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Research Document 2006/042

Document de recherche 2006/042

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Northern shrimp (*Pandalus borealis*) off Baffin Island, Labrador and northeastern Newfoundland

Crevette nordique (*Pandalus borealis*) au large de l'île Baffin, du Labrador et du nord-est de Terre-Neuve

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Ce document est disponible sur l'Internet à:

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ISSN 1499-3848 (Printed / Imprimé)

Canada

ABSTRACT

Updates of northern shrimp (*Pandalus borealis*) assessments were performed for NAFO Div. 0B and 2G, Hopedale + Cartwright Channels as well as Hawke Channel + Div. 3K, which correspond to shrimp fishing areas (SFA) 2, 4, 5 and 6, respectively. Status of the resource in each area was inferred, in part, by examining trends in commercial catch, effort, catch-per-unit effort, fishing pattern and size/sex/age composition of the catches. An autumn multispecies research trawl survey series (1995-2005) provided information on distribution, abundance, biomass, size/ sex composition and age structure of shrimp in SFA. 5 and 6.

Catches increased from 29,000 t in 1994 to over 114,000 t by 2004 due mainly to increases in Total Allowable Catch (TAC). The TAC for the 2005-06 management year was set at 120,414 t; it is anticipated that the quota will be taken in most SFA's.

Annual catches within SFA 6 increased from 11,000 t during 1994-96 to 72,600 t during the 2004 calendar year. The TAC for the 2005-06 management year was set at 77,932 t. It is anticipated that the quota will be taken.

Spatial distribution of the SFA 6 fishery expanded between the mid 90's and 2000 remaining stable thereafter. The 2005 large (>500 t) vessel Catch Per Unit Effort (CPUE) remained at a high level, while the small vessel (<65') CPUE increased significantly during 2004 and remained at a high level during 2005. Biomass and abundance indices from autumn multi-species surveys increased over the 1997-2001 period. Both indices decreased slightly during 2002 but since then abundance remained high while biomass increased to the highest recorded level. The 2003 year class appeared weaker than average; however, the strong residual female biomass is expected to maintain the fishery over the short-term. Medium-term recruitment appears positive due to the presence of a stronger than average 2004 year class. Female spawning stock indices increased from 182,000 t (22 billion animals) in 1997 to 404,000 t (55 billion animals) in 2005. The resource continues to be distributed over a broad area and exploitation rates have remained low with recent catches having no observable impact upon shrimp abundance and biomass.

Catches within SFA 5 (Hopedale + Cartwright Channels) increased from 7500 t in 1994-96 to 26,900 t by 2004. The TAC for the 2005-06 management year was set at 23,300 t and it is anticipated that the quota will be taken. Since 1996, CPUE has remained above the long-term average. Biomass and abundance indices have increased since 1998. Short term recruitment remains uncertain, because the autumn 2005 survey did not extend north of 2J. However, recruitment within Cartwright Channel appears average. Longer term prospects are unknown. The resource continues to be distributed over a broad area and the exploitation rate index remains low. Recent catches have had no observable impact on shrimp abundance and biomass.

The Northern Shrimp Research Foundation, in partnership with the Department of Fisheries and Oceans, conducted a shrimp based research survey into Div. 2G (SFA 4) and 0B (SFA 2). This was the first of at least five consecutive annual surveys into these shrimp fishing areas.

Catches within SFA 4 increased from 4000 t in 1994 to 11,500 t by 2004. The TAC in the 2005-06 management year was set at 10,320 t and it is anticipated that the quota will be taken. Fishery catch rates declined since 2001 to the long-term average in 2004 and 2005.

Catches within SFA 2 (NAFO Div. 0B) increased from 100 t in 1993 to 6,700 t in 2005. The TAC for the 2005-06 management year was set at 8,750 t, but it is doubtful that the quota will be taken. CPUE has been relatively stable at a high level since 1998.

RÉSUMÉ

Nous présentons des mises à jour des évaluations des stocks de crevette nordique (*Pandalus borealis*) des divisions 0B et 2G, des chenaux Hopedale et Cartwright, et du chenal Hawke et de la division 3K, qui correspondent respectivement aux zones de pêche de la crevette (ZPC) 2, 4, 5 et 6. Nous avons examiné les tendances des prises commerciales, de l'effort, des prises par unité d'effort, des habitudes de pêche et de la répartition des prises par taille, sexe et âge afin de déduire, dans une certaine mesure, l'état des ressources dans chaque zone. Un relevé de recherche plurispécifique au chalut, réalisé à l'automne pendant plusieurs années (1995-2005), a permis de recueillir des données sur la répartition, l'abondance, la biomasse, la composition des prises selon la taille et le sexe et la structure par âge de la crevette des ZPC 5 et 6.

Les prises ont augmenté, passant de 29 000 t en 1994 à plus de 114 000 t en 2004 en raison principalement de l'accroissement du total autorisé des captures (TAC). Le TAC pour l'année de gestion 2005-2006 est fixé à 120 414 t; on s'attend à ce que le quota soit atteint dans la plupart des ZPC.

Les prises annelles dans la ZPC 6 ont augmenté; alors qu'elles étaient de 11 000 t en 1994 1996, elles ont totalisé 72 600 t au cours de l'année civile 2004. Le TAC de l'année de gestion 2005-2006 a été fixé à 77 932 t et on prévoit qu'il sera atteint.

La répartition spatiale de la pêche dans la ZPC 6 s'est étendue entre le milieu des années 1990 et 2000, demeurant stable par la suite. Les prises par unité d'effort des gros bateaux (>500 t) en 2005 sont demeurées à un niveau élevé, tandis que celles des petits bateaux (<65 pi) ont connu une hausse considérable en 2004, puis sont demeurées à un niveau élevé en 2005. Les indices de la biomasse et de l'abondance, tirés des relevés plurispécifiques d'automne, ont augmenté entre 1997 et 2001. Ils ont par la suite diminué légèrement en 2002, mais depuis, l'abondance est restée élevée tandis que la biomasse se haussait à un niveau record. La classe d'âge de 2003 a semblé plus faible que la moyenne; toutefois, la forte biomasse femelle résiduelle devrait soutenir la pêche à court terme. Le recrutement à moyen terme semble positif en raison de la présence d'une classe d'âge de 2004 plus forte que la moyenne. Les indices du stock de génitrices a augmenté, passant de 182 000 t (22 milliards de crevettes) en 1997 à 404 000 t (55 milliards de crevettes) en 2005. Les ressources continuent d'être réparties sur une vaste étendue et les taux d'exploitation demeurent faibles, les prises récentes n'ayant eu aucun effet observable sur l'abondance et la biomasse de crevettes.

Dans la ZPC 5 (chenaux Hopedale et Cartwright), les prises ont connu une hausse, de 7 500 t en 1994-1996 à 26 900 t en 2004. Le TAC de l'année de gestion 2005-2006 a été fixé à 23 300 t et l'on croit qu'il sera atteint. Depuis 1996, les prises par unité d'effort sont à un taux supérieur à la moyenne à long terme. Les indices de la biomasse et de l'abondance montent depuis 1998. Le recrutement à court terme demeure incertain, parce que le relevé de l'automne 2005 n'a pas dépassé le nord de 2J. Toutefois, dans le chenal Cartwright, le recrutement semble moyen. Les perspectives à long terme sont inconnues. Les ressources continuent d'être réparties sur une vaste étendue et l'indice du taux d'exploitation demeure faible. Les prises récentes n'ont eu aucun effet observable sur l'abondance et la biomasse des crevettes.

La Northern Shrimp Research Foundation, en collaboration avec le ministère des Pêches et des Océans, a mené un relevé de recherche sur la crevette dans les divisions 2G (ZPC 4) et 0B (ZPC 2). Il s'agissait du premier d'au moins cinq relevés annuels consécutifs dans ces zones de pêche de la crevette.

Les prises dans la ZPC 4 sont passées de 4 000 t en 1994 à 11 500 t en 2004. Le TAC de l'année de gestion 2005-2006 a été fixé à 10 320 t et on prévoit qu'il sera atteint. Les taux de prises des pêches ont diminué depuis 2001 s'établissant au niveau de la moyenne à long terme en 2004 et 2005.

Les prises dans la ZPC 2 (division 0B de l'OPANO) sont passées de 100 t en 1993 à 6 700 t en 2005. Le TAC de l'année de gestion 2005-2006 a été fixé à 8 750 t, mais on doute que le quota soit atteint. Les prises par unité d'effort ont été relativement stables, à un niveau élevé, depuis 1998.

INTRODUCTION

The fishery for northern shrimp off the coast of Labrador began in the mid 1970's, primarily in the Hopedale and Cartwright (SFA 5) Channels (Fig. 1). The history of quotas by SFA is presented in Table 1. Annual catches (Table 2; Fig. 2) increased steadily from less than 3000 t in 1977 to about 4100 t in 1980 but subsequently declined to 1000 t in 1983 and 1984 due to poor markets and high operating costs. Economic conditions improved, thereafter, and catches from SFA's 5 and 6 increased to about 7800 t in 1987. In 1988, fishing effort became more widespread as vessels ventured into Div. OB (SFA 2) and 2G (SFA 4) where both catch rates and sizes of shrimp proved to be very attractive to the industry. Additional commercial concentrations of shrimp were located within SFA 6 in a small area east of St. Anthony Basin and in Funk Island Deep. Catches in both 1988 and 1989 approached 20,000 t and remained in the 15,000 to 17,000 t range from 1990 to 1993. Exploratory fisheries along the slope of the shelf in SFA's 4-6 in 1992 and 1993 revealed commercial concentrations of shrimp in those areas, as well.

Catches from 1994 to 1996 ranged between 22,900 and 46,800 t in response to increased TAC's for several SFA's. Catches increased to 90,100 t in 2000, mainly due to progressive increases in TAC within SFA 6 where the resource was considered to be healthy and exploitation low. The increases after 1996 were primarily reserved for the development of a small vessel (<65') fleet which has since grown to include more than 300 vessels.

In 2003, TAC's increased by 25,000 t of which 3625 t was used to fund northern shrimp research in SFA's 2 and 4. During that year industry was granted a change in fishing season from a calendar (Jan 1-Dec. 31) year to a fiscal (Apr.1-Mar. 31) year. To facilitate this change, an additional 20,229 t interim quota was allocated to the large vessel fleet and the 2003-04 fishing season became 15 months in length. The 2004-05 the fishing season was 12 months in duration and total allocations, within SFA's 2, 4 and 6, equaled 120,302 t. This TAC was maintained throughout the 2005-06 fiscal year.

All northern shrimp fisheries in eastern Canada are subject to the Atlantic Fisheries Regulations regarding territorial waters, bycatches, discarding, vessel logs, etc. The regulations for shrimp refer to the minimum mesh size of 40 mm and that no fishing is permitted in any defined area, after it has been closed. Also, to minimize bycatch of non-target species, large and small vessels must use sorting grates with a maximum bar spacing of 28 mm and 22 mm respectively. Observers are required on all trips by the large vessel fleet and a target of 10% coverage has been established for the small vessel fleet.

This research assessment, conducted during March 2005, included four shrimp fishing areas (SFA's): Hawke Channel + NAFO Div. 3K (SFA 6), Hopedale + Cartwright Channels (SFA 5), Div. 2G (SFA 4) and Div. 0B (SFA 2).

MATERIAL AND METHODS

COMMERCIAL FISHERY DATA

Large vessel (>500 t) CPUE was calculated by year for each SFA and used as an indicator of change in the fishable stock over time. Models derived for the present assessment made use of observer datasets because we wanted to account for the usage of windows (escape openings). The usage of windows is captured in the observer dataset but not in the logbooks. Additionally, there is 100% observer coverage of the large vessel fleet. Records indicating more than one trawl and/or the presence of windows were omitted from these calculations. Raw catch/effort data for each SFA were standardized by multiple regressions, weighted by effort, in an attempt to account for variation due to factors such as year, month, area and vessel. The multiplicative model has the following logarithmic form:

$$Ln(CPUE_{ijkl}) = ln(u) + ln(A_l) + ln(S_j) + ln(V_k) + ln(Y_l) + e_{ijkl}$$

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

The standardized CPUE indices are the antilog of the year coefficient. In order to track only experienced fishermen, and to reduce the number of estimated parameters, vessels with less than four years of experience were excluded from the analyses. This increased our confidence when interpreting results.

Final models included all significant class variables with the YEAR effect used to track trends in stock size over time. The difference (or similarity) between the 2005 YEAR parameter estimate and those of previous years was inferred from the output statistics.

Similar models were developed for the small vessel (<=500 t; <100') fleet. However, these models used the logbook dataset, because observers monitor only 10% of fleet activities.

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

Carapace lengths of male and female shrimp were obtained from commercial samples taken by observers on both large and small vessels. Samples were adjusted upward to set and year for each SFA to derive a series of annual catch-at-length compositions. Age structure was inferred by identifying prominent year classes (modes) within composite length distributions and tracking their development over time. These samples are considered representative throughout much of the time series. However, the small vessel fleet began harvesting shrimp during 1997. Prior to 2000, it was felt that observer coverage and number/ quality of samples were not sufficient for scientific purposes. Therefore, the 1997-99 commercial length distributions, based solely upon on sampling from large vessels (>500 t), might not be representative of catch at length from both fleets.

RESEARCH SURVEY DATA

Shrimp abundance, biomass, maturity and carapace length data have been collected since autumn 1995, as part of the Canadian multispecies surveys conducted using the CCG Wilfred Templeman, CCG Alfred Needler and CCG Teleost. Fishing sets of 15 minute duration and a towing speed of 3 knots were randomly allocated within strata, to depths of 1500 m. Set allocations vary by NAFO division. The minimum allocation of sets per unit area ranged from 1 set per 230 sq. Nmi in 3K to a minimum of 1 set per 350 sq. Nmi in 3N. All vessels used a Campelen 1800 shrimp trawl with a 40 mm codend mesh size and a 12.7 mm liner. SCANMAR sensors estimated that the mean wingspread was 16.8 m. Details of the survey design and fishing protocols are outlined in (Brodie 1996; McCallum and Walsh 1996).

Survey coverage, within Hawke Channel + Div. 3K (SFA 6), has been extensive in areas where shrimp occur and reliable estimates of distribution, abundance and biomass have been obtained each year. Farther north, DFO multi-species survey coverage has not been sufficient to resolve the highly patchy distribution of shrimp. During 1999, it was decided that 2G would no longer be surveyed and that future surveys would extend to the top of 2H in alternate years. During intervening years, the survey would extend to the top of 2J. NAFO Div. 2J3K were surveyed during 2002. However, due to vessel problems, most of 2J and parts of 3K were surveyed during the first two weeks of January 2003 rather than October 2002. Due to recurring vessel problems, 2H was dropped from the 2003 survey. This portion of the survey was completed during 2004. All inshore and offshore strata were surveyed within NAFO Div. 2HJ3K during 2004. The 2005 survey extended to the top of 2J. However, due to vessel problems, both the 2004 and 2005 surveys were completed during January of 2005 and 2006 respectively.

The Northern Shrimp Research Foundation (NSRF) in partnership with the Department of Fisheries and Oceans (DFO) conducted a shrimp based research survey into Div. 2G (SFA 4) and 0B (SFA 2) during 2005. This was the first of at least five consecutive annual surveys into these shrimp fishing areas. The NSRF-DFO survey was conducted using a Campelen 1800 shrimp trawl and made use of protocols similar to those used by the multi-species when surveying SFA's 4-6. The NSRF-DFO survey focused upon shrimp with sets allocated to depths between 100 and 750 m. The 2G allocation plan had a minimum target of at least 1 set per 250 sq. Nmi. This provided similar coverage to the 1997 and 1999 DFO surveys in 2G. The 0B allocation scheme had a minimum target of at least 1 set per 350 sq. Nmi. The 0B allocation target was similar to that used in the annual fall 3N surveys and provided much higher coverage than any of the previous 0B surveys.

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:

1. males;
2. transitionals;
3. primiparous females;
4. ovigerous females,
5. 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.

Abundance and biomass estimates with Monte Carlo confidence intervals were calculated using a non-parametric method known as OGive MAPping (OGMAP) (Evans et al. 2000). Abundance at length and sex were also derived using this technique. Age structure from survey data was determined by identifying year classes within the composite length frequency distributions.

Modal analysis using Mix 3.1A (MacDonald and Pitcher, 1979) was conducted on male research length frequencies.

Exploitation indices were developed by dividing total catch by each of the following estimates from the previous year's survey:

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

The fishable component of the population was defined as all animals greater than 17 mm CL. The male portion of the SFA 6 fishable biomass was determined by converting abundances at length to biomass using the length/weight model:

$$Wt(g) = 0.000676 \times lt(mm)^{2.955}$$

This length weight relationship was estimated from live males obtained within NAFO Div. 3K during autumn 2004. Whereas the male portion of the SFA 5 fishable biomass was determined by converting abundances at length to biomass using the length/weight model:

$$Wt(g) = 0.00046 \times lt(mm)^{3.061}$$

This length weight relationship was estimated from live males obtained within NAFO Div. 2J during autumn 2004.

