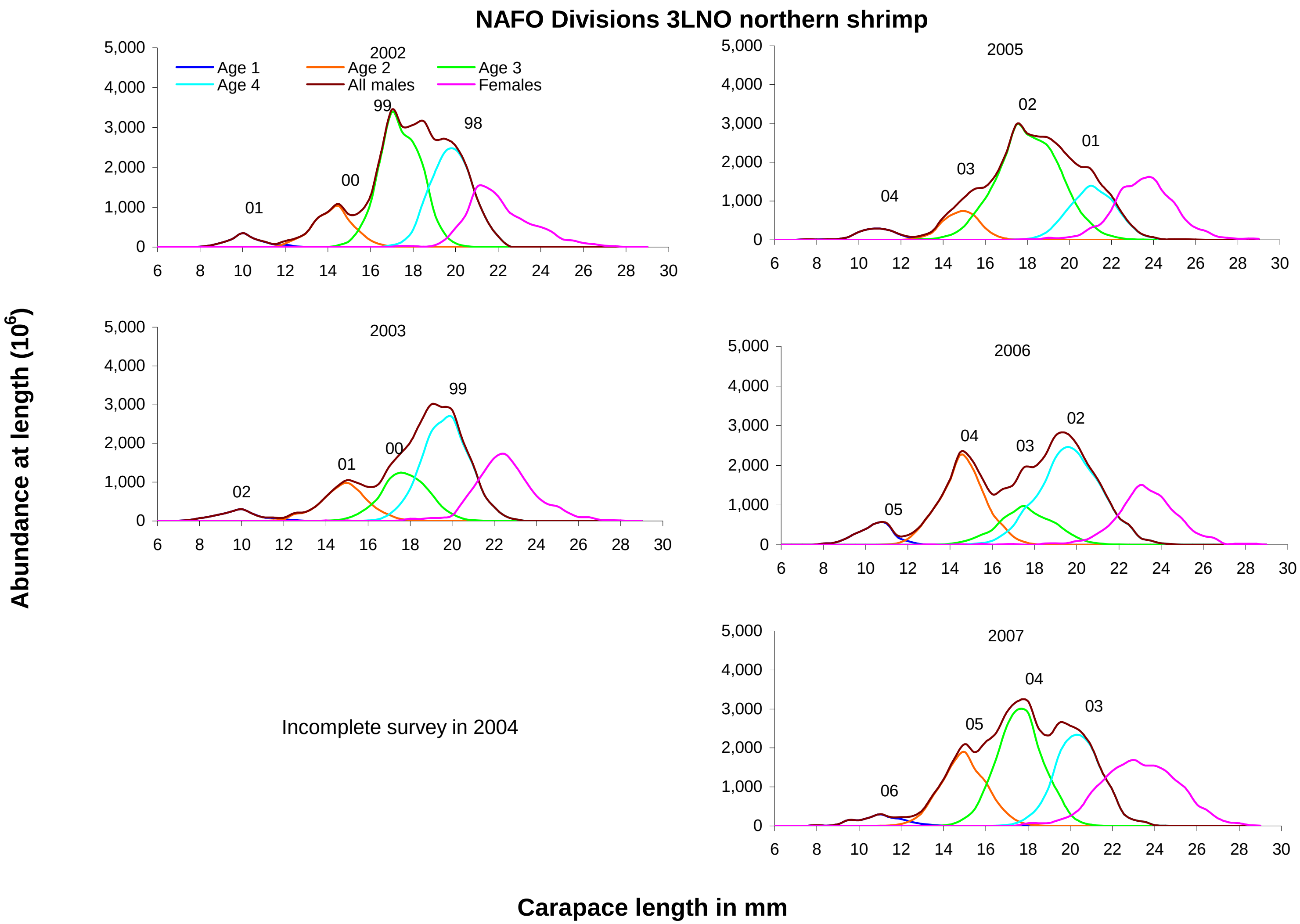


Figure 22. (Continued)

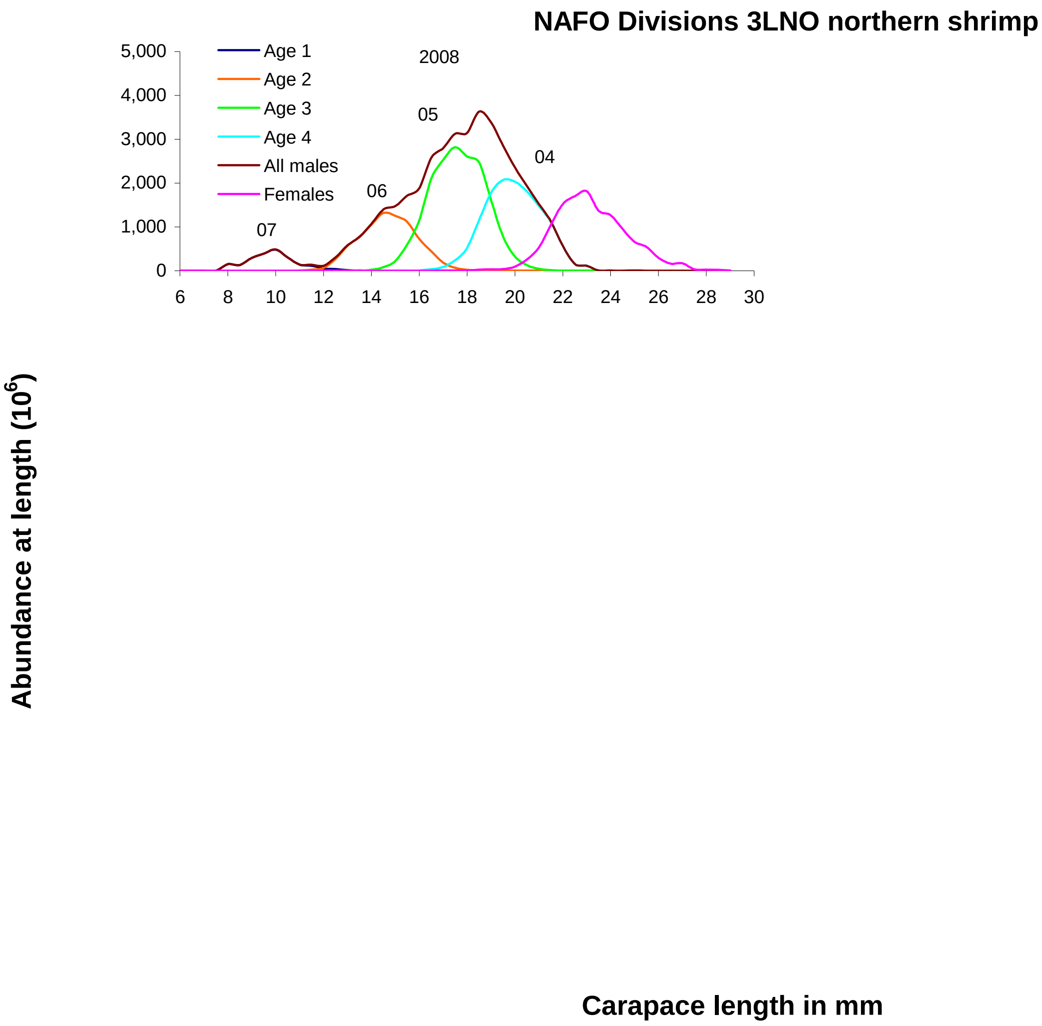


Figure 22 (Continued)