Female biomass (transitionals, primiparous, ovigerous and multiparous females) was determined via Ogmap calculations. Female and male (>17 mm carapace length) biomasses were added together to obtain total fishable biomass. It is important to note that these are not absolute exploitation rates since the catchability of the Campelen trawl is not known. However, these indices allow one to monitor trends in exploitation over the years.

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

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

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

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

ASSESSMENT OF SHRIMP IN HAWKE CHANNEL+DIVISION 3K (SFA 6)

FISHERY DATA

Catch and Effort

Catches increased from about 1,800 t in 1987 to more than 7,800 t in 1988 and ranged between 5,500 and 8,000 t from 1989 to 1993 inclusive. Annual TACs for SFA 6 in the 1994-96 Integrated Fisheries Management Plan (IFMP) were set at 11,050 t and catches increased to 11,000 t. The TAC for 1997, the first year of the 1997-99 multi-year IFMP, was raised to 23,100 t as a first step toward increasing exploitation within a healthy resource. Most of the increase was reserved for the development of a small vessel component. Catches in 1997 were estimated to be approximately 21,200 t, about 6,100 t were caught by vessels less than 100 feet in length. Despite the large increase in catch, relative exploitation in 1997 remained low and the TAC for 1998 was increased again by 100% to 46,200 t. Catches exceeded 46,300 t with the expanding small vessel fleet reporting about 30,100 t. The 1999 TAC was increased (27%) to 58,632 tons. Due to operational problems, small vessel catches were 7,400 t short of their 41,029 t TAC, whereas the large vessel fleet took its 17,600 t allocation. In 2000, the TAC was increased only by 4% to 61,632 t. Approximately 63,000 t were taken, 21,000 t by large vessels and 42,000 t by small vessels. The 2001 TAC remained at 61,632 t, of which 20,000 t were taken by the large vessel fleet while only 33,000 t were taken by the small vessel fleet (Tables 1-4; Fig. 3 and 4). The small vessel fleet did not take its entire quota because shrimp were relatively small, and there was an international glut in the market for peeled, frozen shrimp. This led to a short industry imposed closure throughout July-August, 2001. The closure was also induced by seasonal variances in shrimp yield. On average, yield drops by 5% over the summer period (A. O'Rielly, pers. comm.). The plants and fishermen had to re-negotiate the price structure to account for the seasonal loss in yield. Therefore, plants and fishermen agreed to a small vessel closure, which began on July 1, 2001. Negotiations were completed by September 24 and the fishery reopened with an agreement to harvest no more than 25 million lbs during the fall, 2001. It is worth noting that the closure did not affect operations at the Charlottetown, Lab. plant which continued to purchase shrimp from 2J fishers because the season is shorter in the north.

A second industry imposed closure occurred in August of 2002, again with continued operations at Charlottetown. Once again this was primarily due to low shrimp yield during the summer months.

The TAC remained at 61,632 t during 2002 but further increased, by 26%, to 77,932 t in 2003. An additional interim quota of 7653 t was set for the fishing season January 1-March 31, 2004 to facilitate an industry requested change in fishing season from a calendar year (January 1-December 31) to a fiscal year (April 1-March 31 of the next year). Thus the 2003-04 fishing season was 15 months long and had an 85,585 t TAC.

Prices had been negotiated prior to the 2003 season and industry had developed a management plan requiring trip limits to be reduced from 55,000 lbs during the spring to 38,000 lbs throughout July and 35,000 lbs for August. Additionally, shrimp prices dropped significantly over this period to account for the loss in yield (A. O'Rielly, pers. comm.). Changes in seasonality of the fishery, in price, and trip limits are expected to influence future CPUE model estimates.

The 2004-05 fishing season was 12 months and had a 77,932 t TAC. The TAC in the 2005-06 management year remained unchanged and it is anticipated that the quota will be taken.

The large vessels primarily fish during the first six months of the year whereas the small vessels fish during the spring and summer (Fig. 5 & 6).

The large vessel fleet fished along the shelf edge during the early 1990's. The fishery extended as far south as the St. Anthony Basin and Funk Island Deep because of the establishment of exploratory areas on the shelf slope in 1992 and 1993, and the discovery of dense concentrations of shrimp within these areas. Assessments at that time suggested there was no reason to divide SFA 6 into separate management units. Therefore, the 1994-96 management plan allowed flexibility to fish anywhere within the combined management area. As a result catch and effort shifted away from the St. Anthony Basin and Funk Island Deep areas. Over the years, the large vessel fleet has taken most of their catch from Hawke Channel and within the 500 m contour along the northern portion of SFA 6 (Fig. 7). During September 2002, a 400 Nmi square area within Hawke Channel was closed to all but snow crab fishing. The next year, the close area was expanded to 2500 square Nmi. Then during 2005, the Funk Island Deep box was closed to bottom trawling. The evolution of these closures is presented in figure 7. These changes in fishing pattern are reflected in the change in number of cells required to obtain 95% of the catch (Fig. 8).

During 1993, the cell count was high at a time when an exploratory fishery was established in the south. The number of cells declined between 1994 and 1996 as catch and effort declined in St. Anthony Basin and Funk Island Deep. Since 1996, the index increased with catch indicating that fishable biomass was spread over a broad area.

The small vessel fishery covers vast areas of SFA 6 with concentrations along the 500 m contour in northern 2J, St. Anthony Basin, as well as, southeastern 3K (Fig. 9).

Catch Per Unit Effort (CPUE)

Annual CPUE's for large vessels (single trawl, no windows) increased steadily from 1992 to 1997 and have since fluctuated at a high level (Fig. 10). The CPUE data were analyzed by multiple regression for year, month and vessel effects to standardize the catch rates (Table 5). The model accounts for approximately 76% of the variance in the data. Figure 11 clearly indicates that there are no trends in the scatter of residuals around the parameter estimates.

The model indicated that 1995, 1996, 1998, 1999 and 2002-04 catch rates were similar to the 2005 catch rate (P>0.05). Values prior to 1995 were significantly lower than the 2005 estimate (P<0.05). This would suggest two regimes within the shrimp population, with an inflection point during the mid 1990's. It is important to note that CPUE values are being maintained at a high level at a time when the resource and fishery cover a broad geographic area suggesting that the stock is healthy (Fig. 7-10).

Table 6 provides the small vessel CPUE model output while Fig. 12 indicates the scatter of residuals around estimated parameters. There are no clear trends in the scatter of residuals. The inter-quartile boxes are close to the zero reference lines indicating that there is not a great deal of variation in the data.

The model accounted for only 67% of the variation in explanatory parameters. The 2005 catch rate estimate was significantly P (<0.05) higher than all previous estimates.

Size Composition

Several length frequency observations were taken from large vessel catches (Fig. 13). 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 two years of age. The male modes overlapped to the extent that it was not possible to complete Mix distribution analysis; however, the male modes often had three faint sub-peaks implying the presence of more than one year class. Given that the modes were usually near 16 mm, 18 mm and 20 mm, these animals were probably 2-4 years of age respectively. The female length frequency distributions were also broad indicating that the female portion of the catch probably consists of more than one age group. Catch rates had been maintained at over 200,000 animals per hour. The within year frequency weighted average carapace lengths for males ranged between 17.94 mm and 19.06 mm, while the weighted average carapace lengths for females ranged between 22.07 mm and 23.78 mm. There were no trends in the average size of either males or females.

Probit analyses from winter (January-March) large vessel observer carapace length frequency data are presented in table 7 as well as Fig. 14. Size at sex has decreased since 1991 and has fluctuated at a lower level since 1998. The 2003 estimate (20.34 mm) was statistically similar to the 2005 estimate (20.27 mm) (Table 7; Fig. 14). Even though size at sex change has been decreasing and number of eggs laid by the female is linked to her size, the potential drop in individual fecundity is probably being offset by the large increase in number of females.

RESEARCH SURVEY DATA

Stock Size

Inshore strata along the northeast Newfoundland coast were not sampled in 1995 or 1999; therefore, the analyses were confined to the offshore strata for comparative purposes. Inshore areas, sampled during other surveys, generally produced low catches of shrimp that did not contribute substantially to the biomass/abundance estimates. Additionally, it is important to note that there is uncertainty around the 2002-05 surveys because, due to vessel problems, they were finished in January or early February rather than during December as planned.

Results of the 2005 fall multi-species research survey indicate that shrimp continue to be widely distributed and abundant throughout Hawke Channel + Div. 3K (Fig. 8, 15-16). Point estimates for biomass and abundance increased from about 291,700 t (71 billion) in 1995 to 499,600 t (115 billion) in 1996 but declined to 424,900 t (95 billion) in 1997. Estimates increased steadily to 654,100 t (160 billion) in 2001 with a slight drop to 599,900 t (149 billion) by 2003. Since then abundance has remained at a high level (150 billion) while biomass increased to 691,500 t in 2005, the highest in the time series. The lower 95% confidence intervals for the biomass indices averaged 561,000 t (about 134 billion animals) over the 2001-05 period (Table 8).

The fact that confidence intervals are relatively tight suggesting a relatively uniform distribution throughout the survey area (Table 8; Fig. 17). This is in agreement with the areal index used to track changes in the commercial fishing and research survey data (Fig. 8).

Male biomass/abundance indices increased from 243,200 t (73 billion) in 1997 to 301,400 t (109 billion) during 2001 then decreased to 258,900 t (94 billion) during 2002, increasing again to 287,600 t (95 billion animals) by 2005. The female stock increased from an estimated 181,700 t (22 billion) in 1997 to 403,900 t (55 billion) in 2005. Similarly, fishable biomass has been increasing almost continuously throughout the time series (Table 10; Fig. 18).

Exploitation Rates

Exploitation rate indices were determined using ratios of catch divided by the previous year’s survey index. In this case the survey indices included the lower 95% confidence interval of the biomass estimate, spawning stock biomass and fishable biomass. In general, exploitation has been low even though catches have increased over time because the stock parameters also increased (Table 10). Figure 19 presents the exploitation rate index determined as catch/lower 95% confidence limit of the previous year’s biomass estimate. The 2005 exploitation rate index was 13%.

It should be noted that actual exploitation rates are unknown but are likely lower than indicated above because the Ogmap indices are believed to be underestimates (i.e. catchability of the survey gear is unknown but believed to be <1).

Stock Composition

Length distributions representing abundance – at – length from the autumn 1995-06 surveys are compared in Fig. 20. Modes increase in height as one moves from ages 1-3 indicating that catchability of the research trawl probably improves as the shrimp increase in size. Table 11 provides the modal analysis and the estimated demographics from the autumn survey.

This time series provides a basis for comparison of relative year-class strength and illustrates changes in stock composition over time. The 1997 year-class first appeared as a clear mode, in the 1998 survey (Fig. 20), at 10.11 mm, as two year old shrimp in the 1999 survey at 14.94 mm, as three year old shrimp in the 2000 survey at 17.58 mm and as four year olds in the 2001 survey at 19.18 mm (Table 11). Similarly, the 1998 year-class could be tracked for four years. The fact that strong year classes could be followed for four years until they became females provides strong evidence that these animals change sex at four years of age.

It is important to note that the age 1 animals are not well recruited to the survey gear and therefore may not always give a clear recruitment signal. On the other hand, strong age 2 modes appear strong throughout their history, conversely weak year-classes such as the 1995 and 1996 appear weak as age 2 males and remain weak throughout their history. Therefore, the recruitment index is created from the age 2 abundances.

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 (Table 11; Fig. 20). Shrimp aged 2-4 dominated the male component of the length frequencies in 2005 (2003, 2002 and 2001 year-classes) survey with carapace length frequency modes at 14.74, 17.67 and 20.00 mm respectively. The 2004 year-class, as seen in the autumn 2005 survey, is the most abundant age 1 year-class (16 billion) in any of the surveys.

Female length frequency distributions are broad indicating that they probably consist of more than one year-class. Additionally, residual female biomass and abundance indices are high (Table 9 and 11). Therefore, at present exploitation rates, the fishery can probably be maintained over the short term even with the presence of relatively weak 2003 year-class.

Survival and Mortality Rate Indices

The average survival (S), total annual mortality (A) and instantaneous total mortality (Z) rate indices were .22, .78 and 1.49 respectively (Table 12). The average total annual mortality rate index is much higher than the exploitation rate index (catch/lower 95% confidence limit of the biomass estimate) which has never exceeded 16% (Table 10).

Recruitment Index

Recruitment indices (age 2 abundance) were estimated from the autumn 1995-2005 surveys. Recruitment indices were based upon modal analysis of length frequencies (Fig. 21 A) and all males with 11.5 – 16.0 mm carapace lengths (Fig. 21 B). Regardless of the method used in determining age 2 abundance, the autumn 97 - 99, 01 and 02 year classes were above the long term average. The 03 year class as seen in the autumn 2005 survey is one of the lowest in the time series (Table 11; Fig. 20 and 21A and B).

Once again, the 2004 year-class, as seen in the autumn 2005 survey, is the most abundant age 1 year-class (16 billion) in any of the length frequency analyses (Table 11, Fig. 20). Due to the presence of the stronger than average 2004 year-class, medium term recruitment appears positive; however, it remains to be determined whether the 2004 year-class continues to be strong.

RESOURCE STATUS

The current status of the SFA 6 resource remains positive from both research survey and commercial fishery data. The 2005 large (>500 t) vessel CPUE remained at a high level, while the small vessel (<65') CPUE increased significantly during 2004 and remained at that level during 2005. The biomass and abundance indices from fall multi-species surveys increased over the 1997-2001 period. Both indices decreased slightly during 2002; since then abundance remained at a high level (150 billion animals) while biomass increased to the highest recorded level (692,000 t) during 2005. The 2003 year-class appears weaker than average; however, residual female biomass is expected to maintain the fishery in the short-term. Medium-term recruitment, from the 2005 survey, appears positive from the presence of a stronger than average 2004 year-class. The female biomass has increased from 150,000 t (19 billion animals) during 1995 to 404,000 t (55 billion animals) during 2005. Finally, the resource continues to be distributed over a broad area and the present exploitation rate index is low.

ASSESSMENT OF SHRIMP IN HOPEDALE AND CARTWRIGHT CHANNELS (SFA 5)

FISHERY DATA

Catch And Effort

Shrimp catches in Hopedale and Cartwright Channels increased from about 2,700 t in 1977 to 4,100 t in 1980, declined to 1,000 t in 1983 and 1984, increased again to 7,800 t in 1988, stabilizing at roughly 6,000 t during the 1989-92 period. TAC's for the 1994-96 management plan, which combined the two channels as a single management area, were increased to 7,650 t annually and catches subsequently increased, averaging 7,500 t during that period. Annual TAC's for the 1997-99 plan were increased by 100% to 15,300 t and catches were near 15,100 t each year.

The 15,300 t TAC (note that 1,530 t was set aside for the small vessel fleet) was maintained in the 2000-2002 plan. In 2003, the TAC increased 52% to 23,300 t and included a 2500 t allocation for northern shrimp science research. (In 2003, the fishing season changed to April 1-March 31, and an additional interim quota of 9787 t was set for the period January 1-March 31, 2004. Thus the 2003-04 fishing season was 15 months long and had a 33,087 t TAC). The 2003-04 fiscal year TAC (23,300 t) was maintained for the 2004-05 and 2005-06 seasons. Approximately 27,000 t were taken during the 2004 calendar year and it is anticipated that the 2005-06 quota will be taken (Table 2; Fig. 22). Table 13 and Fig. 23 document the history of the large vessel shrimp fishery in Hopedale and Cartwright Channels (SFA 5). Please note that the history of the total fishery within SFA 5 is presented in Table 1 and 2. An allocation has been available in recent years for small vessels but this fleet sector contributes only in a minor way to the fishery, relative to the large vessel fleet. In latter years, the large vessel catches appear to exceed the large vessel quotas because of quota transfers (Fig. 23); however, as illustrated in Figure 22 the total quotas for all fleets should be met in 2005.

During the late 1970's and throughout the 1980's, the fishery concentrated in four main areas: northern, eastern and southern Hopedale Channel and Cartwright Channel. Fishing continued in the traditional areas during the 1990's, however, more effort has since been reported from the slopes of the shelf, north and east of Cartwright Channel (Fig. 24). Since 1995, the seasonality of the fishery switched from a summer - fall to a winter - spring operation (Fig. 25). The area fished has generally been increasing throughout history of the fishery (Fig. 26).

Catch per unit effort (CPUE)

Annual CPUE data (single trawl, no windows, observer data for vessels >500 t) were analyzed by multiple regression with effort weighting for year, area, month and vessel effects (Table 14; Fig. 27A and B). Lack of data during the early years and filtering resulted in missing points during 1977-79, 1983, as well as 1986-88. The model accounts for approximately 82% of the variance in data. The scatter of residuals around parameter estimates is provided in Fig. 28. There were no trends in the residuals, for the most part they appear centered around the reference line and the inter-quartile boxes appear to be small indicating a relatively good fit between the model and the data. However, there are numerous outlying negative residuals indicating that there were lower than expected catches. A quick look at the data indicates that many of the outliers were associated with catches taken prior to 1995, by several vessels and in all of the study areas. Further work will have to be done to account for these negative outliers.

Standardized catch rates have been fluctuating above the long term mean since 1996 (Fig. 27B). The 1997-2004 catch rates were statistically similar ($P>0.05$) to 2005 ($P < 0.05$). A high cpue over a relatively broad area (Fig. 26) is an indication that the stock is healthy.

Stock Composition

Due to the overlap of modes, it was not possible to complete Mix analysis on the commercial length frequencies. Male and female length frequency distributions are broad indicating that each probably consists of more than one year class (Fig. 29). Catch rates have been maintained at more than 289,000 animals per hour. The within year frequency weighted average carapace lengths for males ranged between 17.96 mm and 19.01 mm, while the weighted average carapace lengths for females ranged between 22.37 mm and 23.57 mm. Size at sex change (L_{50}) has decreased from 23.41 mm in 1993 until 2002 when it was 20.34 mm. Since 2000, the size at sex change has fluctuated at a lower value with the 2001 value statistically similar to the 2005 value (Table 15; Fig 30).

Recruitment of males between approximately 16 and 22 mm was consistent from year to year and males contributed substantially to the catches throughout the time series. In 2000, the relatively strong 1997 year class appeared at 16 mm (age 3) and dominated the male distribution in 2001 at 18 mm (age 4). In 2002, many of these animals had changed into females, but some males are still seen at 20 mm. The relatively strong 1998 year class first appeared as males in 2001 at 16 mm (age 3). The 2002 male distribution is dominated by 16-20 mm animals that are probably from the 1997, 1998 and 1999 year classes (20 mm, 18 mm and 16 mm respectively). The 2000 and 2001 year-classes were of moderate strength but it was not possible to detect these year-classes in subsequent commercial length frequencies.

RESEARCH SURVEY DATA

Stock Size

The annual multi-species surveys were conducted in the northern part of SFA 5 (NAFO Div. 2H) between 1996 and 1999. Since then, SFA 5 was to be surveyed in its entirety during alternating years. However, the lower part of SFA 5 (Cartwright Channel) has been surveyed during all years since 1996. Trends in indices and biological characteristics from SFA 5 and Cartwright Channel were broadly consistent with at 77% of the variance accounted for in a linear regression between SFA 5 and Cartwright Channel biomass estimates (Table 16-17; Fig. 31-35). Therefore, indices from Cartwright Channel are used in this assessment as proxies for the entire of SFA 5.

However, there are several sources of uncertainty within the comparisons. For instance, confidence intervals around the 1996 survey estimates were wide due to two anomalously high catches. Therefore, usefulness of the results by area or for the total was limited. In 1997, the Hopedale Channel results were overestimated because shallow areas (<200 m) of the Nain Bank were not sampled and the Ogmap method interpolated shrimp catches from deeper water over a large area where densities are known to be lower. This could account for the fact that Hopedale estimates increased during 1997 while the Cartwright estimates decreased during the same year. The 1998, 1999, 2001 and 2004 survey indices showed similar trends. Biomass and abundance indices within Cartwright Channel decreased during 2002. Since Hopedale Channel was not surveyed in 2000, 2002, 2003 or 2005 no comparisons could be made between Cartwright and

Hopedale Channels. The autumn 2002, 2003, 2004 and 2005 surveys extended into January or February of the next year, increasing uncertainty of the estimates.

Biomass and abundance indices have increased since 1998 (Table 16; Fig. 33A, B and C). Biomass within Cartwright Channel increased from 43,300 t (9 billion animals) during 1998 to 141,300 t (29 billion animals) during 2005. The lower 95% confidence limit of the biomass estimates averaged 67,800 t (16 billion animals) over the period 2001-05.

Biomass within the entire of SFA 5 increased from 86,200 t (17 billion animals) during 1998 to 247,800 t (61 billion animals) during 2001 and then decreased to 183,000 t (39 billion animals) during 2005. The lower 95% confidence limit of the biomass estimates averaged 155,100 t (36 billion animals) over the period 2001 – 2005.

A comparison between Fig. 7-9, 15 and 16 with 24, 26, 31 and 32 illustrates that the distribution of animals is more widespread and evenly dispersed within SFA 6 than it is SFA 5. The fact that shrimp are highly concentrated in two main channels and along the shelf edge within SFA 5 helps account for the broad confidence limits around the research survey point estimates. The SFA 5 fishery takes place in areas of high research catches (Fig. 24, 31 and 32). The areal index used in tracking the fishery (number of cells accounting for 95% of the catch; Fig. 26) is lower within SFA 5 than in SFA 6, but this is probably more a function of habitat than an indicator of relative stock health. There is more suitable habitat within SFA 6 than there is in SFA 5 therefore the animals and hence the fishery is more dispersed within SFA 6.

Exploitation Rates

Table 18 presents the SFA 5 exploitation rate indices. If exploitation is determined as catch/lower 95% confidence limit of the biomass estimate then exploitation remained below 25% (Fig. 36). Regardless of the method used, the exploitation rate index has decreased in recent years even though catches have increased because the biomass indices have also increased. Since the catchability of the research trawl is thought to be less than 1, it is likely that the true exploitation rates are lower than indicated within Table 16 or Fig. 36. These exploitation rates are higher than those in SFA 6.

The 2001 estimates may not be comparable with estimates from other years because:

1) the survey in SFA 5 was in December rather than October;
2) the survey made use of the CCG Alfred Needler rather than the CCGTeleost and;
3) there were approximately 10 sets in the southeastern portion of 2H that were not surveyed.

Similarly, the 2002-05 estimates may not be comparable with estimates from other years because these surveys were finished a few months later than usual.

Stock Composition

Figure 37 and 38 provide a comparison between Cartwright Channel and SFA 5 length frequency distributions. Similarities can be seen between the two figures. Both figures have modes near 10, 13, 17.5 and 20 mm. The modes are in similar locations as the ages 1-4 modes within the Hawke Channel + 3K (SFA 6) distributions (Table 11; Fig. 20). However, it was not possible to obtain consistent results by running modal analysis on either the Cartwright Channel or the SFA 5 data therefore Mix 3.01A results are not presented here.

It is worth noting that the 10 and 13 mm modes, within all but the 2005 length frequencies, have very low amplitudes, providing evidence that these animals are low in abundance. However, there is a strong mode near 10 mm in the 2005 Cartwright Channel length frequency distribution (Fig. 37) indicating the presence of a stronger than average 2004 year class. This strong mode is similar to the age 1 mode found in the autumn 2005 Hawke Channel + 3K (SFA 6) (Fig. 20) and 2005 NAFO Div. 3LNO length frequencies (Orr et al. 2006). Thus this strong year-class appears over a broad area from Cartwright Channel to the nose of the Grand Banks providing a positive indication of medium term recruitment over at least three shrimp fishing areas.

Recruitment Index

Recruitment indices (age 2 abundance) were estimated as all males with 11.5-16.0 mm carapace lengths from the Cartwright Channel autumn 1996-2005 surveys (Fig. 39). Year-class strength increased from 1995-2001 and then decreased subsequently. The 1995-98 as well as 2002 and 2003 year -classes were below normal. Such a large number of year-classes are below normal due to the 2001 year-class index which is thought to be anomalously high.

RESOURCE STATUS

The issues of timing of the survey, change in ship, missing sets in the southeast and lack of a proven recruitment index force us to be cautious about the interpretation of the research survey results.

However, there has been a significant increase in research survey biomass/abundance estimates since 1998. Biomass within the entire of SFA 5 increased from 86,200 t (17 billion animals) during 1998 to 247,800 t (61 billion animals) during 2001 and then decreased to 183,000 t (39 billion animals) during 2005. The lower 95% confidence limit of the biomass estimates averaged 155,100 t (36 billion animals) over the period 2001-05.

The resource continues to be distributed over a broad area and exploitation rate indices have remained low; therefore, fishery related impacts could not be detected from either the logbook, observer or the research data. The fact that CPUE has remained above the long term average since 1996 and that the fishing fleets are able to take their quotas over broad geographic areas suggests that the stock is healthy. Lacking a complete survey and a proven recruitment index, prospects are uncertain.

ASSESSMENT OF SHRIMP IN NAFO DIVISION 2G (SFA 4)

FISHERY DATA

Catch and effort

Shrimp catches increased from 1,083 t in 1988 to 3842 t in 1989 and remained within the 2500-3000 t range up to and including 1993. In 1994 catches increased to 3982 t with an increase in TAC to 4000 t in the first year of the 1994-96 Management Plan. A second increase to 5200 t for 1995 and 1996 resulted in catches of about 5100 t in both years. The TAC of 5200 t was maintained for 1997 and catch was estimated at 5216 t.

The interim review of stock status in the winter of 1998 indicated that an increase in TAC could be considered. Lacking the basis on which to advise an appropriate level of TAC, an increase of 60% (3120 t) to 8320 t was chosen in the management process. Furthermore, 70% of the increase (2184 t) was applied to the area south of 60^0 N where very little fishing had occurred since 1990. Catches from 1998 to 2002 were estimated at approximately 7900-8500 t each year. In 2003, the quota increased to 10,320 t and included a 1125 t on allocation for northern shrimp science research. During that year, the fishing season changed to April 1-March 31, and an additional interim quota of 2802 t was set for the period January 1-March 31, 2004. Thus the 2003-04 fishing season was 15 months long and had a 13,122 t TAC. The 2003-04 fiscal year TAC (10,320 t) was maintained for the 2004-05 and 2005-06 seasons. Approximately 11,500 t were taken during the 2004 calendar year and it is anticipated that the 2005-06 quota will be taken (Table 2 and19; Fig. 40).

The fishery from 1988 to 1990 occurred throughout the Division which was split into two management zones, north and south of 60^0 N. The 1991-93 Management Plan combined the two zones and, up to 1997, effort concentrated primarily in the north (Fig. 41). Since 1997, more effort has been deployed south of 60^0 N because a separate quota was created for that area. By-catches of *P. montagui* were reported at some northwestern locations during the 1995-2005 period. Fishing occurs during the summer and autumn (Fig. 42).

The number of cells accounting for 95% of the commercial catch reflects changes in Management Plan. The number of cells increased during periods in which there was a separate quota for the southern portion of SFA 4. During 2000, the fishery was spread along the 500 m contour from northern to southern 2G. Since then fishing has been in the northeastern part of 2G and at the mouth of Saglek Channel with exploration along the shelf edge (Fig. 41 and 43).

The area accounting for 95% of the commercial catches is much smaller in SFA 4 than it was in either SFA 5 or 6 (Fig. 8, 26 and 43). There is a gradient of decreasing area of fished as one moves northward from SFA 6 - 4.

Catch per unit effort (CPUE)

The CPUE data were analyzed by multiple regression, weighted by effort, for year, month and vessel effects. The model accounts for 69% of the variation in the parameters and showed that the annual, standardized catch rates for
1991-93, 1998, 2002 and 2004 were similar (P>0.05) to the 2005 estimate. Model catch rates have increased from 1192 kg/hr in 1995 to 3381 kg/hr in 2001, but have since decreased to the long term average (Table 19 and 20; Fig. 44). Anecdotal information from the large vessel fleet indicates that the decrease in CPUE may be due to exploratory fishing along the shelf edge.

The scatter of residuals around the parameter estimates is provided in Fig. 45. There are no trends in the residuals, for the most part they appear centered around the reference line and the inter-quartile boxes appear to be small indicating a relatively good fit between the model and the data.

Size composition

Catch-at-length data for the 1996-2005 period showed variable size distributions between years (Fig. 46). Since 1992, the mean length of females and mean size at sex inversion has declined (Fig. 46 and 47; Table 21). However, decreases since 1998 are thought to reflect increased fishing in southern 2G where growth rates and maturity schedules resemble those seen in the Hopedale and Cartwright Channel areas.

Given the recent high and stable catch rates of primarily female shrimp in this area, it appears that a healthy spawning biomass is being maintained. The broad distribution of males and females throughout the time series suggests that the catches within each sex are composed of more than one year-class.

RESEARCH SURVEY DATA

Results of autumn 1996, 1997 and 1999 multi-species surveys for depths greater than 200 m showed that shrimp were widely distributed throughout Div. 2G each year (Parsons et al. 2000) (Table 22). The 1997 biomass estimate was 64,100 t (11 billion animals) which was similar to the 1999 biomass index (65,100 t; 11 billion animals) but higher than that obtained from the 1996 survey (42,400 t; 7 billion animals). However, there was low survey coverage during these years and a high degree of uncertainty in the estimates as reflected in the broad 95% confidence intervals creating uncertainty in this trend. During 1999, a decision was made to discontinue the DFO multi-species survey in 2G.

During July of 2005, the Northern Shrimp Research Foundation and DFO conducted the first of at least five consecutive surveys into 2G (Fig. 48). Using stratified analysis calculations (Cochran 1977), biomass was estimated to be 76,600 t (15 billion animals) (Table 23). Ninety-three percent of the shrimp, from the 2005 survey, were found along the shelf edge and at Okak Bank, in depths between 200 and 400 m.

There can not be a direct comparison between the 1996-99 multi-species survey and the 2005 NSRF-DFO survey because the former were completed during the early fall on the Teleost while the latter were completed during the summer on the Cape Ballard. However, both surveys made use of similar trawls, as well as fishing and sample processing protocols. It is hoped that the new NSRF-DFO survey can produce a long term series of indices from which reliable trends may be tracked.

Figure 49 provides the abundance at length for 2005 SFA 4 northern shrimp as estimated using stratified areal expansion calculations (Cochran 1977). There are no clear modes in the length frequencies, therefore it is impossible to reliably age the shrimp using modal analysis.

RESOURCE STATUS

The spawning stock appears healthy, as evidenced in continued high catch rates of large female shrimp; however, since 2001 catch rates have declined to the long term average. Anecdotal information provided by the large vessel industry indicates that the decline may be due to exploratory fishing along the shelf edge. Current status appears positive from fishery data however, prospects are unknown because the lack of a survey time series precludes evaluation of trends in stock size, exploitation and future recruitment.

ASSESSMENT OF SHRIMP IN NAFO DIVISION 0B (SFA 2)

FISHERY DATA

Catch and Effort

For the purposes of the assessment, the following analyses will pertain to the northern shrimp (*P. borealis*) fished in SFA 2 and those portions of SFA's 3 and 4 north of 60°30N and west of 63°00W.

Catches of *P. borealis* in Div. 0B increased from about 2800 t in 1988 to 3000 t in 1989 but subsequently declined to 100 t in 1993. The 1994, catch was less than 500 t; however, catches increased substantially to about 3600 and 3200 t in 1995 and 1996, respectively, and to more than 5000 t each year from 1997 to 1999.

Recent catches for the species have been estimated, in part, from the mixed fishery data for *P. borealis/ P. montagui* in the area east of Resolution Island but their accuracy is questionable. TAC's remained at 3500 t from 1989 to 1996 but were increased experimentally to 5250 t for 1997 and 1998. In 1999, an additional 3,500 t were provided for the area north of 63^0 N as an incentive for the offshore fleet to return to grounds not fished extensively since 1995. However, just over 100 t were taken within this area in 1999. In 2000, the additional 3,500 t was not included in the quota report, and accordingly the catch was not counted against the TAC for the south (5250 t). In 2001, the additional 3500 t was included in the quota report as an exploratory quota east of 63^oW. The 8750 t TAC has been maintained through to the 2005-06 management year. Annual catches until 2004-05 were between 4500 and 5600 t. It is anticipated that the 2005-06 quota will not be taken.

In the late 1980's, fishing effort was primarily concentrated between 64^0 and 65^0 N whereas, during the 1990 - 1994 period, proportionately more was distributed south of 64^0 N. The areas fished extensively in the southwest from 1995 to 2000 reflect the targeting of P. *borealis* and *P. montagui* concentrations east of Resolution Island. Most effort since 1996 occurred south of 63^0 N (Fig. 51). The fishery occurs mainly during the summer and autumn (Fig. 52).