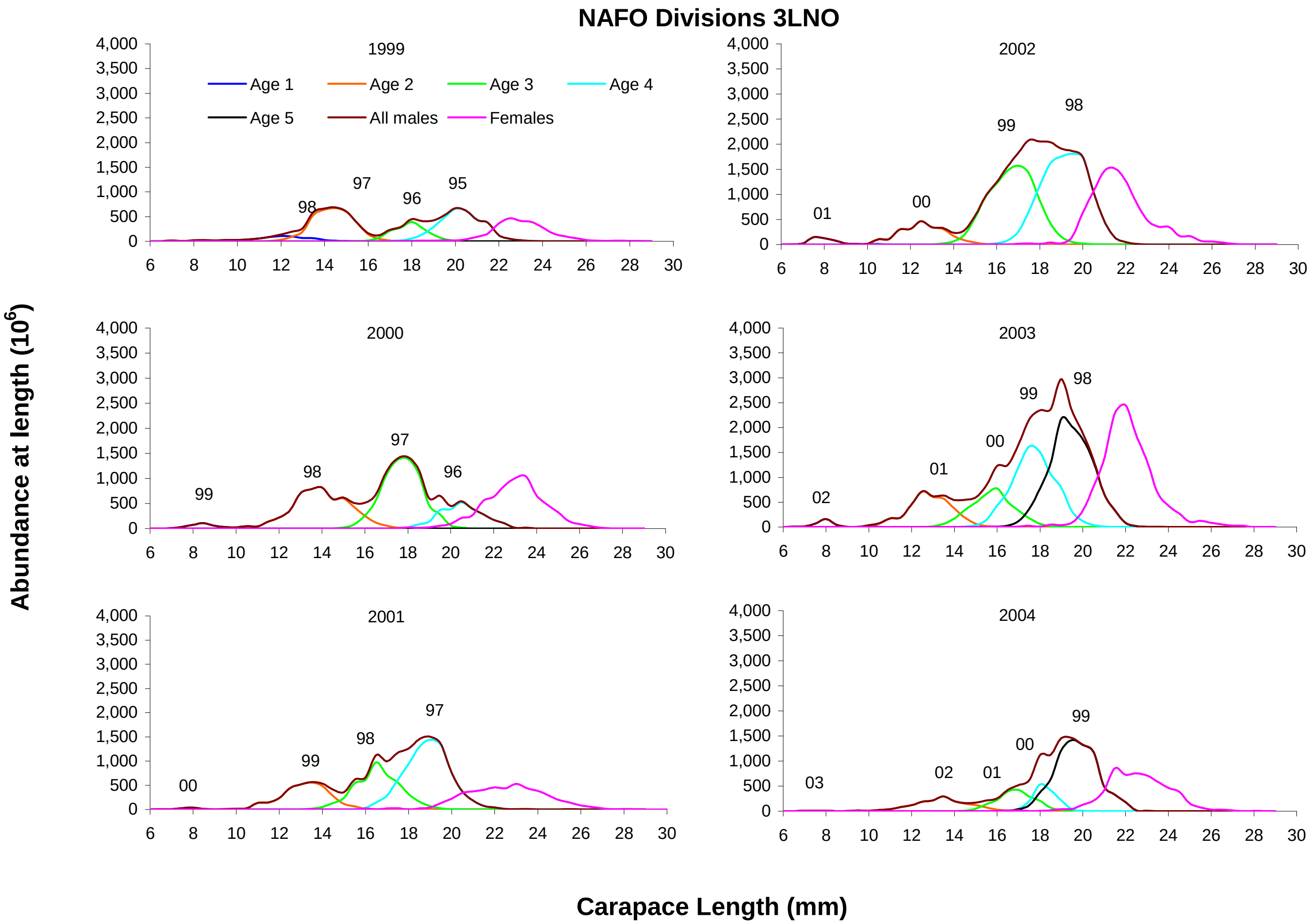


Figure 23. NAFO divisions 3LNO northern shrimp carapace length frequencies as calculated using ogmap calculations. The data were obtained from annual **spring** Canadian research bottom trawl surveys using a Campelen 1800 shrimp trawl. (Offshore strata only. Standard 15 min. tows.). The numbers within each plot indicate year classes as determined using Mix 3.01 (Pitcher and MacDonald, 1993).