The amount of area accounted for 95% of the catch has been fluctuating around the mean over the time series (Fig. 53). The index of area fished may be confounded because of the data reporting problems (both in terms of reporting catches against SFA quota and the mixture of *P. borealis* with *P. montagui*) and the frequent changes in quota. The distribution of shrimp appears to be patchy and as new patches of shrimp were discovered, the fishery changed both terms of area allocations and locations fished.

Catch per unit effort (CPUE)

The standardized CPUE model included year, month and vessel as predictive parameters and was limited to the June-December period. The model accounted for 75% of the variance in the data. Since 1996, catch rates have been fluctuating above the long term mean (Table 25, Fig. 54B). The 1998, 2000, 2001, 2003 and 2004 catch rates were statistically similar to the 2005 estimate ($P>0.05$). The pronounced increase in CPUE after 1994 is associated with the shift in fishing effort to the southwest.

There does not appear to be a trend in the plots of residuals versus class variables (Fig. 55).

Catch rates in this area may be confounded because of the data reporting problems (both in terms of reporting catches against SFA quota and the mixture of *P.* borealis with *P. montagui*) and the frequent changes in quota. As well, anecdotal information indicates that the large vessel fleet may be seeking areas in which the shrimp mixture is greater than 90% northern shrimp. The product has to be sold as striped shrimp if the mixture contains a high percentage of striped shrimp. Since northern shrimp are worth more than striped shrimp the large vessels may be fishing in areas where the catch rates are relatively low but the mixture of shrimp is more acceptable.

Size composition

Catches in most years were composed primarily of large, female shrimp (Fig. 56) with modal lengths between 24.81 and 26.52 mm CL. As seen in the southern areas, the broad distribution of males and females indicates that both sexes are composed of more than one year class.

The mean size at sex change declined since 1995 with the 1999 and 2002-04 values similar to the 2005 size at sex change (Table 26; Fig. 57).

RESEARCH SURVEY DATA

Stock size

This was the first of five consecutive NSRF-DFO joint surveys into 0B. It was the first survey in that area since 1989 when the Gadus Atlantica trip 170 made 13 tows off Baffin Island. Therefore, there are no previous survey data for comparison. One hundred and forty five successful tows were made in 0B. The total biomass was estimated at 52,981 t (6 billion animals); however, the 95% confidence intervals were broad with a negative lower confidence limit. The broad confidence limits were due to the presence of one anomalously high catch in stratum 86 (348 kg). Most of the northern shrimp biomass was found in the 200-400 m depths with a lesser amount in 400-500 m depths (Table 27; Fig. 58)

Figure 59 provides the abundance at length for 2005 SFA 2 northern shrimp as estimated using stratified areal expansion calculations (Cochran 1977). There are no clear modes in the length frequencies; therefore, it is impossible to reliably age the shrimp using modal analysis.

RESOURCE STATUS

Although shrimp concentrations in the northeast are elusive, as evidenced by the low catches in recent years, from the area north of 63^0 N, those adjacent to eastern Resolution Island have persisted since first fished in 1995.

This was the first year of five consecutive annual NSRF-DFO surveys into 0B. Once there is a time series of biomass and abundance estimates it will be possible to discuss survey trends.

The commercial CPUE has been relatively stable at a high level since 1998 but may not be representative of stock conditions. Catch rates in this area may be confounded because of the data reporting problems (both in terms of reporting catches against SFA quota and the mixture of *P.borealis* with *P. montagui*) and the frequent changes in quota. As well, anecdotal information indicates that the large vessel fleet may be seeking areas in which the shrimp mixture is greater than 90% northern shrimp. The product has to be sold as striped shrimp if the mixture contains a high percentage of striped shrimp. Since northern shrimp are worth more than striped shrimp the large vessels may be fishing in areas where the catch rates are relatively low but the mixture of shrimp is more acceptable.

The index of area fished may also be confounded by the elusive nature of the stocks. Patches of shrimp may be present, however, the fishing crews may not always find them. If a crew can fill their quota in a patch, there may not be an incentive to search for other patches. While the current status appears positive from fishery data, future prospects are unknown.

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Table 1. Total Allowable Catch (TAC) history for northern shrimp (*Pandalus borealis*) fished within Davis Strait, along the eastern coasts of Newfoundland and Labrador, and within the NAFO Division 3L Canadian Exclusive Economic Zone (EEZ), 1978-2005.

YEAR	DIV0A-N	DIV0A	DIV0B	HS/UB*	DIV2G	HOPE	CART	HAWKE	DIV3K	DIV3L	TOTAL
	SFA0	SFA1	SFA2	SFA3	SFA4	SFA5		SFA6		SFA7	
1978	-	1,000		100	500	4,500	800	800	500		8,200
1979	-	2,000		100	500	3,200	800	1,750	500		8,850
1980	-	2,500		200	500	4,000	800	850	500		9,350
1981	-	5,000		200	500	4,000	800	850	500		11,850
1982	-	5,000		200	500	4,000	800	850	500		11,850
1983	-	5,000		850	500	4,000	800	850	500		12,500
1984		5,000		850	500	3,500	700	850	500		11,900
1985		6,120		850	500	2,800	770	850	500		12,390
1986		6,120		850	500	3,400	1,000	850	1,200		13,920
1987		6,120		1,200	500	4,000	800	1,500	1,500		15,620
1988		6,120		1,200	500	4,000	800	1,500	1,500		15,620
1989		7,520	3,500	1,200	2,580	4,400	1,600	2,000	3,600		26,400
1990		7,520	3,500	1,200	2,580	4,400	1,600	2,000	3,600		26,400
1991		8,500	3,485	1,190	2,635	4,760	1,615	2,210	2,091		26,486
1992		8,500	3,485	1,190	2,635	4,760	1,615	3,910	3,655		29,750
1993	300	8,500	3,485	1,190	2,735	4,760	1,615	3,846	5,334		31,765
1994	500	8,500	3,500	1,200	4,000	7,650		11,050			36,400
1995	500	8,500	3,500	1,200	5,200	7,650		11,050			37,600
1996	500	8,500	3,500	3,800	5,200	7,650		11,050			40,200
1997	500	8,500	5,250	3,800	5,200	15,300		23,100			61,650
1998	500	7,650	5,250	3,800	8,320	15,300		46,200			87,020
1999	500	9,350	8,750	3,800	8,320	15,300		58,632			104,652
2000	500	9,350	5,250	3,800	8,320	15,300		61,632		4,191	108,343
2001	500	12,040	8,750	3,800	8,320	15,300		61,632		5,000	115,342
2002	500	12,040	8,750	6,300	8,320	15,300		61,632		5,000	117,842
2003	500	14,167	8,750	6,300	13,122**	33,084**		85,585**		10,833	172,341
2004	500	14,167	8,750	6,300	10,320	23,300		77,932		10,833	152,102
2005	500	18,417	8,750	6,300	10,320	23,300		78,044		10,833	156,464
2006	500	18,417	8,726	6,300***	10,238	23,300		77,417		18,333	163,231

* HS/UB = *P. montagui*
Between 1996 and 2001 there has been a 1200 t quota but a 3800 t catch limit for *P. montagui* in SFA 3.
During 2002 the SFA 3 *P. montagui* catch limit was increased to 6300 t.

** The offshore licence holders requested that their quotas starting in 2003 run from April 1 - May 31 rather than January 1 - December 31, therefore the increased quotas for 2003 reflect the amount of shrimp that would have been caught under the Dec. - Jan schedule.
Please note that the change in timetable only affects SFAs 2, 3, 4, 5 & 6.
SFAs 1 and 7 are still on the Jan 1 - Dec. 31 timetable.

*** In 2006 a 400 t *P. borealis* bycatch limit was set within the SFA 3 *P. montagui* fishery.

Table 2. Nominal catches (t) of northern shrimp (*Pandalus borealis*) over the period 1977-2005.

YEAR	DIV0A	DIV0B	HS/UB*	DIV2G	HOPE	CART	HAWKE	DIV3K	DIV3M	DIV3L	TOTAL
	SFA1	SFA2	SFA3	SFA4	SFA5		SFA6		SFA7	SFA7	
1977	-	-	-	-	1,272	1,414	<1	<1	-	-	2,686
1978	-	-	-	-	2,109	1,521	-	-	-	-	3,630
1979	1,732	-	92	3	2,693	1,034	5	-	-	-	5,559
1980	2,726	-	236	<1	3,938	170	-	-	-	-	7,070
1981	5,284	-	13	2	3,382	67	135	-	-	-	8,883
1982	2,064	-	-	5	1,829	154	<1	-	-	-	4,052
1983	5,413	-	-	30	997	3	-	-	-	-	6,443
1984	2,142	-	-	-	712	290	-	-	-	-	3,144
1985	3,069	-	-	-	1,687	2	-	-	-	-	4,758
1986	2,995	-	476	2	3,498	1,328	-	-	-	-	8,299
1987	6,095	-	1,069	7	4,538	1,418	1,678	167	-	-	14,972
1988	5,881	2,826	1,125	1,083	6,584	1,254	3,747	4,102	-	-	26,602
1989	7,235	3,039	1,269	3,842	4,329	1,656	1,855	4,807	-	-	28,032
1990	6,177	1,609	164	2,945	3,769	1,591	1,929	3,669	-	-	21,853
1991	6,788	1,107	605	2,561	4,501	1,617	1,976	3,524	-	-	22,679
1992	7,493	1,291	-	2,706	4,680	1,635	3,015	3,594	-	-	24,414
1993	5,491	106	-	2,723	4,273	1,446	3,672	4,363	3,724	-	25,798
1994	4,766	476	244	3,982		7,499		10,978	1,041	-	28,986
1995	2,361	3,564	245	5,104		7,616		10,914	970	-	30,774
1996	2,632	3,220	-	5,160		7,383		10,923	906	-	30,224
1997	517	5,235	-	5,217		15,103		21,246	785	-	48,103
1998	933	5,163	2,703	8,051		15,170		46,337	484	82	78,923
1999	2,046	5,132	3,714	7,884		15,109		51,202	477	78	85,642
2000	1,588	4,261	2,941	8,048		14,645		63,175	540	4,229	99,427
2001	3,625	6,023	3,751	7,991		15,036		52,554	295	4,876	94,151
2002	6,247	5,597	3,369	8,516		15,180		60,198	8	5,316	104,431
2003	6,654	4,584	754	10,021		16,534		60,150	0	10,612	109,309
2004	6,721	4,538	2,819	11,489		26,863		72,605	0	10,613	135,649
2005	8,013	6,651	2,615	8,063		23,417		77,583	0	11,184	137,528

*HS/UB = *P. montagui*

** In 2003, the offshore licence holders were allowed to change their quota period from January 1 – December 31 to April 1 – March 31.
This table and the following chart track catches and quotas according to a calendar year because the resource is assessed from January - December allowing time for data analysis, RAP, development of a management plan and consultations prior to the fiscal year.
Catches since 2003 have been converted to calendar year catches for consistency.

Table 3. Northern shrimp (*Pandalus borealis*) large vessel (>500 t) catches and quotas for Hawke Channel + 3K (SFA 6), 1977-2005.

YEAR	TAC [1] (t)	FLEET CATCH [2] (t)	UNSTANDARDIZED CPUE (KG/HR)	CPUE INDEX	EFFORT [3] (HR)	STANDARDIZED RELATIVE CPUE	MODELLED CPUE	EFFORT (HRS)
1977		1						
1978	1,300							
1979	2,250	5						
1980	1,350							
1981	1,350	135						
1982	1,350	1						
1983	1,350							
1984	1,350							
1985	1,350							
1986	2,050							
1987	3,000	1,845						
1988	3,000	7,849						
1989	5,600	6,662	869	0.40	7,665	0.62	918	7,259
1990	5,600	5,598	699	0.32	8,003	0.49	720	7,775
1991	4,301	5,500	467	0.21	11,774	0.36	540	10,185
1992	7,565	6,609	578	0.26	11,440	0.36	539	12,252
1993	9,180	8,035	931	0.42	8,632	0.49	732	10,979
1994	11,050	10,978	1,440	0.66	7,621	0.67	992	11,068
1995	11,050	10,914	1,836	0.84	5,946	0.90	1,340	8,144
1996	11,050	10,923	1,977	0.90	5,526	0.95	1,406	7,767
1997	15,335	14,954	1,905	0.87	7,852	1.17	1,736	8,615
1998	16,360	16,264	1,709	0.78	9,517	1.01	1,493	10,895
1999	17,603	17,587	1,774	0.81	9,915	0.98	1,458	12,065
2000	19,387	20,615	2,048	0.93	10,065	1.14	1,691	12,191
2001	20,103	19,894	2,120	0.97	9,383	1.12	1,655	12,021
2002	20,103	20,233	1,646	0.75	12,291	0.96	1,425	14,202
2003	33,276	29,371	2,040	0.93	14,395	0.93	1,376	21,338
2004	25,333	24,460	1,924	0.88	12,711	0.89	1,321	18,510
2005	25,595	25,476	2,191	1.00	11,627	1.00	1,482	17,187

[1]

HISTORICAL TAC'S APPLIED AS FOLLOWS:

1978 TO 1985 - INCLUDES 500 TON EXPLORATORY TAC FOR DIVISION 3K;

1986 TO 1988 - HAWKE CHANNEL, ST. ANTHONY BASIN;

1989 TO 1991 - HAWKE CHANNEL, ST. ANTHONY BASIN, EAST ST. ANTHONY AND FUNK ISLAND DEEP;

1992 - INCLUDES 1700 TONS EXPLORATORY;

1993 - INCLUDES 3400 TONS EXPLORATORY;

1994 - 1999 - ALL AREAS COMBINED.

TAC'S FROM 1987 TO 1990, INCLUSIVE, ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN.1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31).

TAC'S AFTER 1996 MAY INCLUDE TRANSFERS OF QUOTA FROM OTHER SECTORS.

2003 VALUES REFLECT ROLL-OVER FOR THE NEW REPORTING YEAR WHICH WILL BE FROM JAN 1 - Dec. 31 TO APR. 1 - MAR. 31.

THE SFA 6 ROLL-OVER OF QUOTAS AMOUNTED TO 7,653.4 T FOR THE 2003 - 2004 SEASON ONLY.

[2] **Since 2003, catches have been converted to calendar year catches.**

CATCH (TONS) IN CALENDAR YEAR AS REPORTED IN LOG BOOKS FOR 1977, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1978 TO 1989 AND YEAR-END QUOTA REPORTS, THEREAFTER.

2002 - PRESENT CATCHES FROM THE OBSERVER DATASET.

[3]

EFFORT CALCULATED (CATCH/CPUE) FROM LARGE VESSEL OBSERVER DATA, SINGLE TRAWL, NO WINDOWS.

CATCHES SINCE 2003 HAVE BEEN CONVERTED TO CALENDAR YEAR CATCHES FOR CONSISTENCY.

Table 4. Northern shrimp (*Pandalus borealis*) small vessel (<500 t; <100' LOA) catches and quotas for Hawke Channel + 3K (SFA 6), 1997-2005.

YEAR	TAC[1] (t)	FLEET CATCH[2] (t)	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE INDEX	EFFORT[3] (HR)	STANDARDIZED RELATIVE CPUE	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1997	7,765	6,064						
1998	29,840	30,073	361	0.64	83,279	0.67	329	91,290
1999	41,029	33,673	355	0.63	94,923	0.66	328	102,507
2000	41,529	42,560	415	0.73	102,433	0.74	365	116,728
2001	41,529	32,660	399	0.71	81,846	0.77	380	85,856
2002	41,529	39,679	347	0.61	114,280	0.68	334	118,967
2003	52,299	41,856	386	0.68	108,531	0.70	347	120,769
2004	52,599	53,316	560	0.99	95,280	0.95	467	114,200
2005	52,599	49,654	566	1.00	87,772	1.00	495	100,394

[1] TAC'S FOR SMALL VESSEL FISHERY BEGAN IN 1997 - ALL AREAS COMBINED

[2] THE NORTHERN SHRIMP CATCHES FROM YEAR-END QUOTA REPORTS.

[3] EFFORT CALCULATED (CATCH/ CPUE) FROM SMALL VESSEL (<500 t; <100') LOGBOOK DATA.

Table 5. Multiplicative year, month and vessel CPUE model for large vessels (>500 t) fishing shrimp in Hawke Channel + 3K, 1989-2005, weighted by effort (single trawl, no windows, observer data).

The GLM Procedure

Class Level Information

Class	Levels	Values
year	17	1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
CFV	16	
month	12	1 2 4 5 6 7 8 9 10 11 12 13

Number of Observations Read 708
Number of Observations Used 708

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	42	16941.95872	403.37997	49.37	<.0001
Error	665	5433.11408	8.17010		
Corrected Total	707	22375.07280			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.757180	38.73497	2.858338	7.379218

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	16	6024.902703	376.556419	46.09	<.0001
CFV	15	6296.512373	419.767492	51.38	<.0001
month	11	4620.543641	420.049422	51.41	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	16	3631.256866	226.953554	27.78	<.0001
CFV	15	3847.779489	256.518633	31.40	<.0001
month	11	4620.543641	420.049422	51.41	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		7.877847250	B	0.05658910	139.21	<.0001
year	1989	-0.479421493	B	0.16007953	-2.99	0.0028
year	1990	-0.722149560	B	0.16232977	-4.45	<.0001
year	1991	-1.009772349	B	0.10682980	-9.45	<.0001
year	1992	-1.010813289	B	0.11125664	-9.09	<.0001
year	1993	-0.705795827	B	0.07749336	-9.11	<.0001
year	1994	-0.401762536	B	0.05644929	-7.12	<.0001
year	1995	-0.100889819	B	0.06038251	-1.67	0.0952
year	1996	-0.052564570	B	0.06219361	-0.85	0.3983
year	1997	0.157924405	B	0.06074679	2.60	0.0095
year	1998	0.007086530	B	0.05590328	0.13	0.8992
year	1999	-0.016782212	B	0.05542624	-0.30	0.7621
year	2000	0.131689264	B	0.05416486	2.43	0.0153
year	2001	0.110146846	B	0.05544774	1.99	0.0474
year	2002	-0.039680470	B	0.05409192	-0.73	0.4635
year	2003	-0.074089419	B	0.05762427	-1.29	0.1990
year	2004	-0.114856511	B	0.06055046	-1.90	0.0583
year	2005	0.000000000	B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
1989	6.821930	6.519871	7.123989
1990	6.579202	6.272950	6.885453
1991	6.291579	6.100115	6.483042
1992	6.290538	6.089765	6.491311
1993	6.595555	6.465968	6.725143
1994	6.899589	6.822480	6.976698
1995	7.200461	7.113674	7.287248
1996	7.248787	7.156549	7.341024
1997	7.459276	7.380150	7.538401
1998	7.308438	7.240345	7.376530
1999	7.284569	7.218336	7.350802
2000	7.433040	7.370067	7.496014
2001	7.411498	7.342841	7.480155
2002	7.261671	7.195014	7.328328
2003	7.227262	7.145447	7.309076
2004	7.186495	7.097237	7.275752
2005	7.301351	7.213998	7.388704

Table 6. Multiplicative year, month, vessel size and area CPUE model for small vessels (<500 t; LOA<=100') fishing shrimp in Hawke Channel + 3K, 1998-2005, weighted by effort (single trawl logbook data).

The GLM Procedure
Class Level Information

Class	Levels	Values
Year	8	1998 1999 2000 2001 2002 2003 2004 2005
Month	6	5 7 8 9 10 99
Area	6	67 68 80 90 92 100
size_class	3	1 2 3
year	8	1998 1999 2000 2001 2002 2003 2004 2005
month	6	6 5 7 8 9 10 standardization against June
area	6	67 68 69 80 90 92 standardized against area 69
size_class	3	1 2 3

Number of Observations Read 664
Number of Observations Used 663

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	19	20477.15278	1077.74488	67.89	<.0001
Error	643	10207.20381	15.87434		
Corrected Total	662	30684.35659			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.667348	66.47513	3.984262	5.993614

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	7	12560.85036	1794.40719	113.04	<.0001
month	5	441.42473	88.28495	5.56	<.0001
area	5	6210.68863	1242.13773	78.25	<.0001
size_class	2	1264.18907	632.09453	39.82	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	7	6997.056357	999.579480	62.97	<.0001
month	5	1690.866161	338.173232	21.30	<.0001
area	5	6051.528877	1210.305775	76.24	<.0001
size_class	2	1264.189066	632.094533	39.82	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		6.399023587	B	0.02755924	232.19	<.0001
Year	1998	-0.407025962	B	0.02933370	-13.88	<.0001
Year	1999	-0.410324110	B	0.02778303	-14.77	<.0001
Year	2000	-0.298791398	B	0.02735607	-10.92	<.0001
Year	2001	-0.259907032	B	0.02932670	-8.86	<.0001
Year	2002	-0.403799800	B	0.02720322	-14.84	<.0001
Year	2003	-0.349034935	B	0.02730021	-12.79	<.0001
Year	2004	-0.061737979	B	0.02745955	-2.25	0.0249
Year	2005	0.000000000	B	.	.	.

year	LSMEAN	lncpue 95% Confidence Limits	
1998	5.801368	5.762147	5.840588
1999	5.798069	5.761724	5.834415
2000	5.909602	5.872657	5.946548
2001	5.948486	5.908748	5.988225
2002	5.804594	5.769501	5.839686
2003	5.859359	5.823084	5.895633
2004	6.146656	6.105310	6.188001
2005	6.208393	6.162745	6.254042

Table 7. Probit analysis of the 1991-2005 observed large vessel (>500 t) length frequency data to determine the size at sex transition for northern shrimp (*Pandalus borealis*) within Hawke Channel + 3K (SFA 6). In order to reduce the influence of seasonality, the analyses were restricted to data collected within the period January-March of each year. (L_{50} refers to the carapace length at sex change).

The GENMOD Procedure
Model Information

Data Set	WORK.ALL_SHRIMP
Distribution	Binomial
Link Function	Logit
Response Variable (Events)	female_lt
Response Variable (Trials)	total

Number of Observations Read	654
Number of Observations Used	654
Number of Events	658393
Number of Trials	1094847

Class Level Information

Class	Levels	Values
year	15	1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

Parameter Information

Parameter	Effect	year
Prm1	Intercept	
Prm2	length	
Prm3	year	1991
Prm4	year	1992
Prm5	year	1993
Prm6	year	1994
Prm7	year	1995
Prm8	year	1996
Prm9	year	1997
Prm10	year	1998
Prm11	year	1999
Prm12	year	2000
Prm13	year	2001
Prm14	year	2002
Prm15	year	2003
Prm16	year	2004
Prm17	year	2005

The GENMOD Procedure
Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	638	6779.0632	10.6255
Scaled Deviance	638	638.0000	1.0000
Pearson Chi-Square	638	508746.3631	797.4081
Scaled Pearson X2	638	47879.7986	75.0467
Log Likelihood		-24297.7571	

Table 7 (Cont'd.)

Algorithm converged.
Analysis Of Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-31.0118	0.2167	-31.4365	-30.5870	20475.6	<.0001
length	1	1.5286	0.0104	1.5082	1.5489	21627.8	<.0001
year 1991	1	-1.8193	0.0572	-1.9314	-1.7072	1011.44	<.0001
year 1992	1	-1.5648	0.0585	-1.6794	-1.4502	716.10	<.0001
year 1993	1	-2.5989	0.0609	-2.7183	-2.4796	1820.40	<.0001
year 1994	1	-1.5057	0.0753	-1.6533	-1.3581	399.53	<.0001
year 1995	1	-0.9973	0.0836	-1.1612	-0.8334	142.26	<.0001
year 1996	1	-2.0067	0.0551	-2.1147	-1.8987	1325.56	<.0001
year 1997	1	-1.4091	0.0569	-1.5206	-1.2977	614.19	<.0001
year 1998	1	-0.9147	0.0572	-1.0267	-0.8026	256.13	<.0001
year 1999	1	0.2514	0.0567	0.1403	0.3624	19.68	<.0001
year 2000	1	-1.1234	0.0493	-1.2200	-1.0268	519.32	<.0001
year 2001	1	-0.1700	0.0557	-0.2793	-0.0608	9.31	0.0023
year 2002	1	0.4739	0.0600	0.3563	0.5915	62.38	<.0001
year 2003	1	-0.0369	0.0974	-0.2277	0.1540	0.14	0.7049
year 2004	1	0.4996	0.0516	0.3984	0.6008	93.60	<.0001
year 2005	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale	0	3.2597	0.0000	3.2597	3.2597		

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

LR Statistics For Type 1 Analysis

Source	Deviance	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
Intercept	962905.018						
length	72512.6932	1	638	83797.8	<.0001	83797.8	<.0001
year	6779.0632	14	638	441.89	<.0001	6186.41	<.0001

The GENMOD Procedure
Least Squares Means

Effect	year	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq
year	1991	-2.7213	0.0487	1	3124.0	<.0001
year	1992	-2.4668	0.0502	1	2418.4	<.0001
year	1993	-3.5010	0.0541	1	4192.6	<.0001
year	1994	-2.4077	0.0687	1	1229.1	<.0001
year	1995	-1.8993	0.0772	1	605.05	<.0001
year	1996	-2.9087	0.0462	1	3957.8	<.0001
year	1997	-2.3111	0.0481	1	2310.5	<.0001
year	1998	-1.8167	0.0475	1	1463.7	<.0001
year	1999	-0.6506	0.0454	1	205.08	<.0001
year	2000	-2.0254	0.0378	1	2866.6	<.0001
year	2001	-1.0721	0.0452	1	561.88	<.0001
year	2002	-0.4281	0.0490	1	76.42	<.0001
year	2003	-0.9389	0.0913	1	105.84	<.0001
year	2004	-0.4025	0.0382	1	110.94	<.0001
year	2005	-0.9020	0.0359	1	630.78	<.0001

Obs	year	sfa	Probability	L_{50} carapace lt	LowerCL	UpperCL
1	1991	6	0.50	21.4807	21.4631	21.4982
2	1992	6	0.50	21.3890	21.3720	21.4059
3	1993	6	0.50	21.9894	21.9703	22.0085
4	1994	6	0.50	21.2616	21.2342	21.2887
5	1995	6	0.50	20.9632	20.9354	20.9909
6	1996	6	0.50	21.6197	21.6047	21.6346
7	1997	6	0.50	21.1517	21.1319	21.1714
8	1998	6	0.50	20.8851	20.8669	20.9033
9	1999	6	0.50	20.0482	20.0271	20.0691
10	2000	6	0.50	21.0280	21.0144	21.0415
11	2001	6	0.50	20.3730	20.3535	20.3922
12	2002	6	0.50	19.9598	19.9394	19.9802
13	2003	6	0.50	20.3366	20.3052	20.3677
14	2004	6	0.50	19.9806	19.9664	19.9947
15	2005	6	0.50	20.2685	20.2538	20.2831

Table 8. Northern shrimp stock size estimates within Hawke Channel + 3K (SFA 6)[1] determined from annual Canadian autumn multi-species bottom trawl surveys, 1995-2005. All estimates were determined using OGive MAPping. (Offshore strata only; standard 15 min. tows)

Year	Biomass (t)			Abundance (numbers x 10^{-6})			Survey
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1995	232,100	291,700	389,100	59,320	71,184	88,490	195
1996	413,100	499,600	583,300	98,220	115,013	132,100	238
1997	362,100	424,900	467,600	82,940	95,246	104,200	232
1998	404,200	459,500	506,500	95,300	107,722	119,900	234
1999	458,000	521,100	590,400	110,800	124,745	142,000	233
2000	503,700	576,700	645,000	122,500	137,772	151,900	241
2001	566,400	654,100	762,500	141,600	160,370	182,000	252
2002	536,700	609,400	661,400	133,200	147,665	160,000	253
2003	506,700	599,900	665,800	131,300	149,205	165,400	236
2004	594,600	655,100	742,600	129,700	143,809	163,500	214
2005	600,600	691,500	789,900	134,000	150,334	169,800	242

[1] **Area compared each year = 171,048.5 sq. km.**

Table 9. Male and female northern shrimp (*Pandalus borealis*) biomass and abundance estimates within Hawke Channel + 3K (SFA 6)[1] determined from annual Canadian autumn multi-species bottom trawl surveys, 1995-2005. All estimates were determined using OGive MAPping. (Offshore strata only; standard 15 min. tows).

Year	Biomass (t)			Abundance (numbers x 10^{-6})		
	Males	Females	Total	Males	Females	Total
1995	141,700	150,000	291,700	52,544	18,638	71,182
1996	292,800	206,800	499,600	90,685	24,326	115,011
1997	243,200	181,700	424,900	73,296	21,950	95,246
1998	246,500	213,000	459,500	77,507	30,215	107,722
1999	261,700	259,400	521,100	89,744	35,001	124,745
2000	278,400	298,400	576,800	97,235	40,537	137,772
2001	301,400	352,700	654,100	108,825	51,544	160,369
2002	258,900	350,500	609,400	94,372	53,293	147,665
2003	277,500	322,400	599,900	99,722	49,483	149,205
2004	277,000	378,100	655,100	89,730	54,080	143,810
2005	287,600	403,900	691,500	95,377	54,957	150,334

[1] **Area compared each year = 171,048.5 sq. km.**

Table 10. Exploitation rate indices for northern shrimp (*Pandalus borealis*) harvested from Hawke Channel + 3K (SFA 6) as determined using survey and total catch data over the period 1996-2005. Catches since 2003 have been converted to calendar year catches.

	catch (large+ small vessel) (t)	lower CL of total biomass (t)	ssb (t)	fishable biomass (t) all shrimp >17 mm cl
1995		232,100	150,000	218,194
1996	10,923	413,100	206,800	394,069
1997	21,246	362,100	181,700	369,254
1998	46,337	404,200	213,000	417,231
1999	51,202	458,000	259,400	458,290
2000	63,175	503,700	298,400	514,574
2001	52,554	566,400	352,700	578,732
2002	60,198	536,700	350,500	539,925
2003	71,227	506,700	322,400	534,079
2004	77,776	594,600	378,100	563,161
2005	75,129	600,600	403,900	630,349

	catch/ lower 95% confidence limit of the biomass index	catch/ ssb	Catch/ fishable biomass
1996	4.71	7.28	5.01
1997	5.14	10.27	5.39
1998	12.80	25.50	12.55
1999	12.67	24.04	12.27
2000	13.79	24.35	13.78
2001	10.43	17.61	10.21
2002	10.63	17.07	10.40
2003	13.27	20.32	13.19
2004	15.35	24.12	14.56
2005	12.64	19.87	13.34

Table 11. Modal analysis using Mix 3.01 (MacDonald and Pitcher, 1993) of *Pandalus borealis* in Hawke Channel + 3K (SFA 6), from autumn multi-species bottom trawl surveys.

Mean Carapace Length (Standard Error)

	Age				
Year	1	2	3	4	5
1995	10.19 (.023)	14.74 (.024)	18.14 (.166)	19.95 (.194)	
1996	9.62 (.013)	14.70 (.014)	17.17(.022)	20.06(.020	
1997	9.72 (.015)	14.27 (.015)	17.52 (.021)	19.64 (.019)	
1998	10.11 (.013)	14.07 (.026)	16.77 (.018)	19.53 (.009)	
1999	10.26 (.012)	14.94 (.009)	18.01 (.009)	20.13 (.013)	
2000	9.82 (.015)	14.31 (.028)	17.58 (.019)	20.17 (.034)	
2001	9.54 (.044)	13.79 (.169)	16.54 (.084)	19.18 (.067)	
2002	10.06 (.018)	14.33 (.026)	16.88 (.023)	19.15 (.020)	
2003	10.36 (.017)	14.31 (.018)	17.14 (.042)	19.20 (.020)	
2004	10.79 (.035)	14.93 (.025)	17.44 (.047)	19.56 (.033)	
2005	10.35 (.013)	14.74 (.012)	17.67 (.040)	20.00 (.078)	

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

	Age					
Year	1	2	3	4	5	Total
1995	.121 (.002)	.585 (.009)	.162 (.033)	0.132 (.033)		1.000
1996	.036(.000	.320 (.004)	.403 (.003)	.241 (.003)		1.000
1997	.025 (.006)	.235 (.002)	.417 (.005)	.323 (.005)		1.000
1998	.117 (.001)	.107 (.002)	.293 (.002)	.483 (.003)		1.000
1999	.103 (.001)	.385 (.002)	.209 (.003)	.303 (.004)		1.000
2000	.075 (.001)	.321 (.005)	.357 (.010)	.247 (007)		1.000
2001	.022 (.001)	.290 (.037)	.296 (.058)	.392 (.025)		1.000
2002	.073 (.001)	.186 (.003)	.447 (.004)	.294 (.005)		1.000
2003	.091 (.001)	.285 (.003)	.244 (.006)	.380 (.006)		1.000
2004	.035 (.008)	.362 (.006)	.351 (.067)	.252 (.007)		1.000
2005	.155 (.002)	.187 (.016)	.409 (.032)	.249 (.020)		1.000

Distributional Sigmas (Standard Error and constraints)

	Age				
Year	1	2	3	4	5
1995	1.03 (.016)	1.35 (.022)	.97 (0.123)	.950 (.058)	
1996	.691 (.038) CV = .072	1.057 (.038) CV = .072	1.234 (.038) CV = .072	1.442 (.038) CV = .072	
1997	1.137 (.007 Eq)	1.137 (.007 Eq)	1.137 (.007 Eq)	1.137 (.007 Eq)	
1998	1.06 (.005 Eq)	1.06 (.005 Eq)	1.06 (.005 Eq)	1.06 (.005 Eq)	
1999	1.048 (.004 Eq)	1.048 (.004 Eq)	1.048 (.004 Eq)	1.048 (.004 Eq)	
2000	.840 (.011)	1.343 (.022)	0.990 (.024)	1.058 (.016)	
2001	.824 (.026)	1.383 (.073)	1.263 (.145)	1.181 (.022)	
2002	1.178 (.008 Eq)	1.178 (.008 Eq)	1.178 (.008 Eq)	1.178 (.008 Eq)	
2003	1.187 (.007 Eq)	1.187 (.007 Eq)	1.187 (.007 Eq)	1.187 (.007 Eq)	
2004	1.268 (.011 Eq)	1.268 (.011 Eq)	1.268 (.011 Eq)	1.268 (.011 Eq)	
2005	.942 (.009)	1.359 (.073)	1.112 (.055)	1.081 (.026)	

Table 11. (Cont'd.)