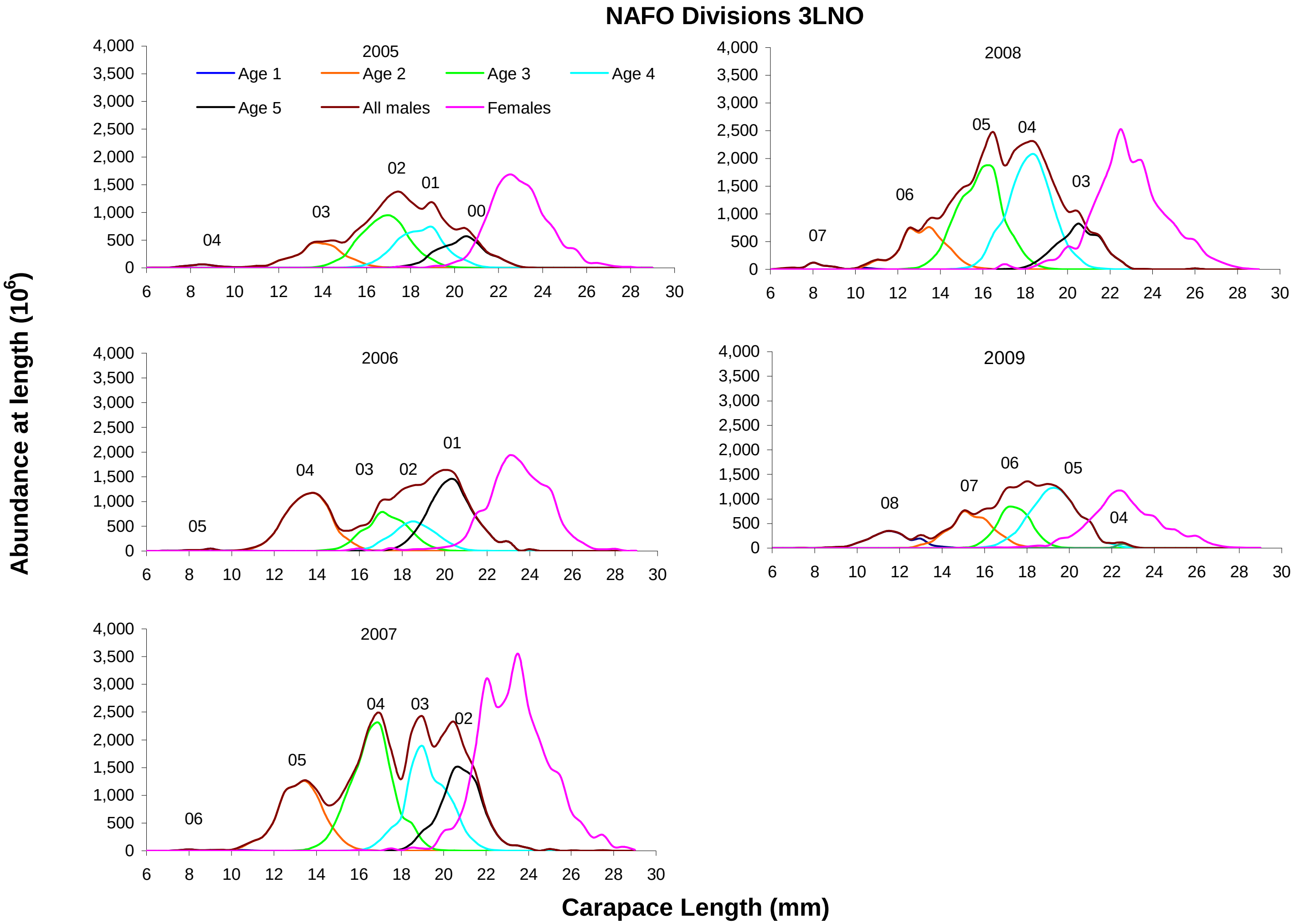


Figure 23. (Continued)

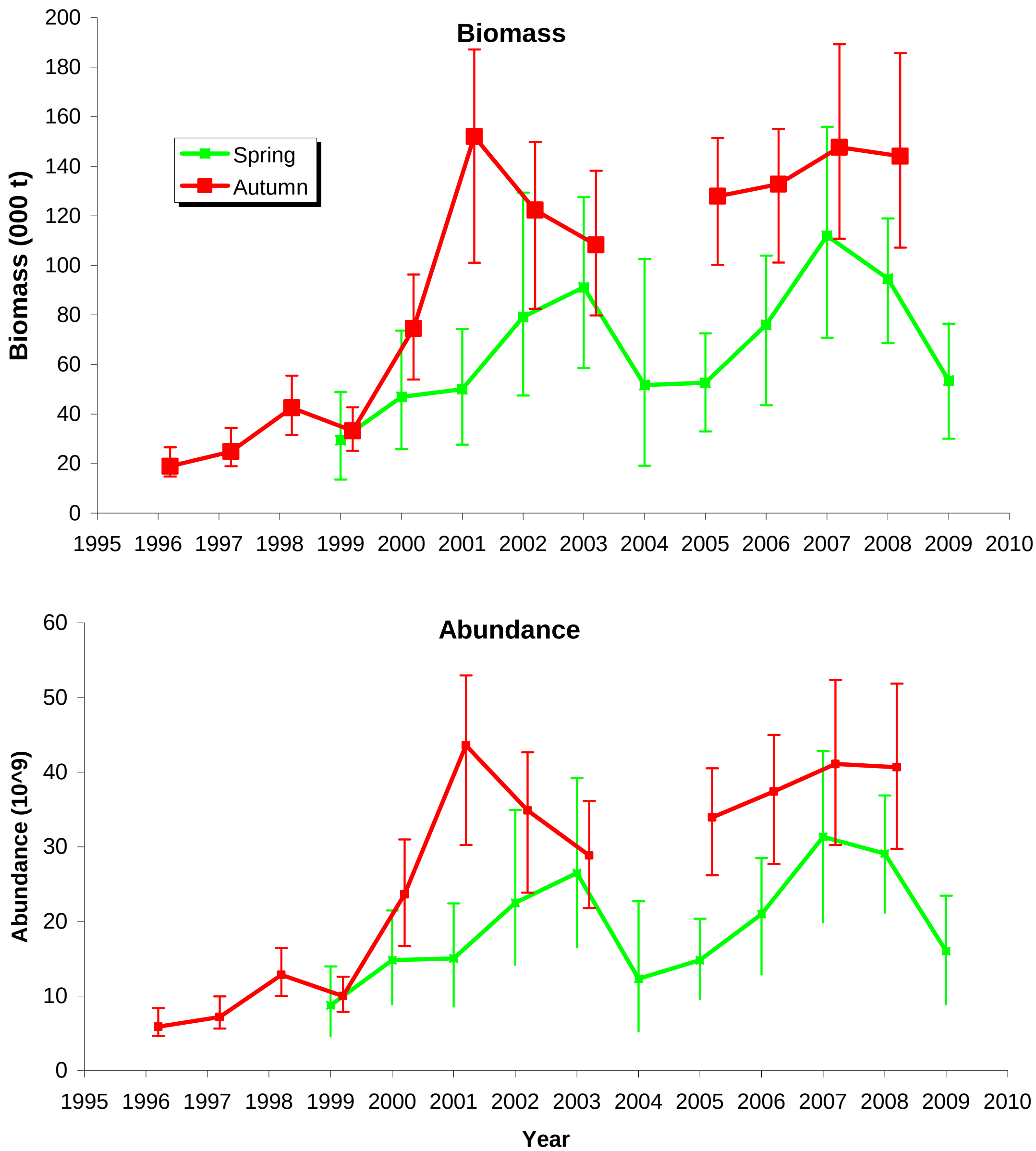


Figure 24. Abundance and biomass of male shrimp within NAFO Divisions 3LNO as estimated from Canadian multi-species survey data using Ogmap calculations.