Population at Age Estimates (000,000's)

	Male Ages						Female	Total
Year	0	1	2	3	4	5		
1995	2	7,463	31,726	8,165	5,152	0	18,632	71,140
1996	88	3,414	35,239	34,707	17,706	9	23,859	115,023
1997	45	2,405	20,300	32,248	18,377	0	21,911	95,286
1998	8	9,759	10,195	25,396	32,166	5	30,210	107,739
1999	1	10,298	37,261	19,937	22,250	2	35,006	124,755
2000	0	8,295	35,164	34,801	18,969	11	40,529	137,769
2001	12	3,171	36,487	33,243	35,896	32	51,539	160,380
2002	9	7,937	21,900	43,072	21,454	0	53,299	147,670
2003	72	10,760	31,128	25,587	31,314	11	48,049	146,921
2004	41	4,130	37,543	30,320	17,650	28	54,414	144,126
2005	37	15,906	21,266	40,105	18,057	3	54,957	150,332

Table 12. Determination of survival, annual mortality and instantaneous mortality rates of northern shrimp (*Pandalus borealis*) within Hawke Channel + 3K (SFA 6). Survival and mortality rates made use of values averaged over three years to account for vagaries within the survey and due to aging by modal analysis. In other words the survival rate (red) was determined as the total number of age 4 + males and all females from 1995 to 1997 (green) that survived through the years 1996-98 as females (yellow). Overall average survival, annual mortality and instantaneous mortality rates were: 22, .78 and 1.49 respectively.

Year	Age 4 + males and total female abundance (millions) (year)	Age 5 and total females abundance (millions) (year+1)	Survival Rate ($S = e^{-Z}$)	Annual mortality rate ($A = 1- e^{-Z}$)	Instantaneous mortality rate (Z = fishing mortality + natural mortality)
1995	23,784	18,632			
1996	41,574	23,868			
1997	40,288	21,911	0.207400186	0.792599814	1.573105089
1998	62,381	30,215	0.209472903	0.790527097	1.563160888
1999	57,258	35,008	0.218899873	0.781100127	1.519140854
2000	59,509	40,540	0.226293344	0.773706656	1.485923139
2001	87,467	51,571	0.252509376	0.747490624	1.376306896
2002	74,753	53,299	0.240379021	0.759620979	1.425538346
2003	79,374	48,060	0.198928781	0.801071219	1.614808401
2004	72,092	54,442	0.240660599	0.759339401	1.424367642
2005	73,017	54,960			

Table 13. Northern shrimp (*Pandalus borealis*) large vessel (>500 t) catches and quotas for Hopedale and Cartwright Channels (SFA 5), 1977-2005.

YEAR	TAC[1] (t)	FLEET CATCH[2] (t)	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE INDEX	EFFORT[3] (HR)	STANDARDIZED RELATIVE CPUE	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1977		2,686						
1978	5,300	3,630						
1979	4,000	3,727						
1980	4,800	4,108	468	0.18	8,778	0.51	907	4,528
1981	4,800	3,449	480	0.19	7,185	0.54	976	3,532
1982	4,800	1,983	401	0.16	4,939	0.49	875	2,266
1983	4,800	1,000						
1984	4,200	1,002	362	0.14	2,766	0.42	747	1,341
1985	3,570	1,689	346	0.14	4,882	0.37	655	2,578
1986	4,400	4,826						
1987	4,800	5,956						
1988	4,800	7,838						
1989	6,000	5,985	1,016	0.40	5,894	0.69	1,232	4,859
1990	6,000	5,360	614	0.24	8,730	0.58	1,042	5,144
1991	6,375	6,118	554	0.22	11,043	0.46	826	7,408
1992	6,375	6,315	655	0.26	9,639	0.42	755	8,359
1993	6,375	5,719	647	0.25	8,833	0.44	797	7,176
1994	7,650	7,499	815	0.32	9,200	0.50	894	8,384
1995	7,650	7,616	1,459	0.57	5,218	0.65	1,157	6,584
1996	7,650	7,383	2,025	0.79	3,646	0.82	1,464	5,044
1997	15,300	15,103	1,536	0.60	9,836	0.93	1,664	9,077
1998	14,929	14,827	2,124	0.83	6,982	0.90	1,619	9,158
1999	15,136	14,720	2,128	0.83	6,919	0.98	1,759	8,370
2000	14,050	14,451	2,333	0.91	6,195	1.06	1,892	7,639
2001	14,694	15,036	2,540	1.00	5,919	1.11	1,996	7,533
2002	15,089	15,121	2,825	1.11	5,352	1.12	2,008	7,530
2003	28,072[4]	29,882	2,784	1.09	10,732	1.07	1,920	15,565
2004	16,780	21,048	2,369	0.93	8,886	0.97	1,736	12,123
2005	17,623	21,756	2,552	1.00	8,523	1.00	1,792	12,143

[1] **TAC'S FROM 1987 TO 1990, INCLUSIVE ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN. 1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31).**
TAC'S AFTER 1996 MAY INCLUDE TRANSFERS FROM OTHER SECTORS.

[2] **CATCH (TONS) IN CALENDAR YEAR AS REPORTED IN LOG BOOKS FOR 1977, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1978 TO 1989 AND YEAR-END QUOTA REPORTS, THEREAFTER.**

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

[4] **DURING 2003, A 2,500 T SCIENTIFIC QUOTA WAS CREATED FOR THE LARGE VESSELS IN SFA 5 AND THERE WAS AN INDUSTRY REQUESTED CHANGE IN FISHING SEASON FROM JAN. 1 - DEC. 31 TO APR. 1 - MAR. 31, THUS THERE WAS A SEASON ROLL-OVER MAKING THE 2003-MAR 2004 A 15 MONTH YEAR WITH A ROLL-OVER INCREASE IN QUOTA OF 9,785.5 T.**
AFTER 2002, CATCHES HAVE BEEN CONVERTED TO CALENDAR YEAR CATCHES FOR CONSISTENCY.

Table 14. Multiplicative year, month, vessel and area CPUE model for large vessels (>500 t) fishing shrimp in Hopedale and Cartwright Channels (SFA 5), 1980 -2005, weighted by effort (single trawl, no windows, observer data).

The GLM Procedure
Class Level Information

Class	Levels	Values
year	22	1980 1981 1982 1984 1985 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
area	4	52 53 54 99
month	12	1 2 3 4 5 7 8 9 10 11 12 13
CFV	15	

Number of Observations Read 1039
Number of Observations Used 1039

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	49	33473.49311	683.13251	89.76	<.0001
Error	989	7527.03177	7.61075		
Corrected Total	1038	41000.52488			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.816416	38.15323	2.758759	7.230735

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	21	24100.03802	1147.62086	150.79	<.0001
area	3	1324.42633	441.47544	58.01	<.0001
month	11	4684.22959	425.83905	55.95	<.0001
CFV	14	3364.79916	240.34280	31.58	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	21	5300.048549	252.383264	33.16	<.0001
area	3	392.943521	130.981174	17.21	<.0001
month	11	3210.086965	291.826088	38.34	<.0001
CFV	14	3364.799163	240.342797	31.58	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		6.943722430	B	0.08343681	83.22	<.0001
year	1980	-0.680366341	B	0.09929508	-6.85	<.0001
year	1981	-0.606928503	B	0.11290402	-5.38	<.0001
year	1982	-0.716639874	B	0.12950833	-5.53	<.0001
year	1984	-0.874308482	B	0.15842093	-5.52	<.0001
year	1985	-1.005928177	B	0.13426333	-7.49	<.0001
year	1989	-0.374599424	B	0.10796257	-3.47	0.0005
year	1990	-0.542057437	B	0.11346883	-4.78	<.0001
year	1991	-0.774447068	B	0.08750800	-8.85	<.0001
year	1992	-0.863587636	B	0.08331826	-10.36	<.0001
year	1993	-0.810054678	B	0.06974467	-11.61	<.0001
year	1994	-0.694722941	B	0.05948303	-11.68	<.0001
year	1995	-0.437562086	B	0.06192995	-7.07	<.0001
year	1996	-0.202151076	B	0.06822569	-2.96	0.0031
year	1997	-0.074025799	B	0.05878718	-1.26	0.2082
year	1998	-0.101273577	B	0.06071703	-1.67	0.0956
year	1999	-0.018539509	B	0.06074156	-0.31	0.7603
year	2000	0.054319519	B	0.05972278	0.91	0.3633
year	2001	0.108063967	B	0.06042940	1.79	0.0740
year	2002	0.114006939	B	0.06259669	1.82	0.0689
year	2003	0.069085045	B	0.06359082	1.09	0.2776
year	2004	-0.031470950	B	0.05948031	-0.53	0.5969
year	2005	0.000000000	B	.	.	.

Table 14 (Cont'd.)

year	lncpue LSMEAN	95% Confidence Limits	
1980	6.810509	6.643137	6.977882
1981	6.883947	6.682737	7.085157
1982	6.774236	6.537909	7.010563
1984	6.616567	6.319813	6.913321
1985	6.484947	6.238086	6.731809
1989	7.116276	6.920880	7.311672
1990	6.948818	6.744103	7.153533
1991	6.716429	6.569606	6.863251
1992	6.627288	6.494158	6.760418
1993	6.680821	6.576197	6.785445
1994	6.796153	6.717512	6.874793
1995	7.053313	6.959919	7.146708
1996	7.288725	7.179269	7.398180
1997	7.416850	7.333946	7.499754
1998	7.389602	7.299499	7.479705
1999	7.472336	7.384087	7.560585
2000	7.545195	7.457129	7.633261
2001	7.598940	7.508871	7.689008
2002	7.604883	7.507644	7.702121
2003	7.559961	7.457455	7.662466
2004	7.459405	7.368331	7.550478
2005	7.490876	7.389307	7.592444

Table 15. Probit analysis of the 1992-2005 observed large vessel (>500 t) length frequency data to determine the size at sex transition for northern shrimp (*Pandalus borealis*) within Hopedale and Cartwright Channels (SFA 5). In order to reduce the influence of seasonality, the analyses were restricted to data collected within the period January-March of each year. (L_{50} refers to the carapace length at sex change).

The GENMOD Procedure

Model Information

Data Set	WORK.ALL_SHRIMP
Distribution	Binomial
Link Function	Logit
Response Variable (Events)	female_lt
Response Variable (Trials)	total

Number of Observations Read	564
Number of Observations Used	564
Number of Events	345134
Number of Trials	640684

Class Level Information

Class	Levels	Values
year	14	1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

Parameter Information

Parameter	Effect	year
Prm1	Intercept	
Prm2	length	
Prm3	year	1992
Prm4	year	1993
Prm5	year	1994
Prm6	year	1995
Prm7	year	1996
Prm8	year	1997
Prm9	year	1998
Prm10	year	1999
Prm11	year	2000
Prm12	year	2001
Prm13	year	2002
Prm14	year	2003
Prm15	year	2004
Prm16	year	2005

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	549	2645.5269	4.8188
Scaled Deviance	549	549.0000	1.0000

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Pearson Chi-Square	549	8790.9938	16.0127
Scaled Pearson X2	549	1824.3079	3.3230
Log Likelihood		-28130.2998	

Algorithm converged.

Table 15 (Cont'd.)

Analysis Of Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept		1	-34.5782	0.2125	-34.9947	-34.1618	26478.6	<.0001
length		1	1.6902	0.0102	1.6702	1.7101	27549.5	<.0001
year	1992	1	-2.7518	0.0815	-2.9115	-2.5921	1140.73	<.0001
year	1993	1	-5.0878	0.6891	-6.4384	-3.7373	54.52	<.0001
year	1994	1	-2.3723	0.1508	-2.6679	-2.0767	247.43	<.0001
year	1995	1	-1.2418	0.0853	-1.4088	-1.0747	212.16	<.0001
year	1996	1	-2.0225	0.0537	-2.1277	-1.9173	1420.27	<.0001
year	1997	1	-1.4755	0.0541	-1.5816	-1.3695	743.42	<.0001
year	1998	1	-0.9887	0.0490	-1.0847	-0.8928	407.92	<.0001
year	1999	1	-0.8219	0.0468	-0.9136	-0.7302	308.60	<.0001
year	2000	1	-1.0311	0.0485	-1.1263	-0.9360	451.46	<.0001
year	2001	1	-0.0356	0.0592	-0.1517	0.0804	0.36	0.5471
year	2002	1	0.1740	0.0536	0.0691	0.2790	10.56	0.0012
year	2003	1	-0.3768	0.0702	-0.5144	-0.2391	28.78	<.0001
year	2004	1	0.1409	0.0455	0.0517	0.2302	9.57	0.0020
year	2005	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale		0	2.1952	0.0000	2.1952	2.1952		

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

LR Statistics For Type 1 Analysis

Source	Deviance	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
Intercept	615871.722						
length	25980.7573	1	549	122414	<.0001	122414	<.0001
year	2645.5269	13	549	372.50	<.0001	4842.53	<.0001

Least Squares Means

Effect	year	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq
year	1992	-3.1639	0.0737	1	1845.1	<.0001
year	1993	-5.4999	0.6882	1	63.86	<.0001
year	1994	-2.7844	0.1467	1	360.16	<.0001
year	1995	-1.6538	0.0774	1	456.45	<.0001
year	1996	-2.4345	0.0404	1	3634.7	<.0001
year	1997	-1.8876	0.0408	1	2135.3	<.0001
year	1998	-1.4008	0.0333	1	1767.1	<.0001
year	1999	-1.2339	0.0300	1	1693.8	<.0001
year	2000	-1.4432	0.0329	1	1922.8	<.0001
year	2001	-0.4477	0.0470	1	90.82	<.0001
year	2002	-0.2380	0.0393	1	36.75	<.0001
year	2003	-0.7888	0.0602	1	171.86	<.0001
year	2004	-0.2711	0.0272	1	99.41	<.0001
year	2005	-0.4121	0.0367	1	125.81	<.0001

Obs	year	sfa	Probability	L_{50} carapace lt	LowerCL	UpperCL
1	1992	5	0.50	22.0747	22.0324	22.1169
2	1993	5	0.50	23.4146	23.0509	24.0017
3	1994	5	0.50	21.8050	21.7164	21.8920
4	1995	5	0.50	21.2063	21.1687	21.2437
5	1996	5	0.50	21.6521	21.6333	21.6709
6	1997	5	0.50	21.3346	21.3141	21.3550
7	1998	5	0.50	21.0485	21.0321	21.0648
8	1999	5	0.50	20.9398	20.9242	20.9554
9	2000	5	0.50	21.0539	21.0364	21.0713
10	2001	5	0.50	20.5466	20.5218	20.5711
11	2002	5	0.50	20.3392	20.3175	20.3608
12	2003	5	0.50	20.6791	20.6468	20.7113
13	2004	5	0.50	20.3764	20.3623	20.3905
14	2005	5	0.50	20.4476	20.4270	20.4681

Table 16. Northern shrimp stock size estimates within Hopedale and Cartwright Channels (SFA 5) determined from annual Canadian autumn multi-species bottom trawl surveys, 1996-2005. All estimates were determined using Ogmap. (standard 15 min. tows.)

A) Cartwright Channel[1]

Year	Biomass (t)			Abundance (numbers x 10^6)			No.
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1996	25,810	80,400	213,000	5,942	22,224	60,250	34
1997	34,840	48,900	75,040	7,192	10,374	16,410	40
1998	32,140	43,300	58,510	6,574	8,585	11,750	36
1999	41,210	56,900	77,710	8,205	11,021	14,780	36
2000	44,800	73,900	121,300	10,970	17,153	26,720	35
2001	70,060	89,500	123,500	17,380	21,847	28,800	33
2002	45,410	58,300	76,760	12,480	16,135	20,270	39
2003	65,850	95,300	134,100	16,100	21,327	28,690	31
2004	64,090	85,600	108,400	13,290	17,735	22,940	33
2005	93,750	141,300	192,400	21,540	29,248	36,450	29

[1] Area compared each year = 25204.6 sq. km.