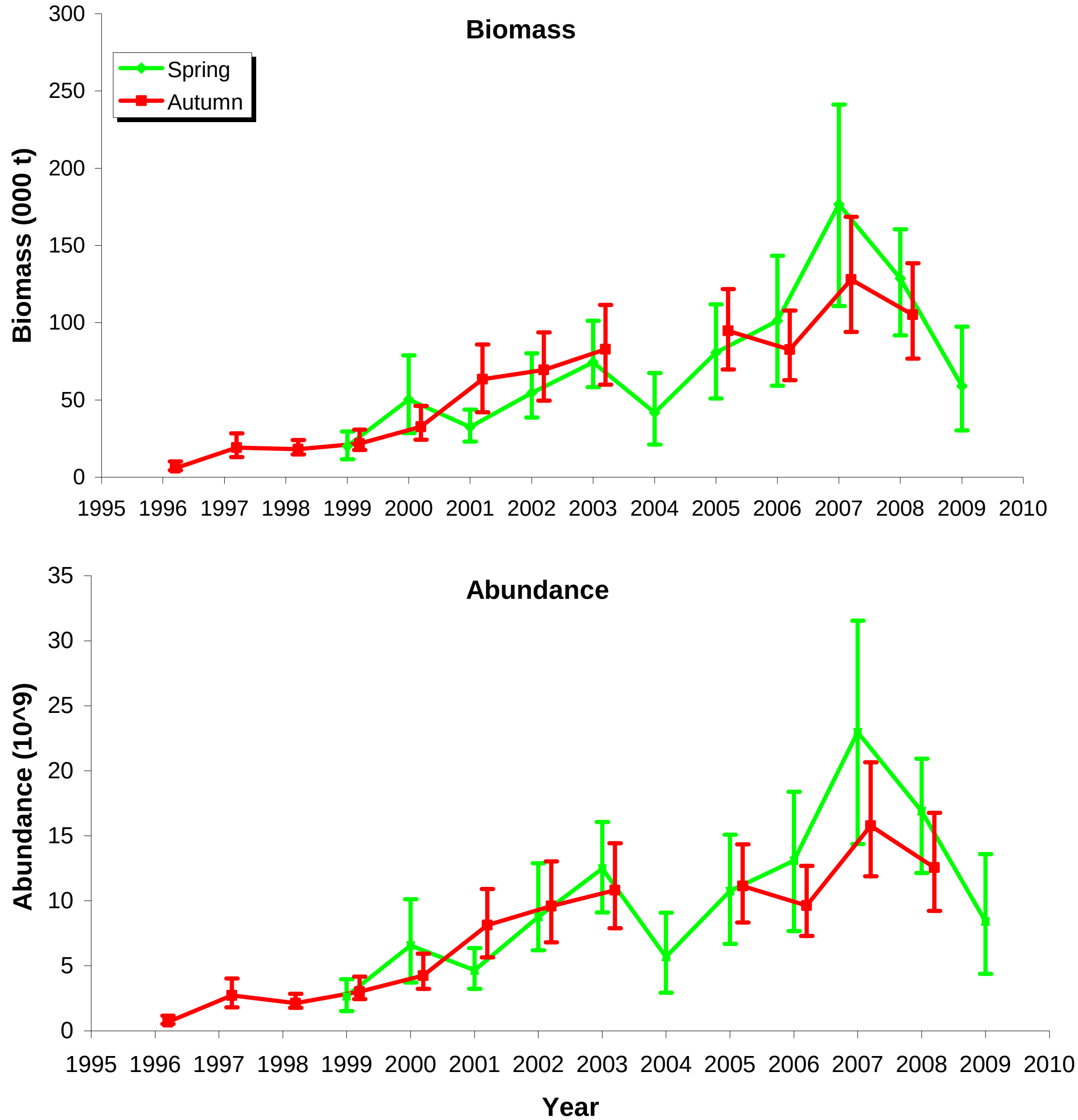


Figure 25. NAFO Divisions 3LNO female spawning stock biomass and abundance as determined from annual Canadian autumn and spring multi-species research bottom trawl survey data, 1996 – 2009 using Ogmap calculations.