B) Hopedale Channel[2]

Year	Biomass (t)			Abundance (numbers x 10^6)			No.
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1996	25,960	64,300	127,400	6,142	14,523	32,050	77
1997	41,990	80,000	115,800	9,156	17,962	27,990	72
1998	23,220	44,100	68,520	4,626	9,100	14,100	83
1999	27,200	51,500	85,950	4,939	10,816	18,230	81
2000							
2001	96,370	154,100	219,600	24,140	38,430	56,010	57
2002							
2003							
2004	52,600	93,100	137,700	11,350	20,490	31,410	86

[2] Area compared each year = 34,282.2 sq. km.

C) Entire SFA 5[3]

Year	Biomass (t)			Abundance (numbers x 10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	62,490	151,300	310,700	13,060	38,942	90,800
1997	85,780	129,200	174,800	17,950	28,636	40,430
1998	60,750	86,200	117,700	12,350	17,354	23,960
1999	72,970	108,100	153,900	14,190	21,471	30,150
2000						
2001	178,500	247,800	330,600	44,270	61,522	80,970
2002						
2003						
2004	131,700	183,000	237,200	26,790	39,075	52,170

[3] Area compared each year = 60,578.6 sq. km.

Table 17. Northern shrimp stock size estimates within Cartwright Channel and the entire of SFA 5 determined from annual Canadian autumn multi-species bottom trawl surveys, 1996-2005. All estimates were determined using Ogmap. (standard 15 min. tows.)

A) Cartwright Channel[1]

Year	Biomass (t)			Abundance (numbers x 10^6)		
	Males	Females	Total	Males	Females	Total
1996	64,400	16,000	80,400	20,364	1,856	22,220
1997	30,500	18,400	48,900	8,146	2,228	10,374
1998	21,400	20,700	42,100	6,071	2,514	8,585
1999	26,200	30,800	57,000	7,174	3,847	11,021
2000	40,900	33,100	74,000	12,956	4,198	17,154
2001	48,300	41,200	89,500	16,465	5,382	21,847
2002	33,700	24,600	58,300	12,396	3,738	16,134
2003	42,300	53,000	95,300	13,749	7,578	21,327
2004	39,300	46,300	85,600	11,324	6,410	17,734
2005	65,100	76,200	141,300	19,067	10,181	29,248

[1] Area compared each year = 25,204.6 sq. km.

B) Entire of SFA 5[2]

Year	Biomass (t)			Abundance (numbers x 10^6)		
	Males	Females	Total	Males	Females	Total
1996	117,900	33,200	151,100	34,948	3,959	38,907
1997	89,500	39,700	129,200	23,777	4,859	28,636
1998	47,900	38,300	86,200	12,626	4,728	17,354
1999	56,900	51,100	108,000	15,112	6,359	21,471
2000						
2001	152,500	95,300	247,800	48,879	12,642	61,521
2002						
2003						
2004	96,600	87,300	183,900	27,099	12,230	39,329

[2] Area compared each year = 60,578.6 sq. km.

Table 18. Exploitation rate indices for northern shrimp (*Pandalus borealis*) harvested from the entire of SFA 5 as determined using survey and total catch data over the period 1996-2005.

	catch (large+ small vessel) (t)	lower CL of total biomass (t)	ssb (t)	fishable biomass (t) all shrimp >17 mm cl
1996	7,383	62,490	33,200	110,322
1997	15,103	85,780	39,700	117,456
1998	15,170	60,750	38,300	81,149
1999	14,776	72,970	51,100	103,284
2000	14,777			
2001	15,151	178,500	95,300	209,952
2002	15,332			
2003	30,437			
2004	22,690	131,700	87,300	173,520
2005	22,898			

	catch/ lower 95% confidence limit of the biomass index	catch/ ssb	Catch/ fishable biomass
1997	24.17	45.49	13.69
1998	17.68	38.21	12.92
1999	24.32	38.58	18.21
2000	20.25	28.92	14.31
2001			
2002	8.59	16.09	7.30
2003			
2004			
2005	17.39	26.23	13.20

Table 19. Northern shrimp (*Pandalus borealis*) large vessel (>500 t) catches and quotas for NAFO Division 2G (SFA 4), 1979-2005.

YEAR	TAC [1] (t)	FLEET [2] CATCH (t)	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE INDEX	EFFORT [3] (HR)	RELATIVE CPUE	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1979	500	3						
1980	500	<1						
1981	500	2						
1982	500	5						
1983	500	30						
1984	500							
1985	500							
1986	500	2						
1987	500	7						
1988	500	1,083						
1989	2,580	3,842	352	0.16	10,926	0.31	581	6,618
1990	2,580	2,945	719	0.33	4,096	0.30	563	5,228
1991	2,635	2,561	1,714	0.78	1,494	1.26	2,364	1,083
1992	2,635	2,706	2,110	0.96	1,283	1.10	2,062	1,312
1993	2,735	2,723	2,210	1.00	1,232	0.97	1,822	1,495
1994	4,000	3,982	3,740	1.70	1,065	1.73	3,247	1,226
1995	5,200	5,104	1,245	0.57	4,100	0.64	1,192	4,281
1996	5,200	5,160	1,329	0.60	3,882	0.70	1,309	3,940
1997	5,200	5,216	3,095	1.40	1,685	1.52	2,842	1,835
1998	8,008	7,918	2,145	0.97	3,691	1.12	2,093	3,783
1999	8,008	7,836	2,334	1.06	3,358	1.19	2,226	3,520
2000	8,008	8,048	2,591	1.18	3,106	1.29	2,418	3,329
2001	8,008	7,991	3,897	1.77	2,050	1.80	3,381	2,364
2002	8,008	8,516	2,479	1.13	3,435	1.14	2,131	3,996
2003	14,121 [4]	13,020	3,214	1.46	4,051	1.40	2,628	4,954
2004	10,243	9,644	2,282	1.04	4,227	1.05	1,974	4,885
2005	10,249	10,247	2,203	1.00	4,651	1.00	1,874	5,467

[1] **TAC'S FROM 1987 TO 1990, INCLUSIVE ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30, MAKING 1986 A 16 MONTH YEAR (JAN.1, 1986 - APRIL 30, 1987) AND 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31). TAC'S AFTER 1996 INCLUDE TRANSFERS FROM OTHER SECTORS.**

[2] **CATCH (TONS) AS REPORTED IN: LOGBOOKS FOR 1979, ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY FROM 1980 TO 1989 AND FROM YEAR-END QUOTA REPORTS, LOGBOOKS AND/ OR OBSERVED DATA, THEREAFTER.**

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

[4] **DURING 2003, A 1,125 T SCIENTIFIC QUOTA WAS CREATED FOR THE LARGE VESSELS IN SFA 4 AND THERE WAS AN INDUSTRY REQUESTED CHANGE IN FISHING SEASON FROM JAN. 1 - DEC. 31 TO APR. 1 - MAR. 31, THUS THERE WAS A SEASON ROLL-OVER MAKING THE 2003-MAR 2004 A 15 MONTH YEAR WITH A ROLL-OVER INCREASE IN QUOTA OF 1,183.5 T IN SFA 4N AND 1,618.1 T IN SFA 4S.**
Since 2003 the catches have been converted to calendar year catches.

Table 20. Multiplicative year, month and vessel CPUE model for large vessels (>500 t) fishing shrimp in NAFO Division (SFA 4), 1989-2005, weighted by effort (single trawl, no windows, observer data).

The GLM Procedure
Class Level Information

Class	Levels	Values
year	17	1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005
CFV	15	
month	8	5 6 8 9 10 11 12 99

Number of Observations Read 399
Number of Observations Used 399
Dependent Variable: lncpue

Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	37	5785.440578	156.363259	21.32	<.0001
Error	361	2647.392828	7.333498		
Corrected Total	398	8432.833406			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.686061	35.78793	2.708043	7.566918

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	16	4250.115702	265.632231	36.22	<.0001
CFV	14	1264.003723	90.285980	12.31	<.0001
month	7	271.321154	38.760165	5.29	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	16	2656.101552	166.006347	22.64	<.0001
CFV	14	1174.168615	83.869187	11.44	<.0001
month	7	271.321154	38.760165	5.29	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		7.067743371	B	0.13875601	50.94	<.0001
year	1989	-1.172125551	B	0.22162150	-5.29	<.0001
year	1990	-1.202225279	B	0.16563310	-7.26	<.0001
year	1991	0.231998503	B	0.19361746	1.20	0.2316
year	1992	0.095492187	B	0.17100695	0.56	0.5769
year	1993	-0.028581078	B	0.20720206	-0.14	0.8904
year	1994	0.549501184	B	0.13130021	4.19	<.0001
year	1995	-0.452398852	B	0.08142664	-5.56	<.0001
year	1996	-0.358661892	B	0.08617737	-4.16	<.0001
year	1997	0.416278334	B	0.10861971	3.83	0.0001
year	1998	0.110301834	B	0.07728921	1.43	0.1544
year	1999	0.171969280	B	0.08015418	2.15	0.0326
year	2000	0.254435495	B	0.07939825	3.20	0.0015
year	2001	0.589852861	B	0.09720455	6.07	<.0001
year	2002	0.128468267	B	0.08489373	1.51	0.1311
year	2003	0.337981674	B	0.08706240	3.88	0.0001
year	2004	0.051919667	B	0.08406046	0.62	0.5372
year	2005	0.000000000	B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
1989	6.363932	5.948774	6.779090
1990	6.333833	6.029267	6.638398
1991	7.768056	7.413341	8.122772
1992	7.631550	7.321948	7.941152
1993	7.507477	7.113739	7.901214
1994	8.085559	7.853416	8.317702
1995	7.083659	6.968201	7.199116
1996	7.177396	7.048863	7.305929
1997	7.952336	7.778347	8.126325
1998	7.646360	7.546722	7.745997
1999	7.708027	7.605393	7.810661
2000	7.790493	7.676584	7.904402
2001	8.125911	7.969230	8.282591
2002	7.664526	7.532370	7.796682
2003	7.874039	7.732172	8.015907
2004	7.587977	7.458359	7.717596
2005	7.536058	7.417046	7.655070

Table 21. Probit analysis of the 1992-2005 observed large vessel (>500 t) length frequency data to determine the size at sex transition for northern shrimp (*Pandalus borealis*) within NAFO Division (SFA 4). In order to reduce the influence of seasonality, the analyses were restricted to data collected within the period October - December of each year. (L_{50} refers to the carapace length at sex change).

The GENMOD Procedure

Data Set	WORK.ALL_SHRIMP
Distribution	Binomial
Link Function	Logit
Response Variable (Events)	female_lt
Response Variable (Trials)	total

Number of Observations Read	502
Number of Observations Used	502
Number of Events	292015
Number of Trials	364709

Class Level Information

Class	Levels	Values
year	14	1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

Parameter Information

Parameter	Effect	year
Prm1	Intercept	
Prm2	length	
Prm3	year	1992
Prm4	year	1993
Prm5	year	1994
Prm6	year	1995
Prm7	year	1996
Prm8	year	1997
Prm9	year	1998
Prm10	year	1999
Prm11	year	2000
Prm12	year	2001
Prm13	year	2002
Prm14	year	2003
Prm15	year	2004
Prm16	year	2005

The GENMOD Procedure
Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	487	5371.4164	11.0296
Scaled Deviance	487	487.0000	1.0000
Pearson Chi-Square	487	14941.0490	30.6798
Scaled Pearson X2	487	1354.6317	2.7816
Log Likelihood		-8068.4321	

Table 21 (Cont'd.)

Algorithm converged.

Analysis Of Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-25.6662	0.3382	-26.3292	-25.0033	5758.34	<.0001
length	1	1.2100	0.0152	1.1801	1.2399	6304.09	<.0001
year 1992	1	-3.8008	0.5805	-4.9386	-2.6630	42.87	<.0001
year 1993	1	-2.7749	0.1257	-3.0213	-2.5286	487.33	<.0001
year 1994	1	-2.4586	0.2706	-2.9890	-1.9282	82.55	<.0001
year 1995	1	-2.6450	0.1204	-2.8809	-2.4091	482.95	<.0001
year 1996	1	-2.2896	0.0797	-2.4458	-2.1335	825.80	<.0001
year 1997	1	-1.0809	0.1176	-1.3115	-0.8504	84.43	<.0001
year 1998	1	-0.4300	0.1237	-0.6725	-0.1875	12.08	0.0005
year 1999	1	-0.7619	0.0933	-0.9447	-0.5791	66.73	<.0001
year 2000	1	-0.8457	0.0766	-0.9958	-0.6957	121.97	<.0001
year 2001	1	-1.3911	0.0965	-1.5802	-1.2020	207.81	<.0001
year 2002	1	-1.1686	0.0925	-1.3499	-0.9874	159.71	<.0001
year 2003	1	-0.7738	0.0944	-0.9589	-0.5888	67.16	<.0001
year 2004	1	-0.0504	0.0831	-0.2132	0.1124	0.37	0.5444
year 2005	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale	0	3.3211	0.0000	3.3211	3.3211		

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

LR Statistics For Type 1 Analysis

Source	Deviance	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
Intercept	191702.654						
length	23834.1459	1	487	15219.8	<.0001	15219.8	<.0001
year	5371.4164	13	487	128.76	<.0001	1673.93	<.0001

Least Squares Means

Effect	year	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq
year	1992	-2.0588	0.5774	1	12.71	0.0004
year	1993	-1.0329	0.1100	1	88.14	<.0001
year	1994	-0.7165	0.2636	1	7.39	0.0066
year	1995	-0.9030	0.1039	1	75.59	<.0001
year	1996	-0.5476	0.0537	1	104.00	<.0001
year	1997	0.6611	0.1028	1	41.32	<.0001
year	1998	1.3120	0.1102	1	141.69	<.0001
year	1999	0.9801	0.0739	1	175.97	<.0001
year	2000	0.8963	0.0515	1	302.50	<.0001
year	2001	0.3509	0.0771	1	20.72	<.0001
year	2002	0.5734	0.0726	1	62.33	<.0001
year	2003	0.9682	0.0762	1	161.34	<.0001
year	2004	1.6917	0.0633	1	715.03	<.0001
year	2005	1.7420	0.0563	1	958.02	<.0001

Obs	year	sfa	Probability	L_{50} carapace lt	LowerCL	UpperCL
1	1992	4	0.50	24.2576	24.0376	24.4939
2	1993	4	0.50	23.6423	23.5933	23.6901
3	1994	4	0.50	23.3829	23.2314	23.5188
4	1995	4	0.50	23.1082	23.0347	23.1788
5	1996	4	0.50	22.9877	22.9568	23.0182
6	1997	4	0.50	22.0283	21.9645	22.0897
7	1998	4	0.50	21.5287	21.4550	21.5986
8	1999	4	0.50	22.0533	22.0161	22.0893
9	2000	4	0.50	22.0567	22.0305	22.0824
10	2001	4	0.50	22.5247	22.4861	22.5621
11	2002	4	0.50	22.1107	22.0676	22.1529
12	2003	4	0.50	21.8627	21.8222	21.9023
13	2004	4	0.50	21.3035	21.2716	21.3347
14	2005	4	0.50	21.2605	21.2315	21.2890

Table 21 (Cont'd.)

Algorithm converged.
Analysis Of Parameter Estimates

Parameter	DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept	1	-25.6662	0.3382	-26.3292	-25.0033	5758.34	<.0001
length	1	1.2100	0.0152	1.1801	1.2399	6304.09	<.0001
year 1992	1	-3.8008	0.5805	-4.9386	-2.6630	42.87	<.0001
year 1993	1	-2.7749	0.1257	-3.0213	-2.5286	487.33	<.0001
year 1994	1	-2.4586	0.2706	-2.9890	-1.9282	82.55	<.0001
year 1995	1	-2.6450	0.1204	-2.8809	-2.4091	482.95	<.0001
year 1996	1	-2.2896	0.0797	-2.4458	-2.1335	825.80	<.0001
year 1997	1	-1.0809	0.1176	-1.3115	-0.8504	84.43	<.0001
year 1998	1	-0.4300	0.1237	-0.6725	-0.1875	12.08	0.0005
year 1999	1	-0.7619	0.0933	-0.9447	-0.5791	66.73	<.0001
year 2000	1	-0.8457	0.0766	-0.9958	-0.6957	121.97	<.0001
year 2001	1	-1.3911	0.0965	-1.5802	-1.2020	207.81	<.0001
year 2002	1	-1.1686	0.0925	-1.3499	-0.9874	159.71	<.0001
year 2003	1	-0.7738	0.0944	-0.9589	-0.5888	67.16	<.0001
year 2004	1	-0.0504	0.0831	-0.2132	0.1124	0.37	0.5444
year 2005	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale	0	3.3211	0.0000	3.3211	3.3211		

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

LR Statistics For Type 1 Analysis

Source	Deviance	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
Intercept	191702.654						
length	23834.1459	1	487	15219.8	<.0001	15219.8	<.0001
year	5371.4164	13	487	128.76	<.0001	1673.93	<.0001

Table 21 (Cont'd.)