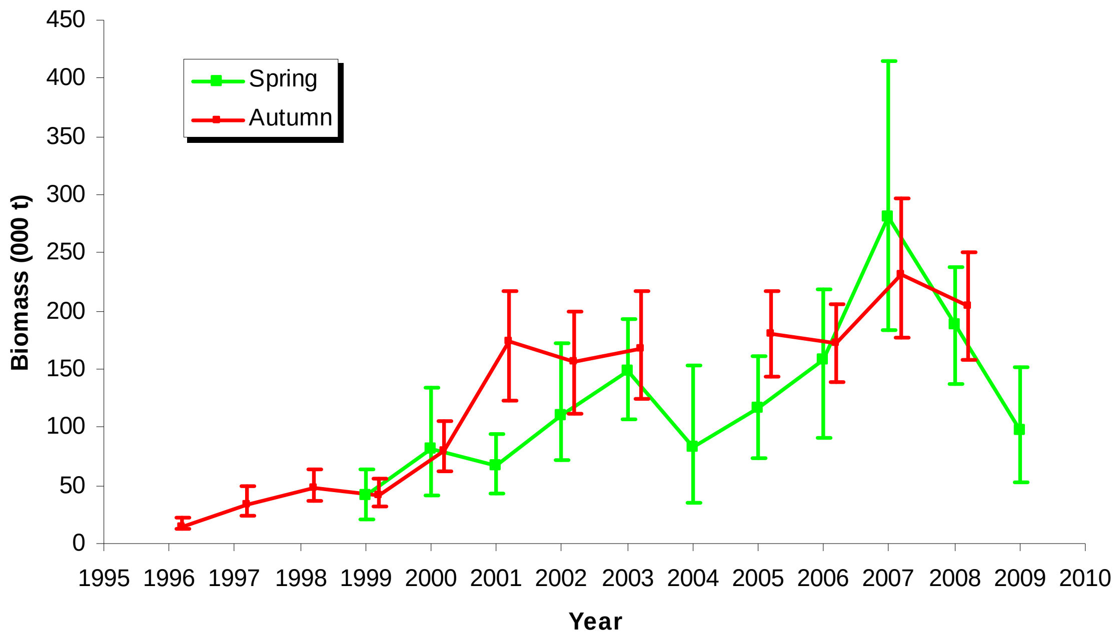


Figure 26. Fishable biomass (t) indices (total weight of all females + weight of all males with carapace lengths => 17.5 mm) as determined using ogmap calculations from autumn and spring Canadian multi-species bottom trawl survey data, 1996 – 2009. The bars represent 95% confidence intervals around the proposed fishable biomass indices.

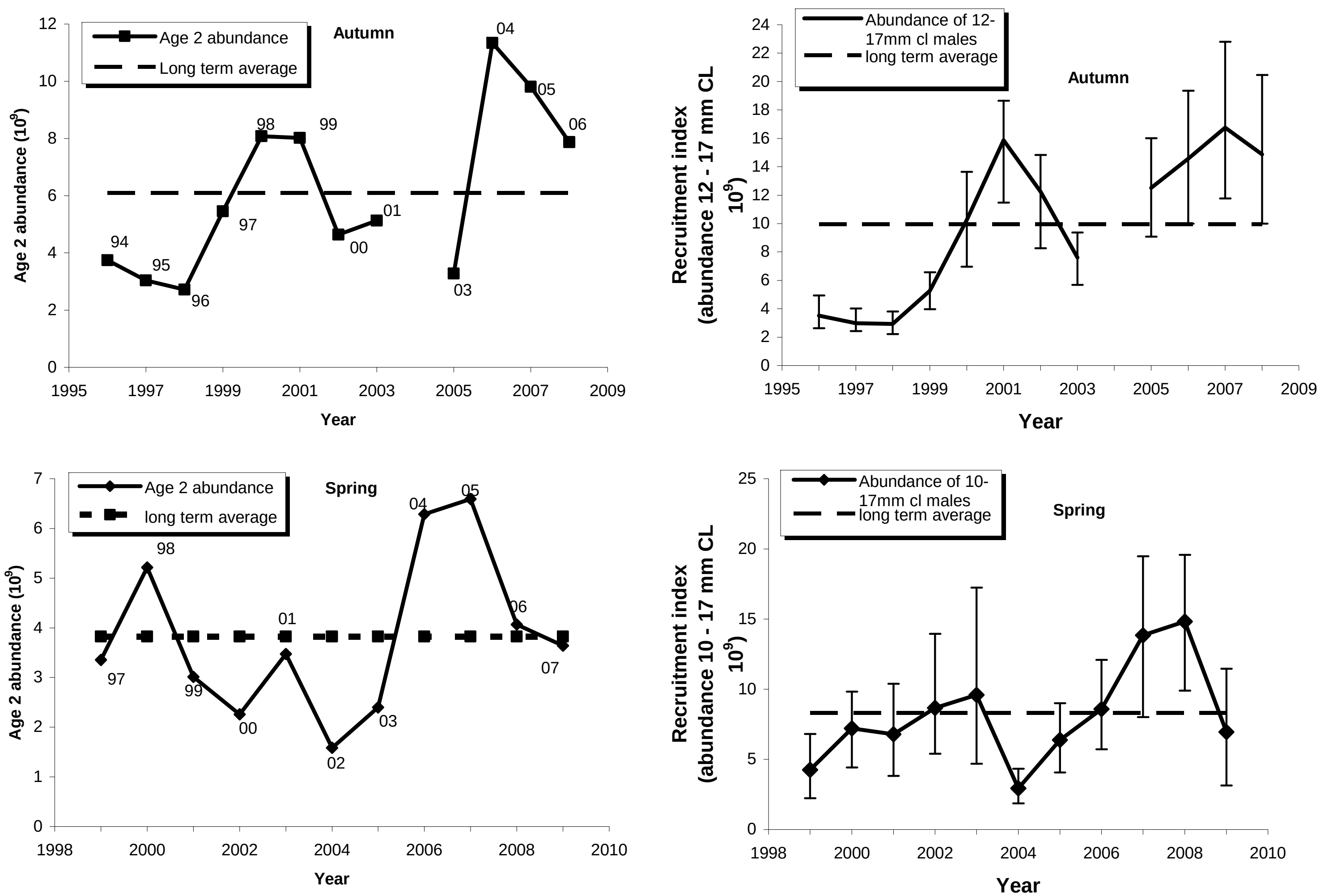


Figure 27. Recruitment indices as determined using Ogmap calculations from autumn and spring Canadian multi-species bottom trawl survey data, autumn 1996 – spring 2009. The bars represent 95% confidence intervals around the index.

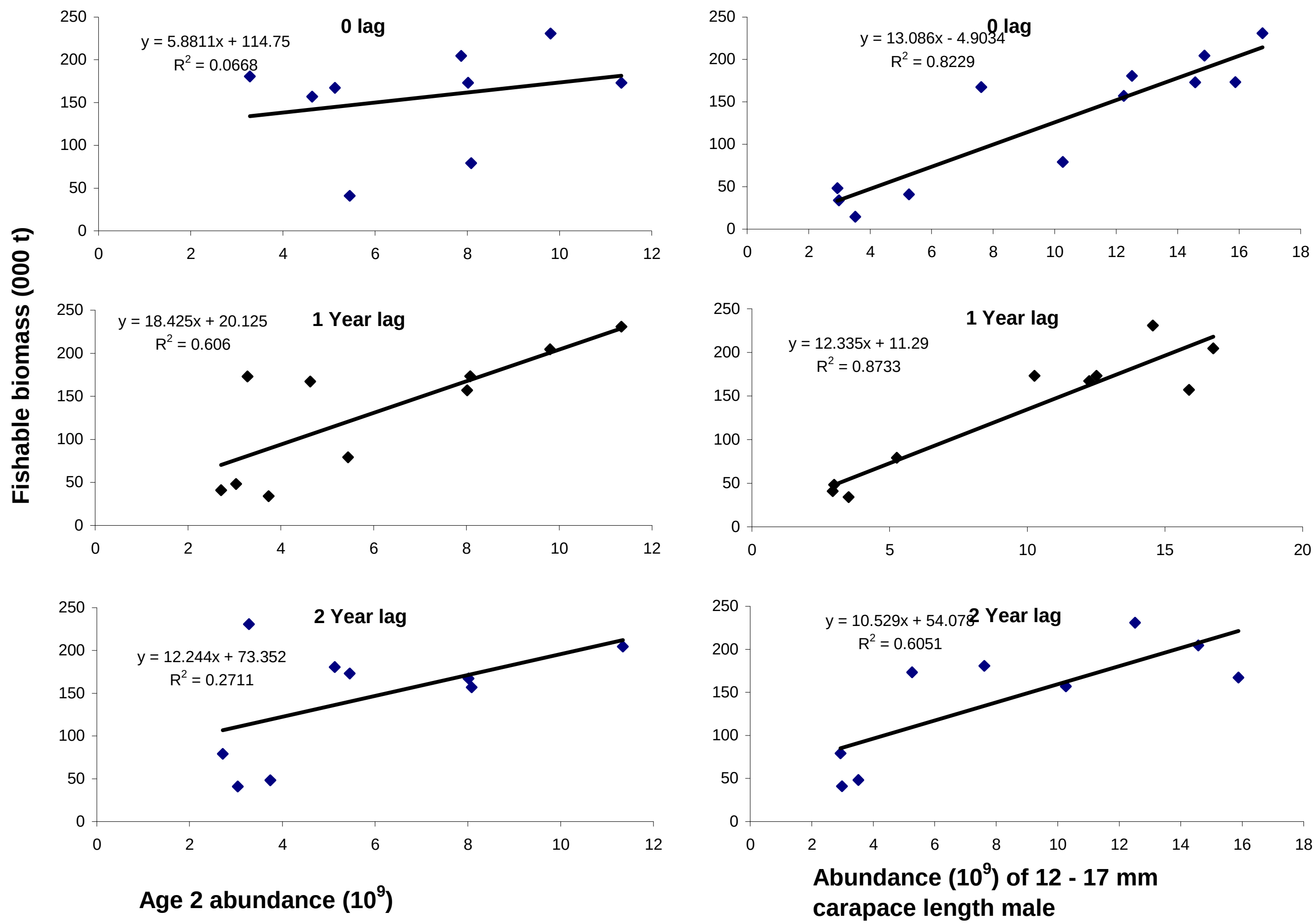


Figure 28. Regression analysis to determine the appropriate lag when predicting fishable biomass from recruitment index. Recruitment indices were determined by way of modal analysis as well as the abundance of males within 12 – 17 mm carapace lengths. Data are from the **autumn** Canadian multi-species surveys.

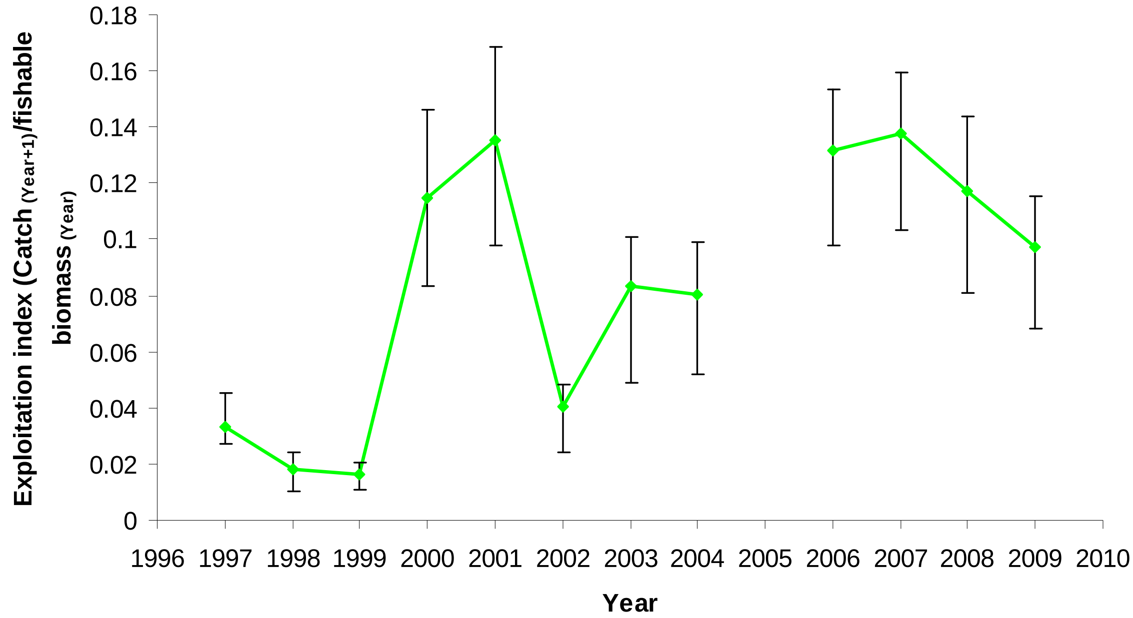


Figure 29. Trends in exploitation as derived by catch divided by the previous year's **autumn** fishable biomass index. The bars represent 95% confidence intervals around the exploitation rates for the proposed method.

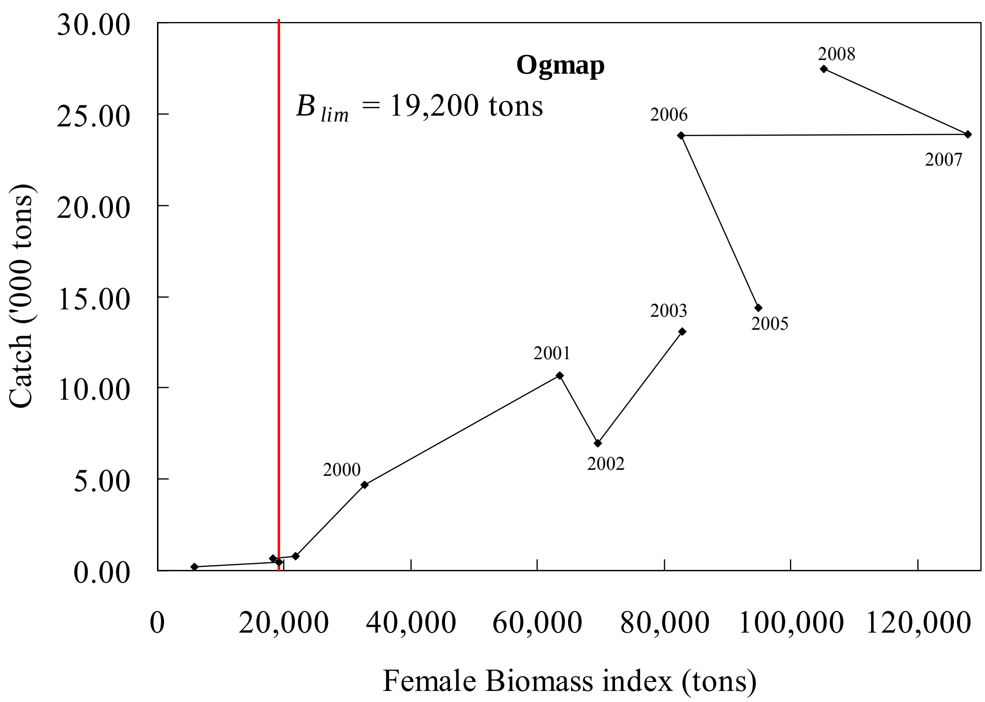


Figure 30. Catch plotted against female biomass index from the Canadian **autumn** multi-species survey data as derived using Ogmap calculations. Line denoting B_{lim} is drawn where the female biomass is 85% lower than the maximum point (2007 value).