Least Squares Means

Effect	year	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq
year	1992	-2.0588	0.5774	1	12.71	0.0004
year	1993	-1.0329	0.1100	1	88.14	<.0001
year	1994	-0.7165	0.2636	1	7.39	0.0066
year	1995	-0.9030	0.1039	1	75.59	<.0001
year	1996	-0.5476	0.0537	1	104.00	<.0001
year	1997	0.6611	0.1028	1	41.32	<.0001
year	1998	1.3120	0.1102	1	141.69	<.0001
year	1999	0.9801	0.0739	1	175.97	<.0001
year	2000	0.8963	0.0515	1	302.50	<.0001
year	2001	0.3509	0.0771	1	20.72	<.0001
year	2002	0.5734	0.0726	1	62.33	<.0001
year	2003	0.9682	0.0762	1	161.34	<.0001
year	2004	1.6917	0.0633	1	715.03	<.0001
year	2005	1.7420	0.0563	1	958.02	<.0001

Obs	year	sfa	Probability	L_{50} carapace lt	LowerCL	UpperCL
1	1992	4	0.50	24.2576	24.0376	24.4939
2	1993	4	0.50	23.6423	23.5933	23.6901
3	1994	4	0.50	23.3829	23.2314	23.5188
4	1995	4	0.50	23.1082	23.0347	23.1788
5	1996	4	0.50	22.9877	22.9568	23.0182
6	1997	4	0.50	22.0283	21.9645	22.0897
7	1998	4	0.50	21.5287	21.4550	21.5986
8	1999	4	0.50	22.0533	22.0161	22.0893
9	2000	4	0.50	22.0567	22.0305	22.0824
10	2001	4	0.50	22.5247	22.4861	22.5621
11	2002	4	0.50	22.1107	22.0676	22.1529
12	2003	4	0.50	21.8627	21.8222	21.9023
13	2004	4	0.50	21.3035	21.2716	21.3347
14	2005	4	0.50	21.2605	21.2315	21.2890

Table 22. Northern shrimp stock size estimates within NAFO Division 2G (SFA 4)[1] determined from annual Canadian autumn multi-species bottom trawl surveys, 1996-2005. All estimates were determined using Ogmap. (standard 15 min. tows.) (Parsons et al. 2000).

Year	Biomass (t)			Abundance (number X 10^6)			
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	No. Sets
1996	23,610	42,400	66,840	3,476	7,187	12,100	29
1997	30,670	64,100	110,800	5,670	10,943	18,410	69
1999	42,420	65,100	86,850	74,462	11,068	14,710	44

[1] Area compared each year = 23,467.9 sq. km.

Table 23. Northern shrimp stock size estimates within NAFO Division 2G (SFA 4) determined from the 2005 Northern Shrimp Research Foundation - DFO bottom trawl survey. All estimates were determined using stratified analysis calculations (Cochran 1977). (79 standard 15 min. tows.)

Depth Range m	Area Nmi^2	Stratum	2005 biomass (t)	2005 abundance (x 10^6)
<=200	1643	909	4,910	999
<=200	2397	910	41	6
<=200	2009	925	17	2
<=200	1007	930	.	.
<=200	213	931	.	.
201 - 300	1225	901	12,787	3,008
201 - 300	607	908	28,286	5,643
201 - 300	717	911	17,902	3,645
201 - 300	833	924	3,292	411
201 - 300	462	926	2,684	509
301 - 400	128	902	86	11
301 - 400	67	912	1	0
301 - 400	248	923	6,210	926
301 - 400	452	927	259	43
401 - 500	88	903	0	0
401 - 500	54	913	0	0
401 - 500	195	922	4	1
401 - 500	365	928	72	12
501 - 750	152	904	1	0
501 - 750	130	914	0	0
501 - 750	161	921	0	0
501 - 750	742	929	0	0
		Total	76,551	15,216
		Upper 95% limit	141,074	28,651
		Lower 95% limit	12,028	1,781
		Percent within depth ranges		
		<200m	6	7
		200 - 400 m m	93	93
		>400 m	0	0

Table 24. Northern shrimp (*Pandalus borealis*) large vessel (>500 t) catches and quotas for NAFO Division 0B (SFA 2), 1988-2005. For the purposes of this report, the data are from shrimp fished in SFA 2 and those portions of SFA's 3 and 4 north of 60°30N and west of 63°00W.

YEAR	TAC[1] (t)	CATCH[2] (t)	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE INDEX	EFFORT[3] (HR)	STANDARDIZED RELATIVE CPUE	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1988		2,826						
1989	3,500	3,039	268	0.14	11,323	0.20	289	10,501
1990	3,500	1,609	589	0.30	2,732	0.42	612	2,627
1991	3,485	1,107	289	0.15	3,828	0.19	274	4,033
1992	3,485	1,291	340	0.17	3,796	0.17	249	5,191
1993	3,485	106	176	0.09	601	0.11	157	675
1994	3,500	476	337	0.17	1,411	0.16	232	2,050
1995	3,500	3,564	522	0.27	6,830	0.25	374	9,530
1996	3,500	3,220	740	0.38	4,349	0.47	692	4,651
1997	5,250	5,235	1,062	0.55	4,930	0.64	933	5,612
1998	5,250	5,163	1,545	0.79	3,342	0.88	1,298	3,979
1999	8,750	5,132	1,205	0.62	4,258	0.69	1,017	5,047
2000	5,250	4,261	1,680	0.86	2,536	0.92	1,348	3,161
2001	8,750	6,023	1,610	0.83	3,741	0.84	1,228	4,906
2002	8,750	5,597	1,446	0.74	3,870	0.77	1,124	4,980
2003	8,750	4,584	1,733	0.89	2,646	0.94	1,381	3,320
2004	8,750	4,488	1,722	0.89	2,606	0.98	1,438	3,121
2005	8,750	6,200	1,946	1.00	3,186	1.00	1,468	4,225

[1] TAC'S FOR 1989 AND 1990 ARE FOR THE FISHING SEASON MAY 1 TO APRIL 30 AND FOR THE CALENDAR YEAR, THEREAFTER, MAKING 1991 AN 8 MONTH YEAR (MAY 1 - DEC. 31)
TAC'S AFTER 1996 MAY INCLUDE TRANSFERS FROM OTHER SECTORS.

[2] CATCH (TONS) FOR 1988 AND 1989 AS REPORTED IN ECONOMIC ASSESSMENT OF THE NORTHERN SHRIMP FISHERY AND FROM YEAR-END QUOTA REPORTS, LOGBOOK RECORDS AND/ OR OBSERVED DATA, THEREAFTER.

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

AN INDUSTRY REQUESTED CHANGE OF SEASON FROM JAN. 1 - DEC. 31 TO APR. 1 - MAR. 31 BEGAN DURING 2003
SINCE 2003 CATCHES HAVE BEEN CONVERTED TO CALENDAR YEAR CATCHES

Table 25. Multiplicative year, month, vessel CPUE model for large vessels (>500 t) fishing for northern shrimp (*Pandalus borealis*) in NAFO Division 0B (SFA 2), 1989-2005. For the purposes of this report, the data are from shrimp fished in SFA 2 and those portions of SFA's 3 and 4 north of 60°30N and west of 63°00W.

```
                                     The GLM Procedure
                                  Class Level Information
           Class         Levels    Values
           year              17    1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999
                                   2000 2001 2002 2003 2004 2005
           month              7    6 7 8 9 10 12 13
           CFV               15
                                 Number of Observations Read         423
                                 Number of Observations Used         423
Dependent Variable: lncpue
Weight: effort
                                  Sum of
Source                      DF        Squares     Mean Square    F Value    Pr > F
Model                       36    20526.68779      570.18577      32.00    <.0001
Error                      386     6877.66102       17.81777
Corrected Total            422    27404.34881
R-Square     Coeff Var      Root MSE     lncpue Mean
0.749030      62.05853      4.221111        6.801822

Source                      DF      Type I SS     Mean Square    F Value    Pr > F
year                        16    17466.04103     1091.62756      61.27    <.0001
month                        6     1062.31094      177.05182       9.94    <.0001
CFV                         14     1998.33582      142.73827       8.01    <.0001

Source                      DF    Type III SS     Mean Square    F Value    Pr > F
year                        16    10506.44432      656.65277      36.85    <.0001
month                        6      991.91886      165.31981       9.28    <.0001
CFV                         14     1998.33582      142.73827       8.01    <.0001

                                           Standard
Parameter              Estimate               Error    t Value    Pr > |t|
Intercept           6.853583767 B        0.16545783      41.42      <.0001
year       1989    -1.623498386 B        0.16809381      -9.66      <.0001
year       1990    -0.873952538 B        0.25947648      -3.37      0.0008
year       1991    -1.676530455 B        0.26100354      -6.42      <.0001
year       1992    -1.775123865 B        0.14806573     -11.99      <.0001
year       1993    -2.234453770 B        0.33721629      -6.63      <.0001
year       1994    -1.843612262 B        0.18092521     -10.19      <.0001
year       1995    -1.367149121 B        0.12399665     -11.03      <.0001
year       1996    -0.751283003 B        0.13133388      -5.72      <.0001
year       1997    -0.453071497 B        0.12190286      -3.72      0.0002
year       1998    -0.123073181 B        0.12979943      -0.95      0.3436
year       1999    -0.366826855 B        0.12413674      -2.96      0.0033
year       2000    -0.084865413 B        0.12721466      -0.67      0.5051
year       2001    -0.178496371 B        0.12734508      -1.40      0.1618
year       2002    -0.266757361 B        0.12533819      -2.13      0.0339
year       2003    -0.060893493 B        0.12977786      -0.47      0.6392
year       2004    -0.020265216 B        0.13520619      -0.15      0.8809
year       2005     0.000000000 B         .                .          .


                        lncpue
           year         LSMEAN        95% Confidence Limits
           1989       5.667818        5.398876     5.936760
           1990       6.417364        5.942005     6.892722
           1991       5.614786        5.141057     6.088515
           1992       5.516192        5.297355     5.735030
           1993       5.056862        4.427823     5.685902
           1994       5.447704        5.152636     5.742772
           1995       5.924167        5.783211     6.065123
           1996       6.540033        6.377673     6.702393
           1997       6.838245        6.698203     6.978286
           1998       7.168243        7.002902     7.333584
           1999       6.924489        6.778657     7.070322
           2000       7.206451        7.045956     7.366945
           2001       7.112820        6.947304     7.278336
           2002       7.024559        6.859695     7.189423
           2003       7.230423        7.053665     7.407181
           2004       7.271051        7.076064     7.466038
           2005       7.291316        7.095885     7.486748
```

Table 26. Probit analysis of the 1992-2005 observed large vessel (>500 t) length frequency data to determine the size at sex transition for northern shrimp (*Pandalus borealis*) within NAFO Division 0B (SFA 2). In order to reduce the influence of seasonality, the analyses were restricted to data collected within the period June-August of each year. For the purposes of this report, the data are from shrimp fished in SFA 2 and those portions of SFAs 3 & 4 north of 60°30N and west of 63°00W. (L_{50} refers to the carapace length at sex change).

The GENMOD Procedure

Model Information

Data Set	WORK.ALL_SHRIMP
Distribution	Binomial
Link Function	Logit
Response Variable (Events)	female_lt
Response Variable (Trials)	total

Number of Observations Read	525
Number of Observations Used	525
Number of Events	243649
Number of Trials	400696

Class Level Information

Class	Levels	Values
year	13	1992 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005

Parameter Information

Parameter	Effect	year
Prm1	Intercept	
Prm2	length	
Prm3	year	1992
Prm4	year	1994
Prm5	year	1995
Prm6	year	1996
Prm7	year	1997
Prm8	year	1998
Prm9	year	1999
Prm10	year	2000
Prm11	year	2001
Prm12	year	2002
Prm13	year	2003
Prm14	year	2004
Prm15	year	2005

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	511	11082.0846	21.6871
Scaled Deviance	511	511.0000	1.0000
Pearson Chi-Square	511	27979.9052	54.7552

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Scaled Pearson X2	511	1290.1663	2.5248
Log Likelihood		-4438.3164	

Table 26 (Cont'd.)

Algorithm converged.
Analysis Of Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept		1	-31.4955	0.4980	-32.4715	-30.5196	4000.56	<.0001
length		1	1.3867	0.0212	1.3451	1.4283	4274.53	<.0001
year	1992	1	-2.2606	0.2583	-2.7668	-1.7544	76.60	<.0001
year	1994	1	-2.6695	0.4195	-3.4917	-1.8474	40.50	<.0001
year	1995	1	-2.8862	0.1687	-3.2168	-2.5557	292.85	<.0001
year	1996	1	-1.9362	0.1270	-2.1850	-1.6873	232.59	<.0001
year	1997	1	-1.0530	0.1176	-1.2834	-0.8225	80.21	<.0001
year	1998	1	-0.4222	0.1291	-0.6751	-0.1692	10.70	0.0011
year	1999	1	-0.2308	0.1208	-0.4677	0.0060	3.65	0.0561
year	2000	1	-0.8438	0.1272	-1.0931	-0.5946	44.02	<.0001
year	2001	1	-0.9024	0.1469	-1.1903	-0.6144	37.73	<.0001
year	2002	1	-0.2430	0.1506	-0.5382	0.0522	2.60	0.1066
year	2003	1	-0.5262	0.3542	-1.2204	0.1680	2.21	0.1374
year	2004	1	0.1427	0.1885	-0.2268	0.5121	0.57	0.4491
year	2005	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale		0	4.6569	0.0000	4.6569	4.6569		

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

LR Statistics For Type 1 Analysis

Source	Deviance	Num DF	Den DF	F Value	Pr > F	Chi-Square	Pr > ChiSq
Intercept	355190.966						
length	27108.9295	1	511	15128.0	<.0001	15128.0	<.0001
year	11082.0846	12	511	61.58	<.0001	739.01	<.0001

Least Squares Means

Effect	year	Estimate	Standard Error	DF	Chi-Square	Pr > ChiSq
year	1992	-2.2647	0.2397	1	89.25	<.0001
year	1994	-2.6736	0.4084	1	42.86	<.0001
year	1995	-2.8903	0.1387	1	434.04	<.0001
year	1996	-1.9402	0.0823	1	555.99	<.0001
year	1997	-1.0570	0.0653	1	262.29	<.0001
year	1998	-0.4262	0.0835	1	26.06	<.0001
year	1999	-0.2349	0.0705	1	11.08	0.0009
year	2000	-0.8479	0.0814	1	108.41	<.0001
year	2001	-0.9064	0.1098	1	68.10	<.0001
year	2002	-0.2471	0.1141	1	4.69	0.0304
year	2003	-0.5302	0.3404	1	2.43	0.1194
year	2004	0.1386	0.1606	1	0.74	0.3882
year	2005	-0.0041	0.0989	1	0.00	0.9673

Obs	year	sfa	Probability	L_{50} carapace lt	LowerCL	UpperCL
1	1992	2	0.50	24.4487	24.3849	24.5116
2	1994	2	0.50	24.7467	24.6433	24.8454
3	1995	2	0.50	24.8126	24.7770	24.8479
4	1996	2	0.50	23.9970	23.9693	24.0245
5	1997	2	0.50	23.4754	23.4567	23.4940
6	1998	2	0.50	23.0327	23.0105	23.0549
7	1999	2	0.50	22.8210	22.7968	22.8450
8	2000	2	0.50	23.3841	23.3623	23.4056
9	2001	2	0.50	23.3865	23.3535	23.4190
10	2002	2	0.50	22.9300	22.8970	22.9627
11	2003	2	0.50	23.2494	23.1565	23.3376
12	2004	2	0.50	22.7219	22.6819	22.7613
13	2005	2	0.50	22.6807	22.6479	22.7131

Table 27. Northern shrimp stock size estimates within NAFO Division 0B (SFA 2) determined from the 2005 Northern Shrimp Research Foundation-DFO bottom trawl survey. All estimates were determined using stratified analysis calculations (Cochran 1977). (145 standard 15 min. tows.)

Depth Range m	Area Nmi^2	Stratum	2005 biomass (t)	2005 abundance ($X10^6$)
100 - 200	388	63	.	
100 - 200	1306	77	0	0
100 - 200	1621	79	1	0
100 - 200	1022	84	0	0
100 - 200	1617	96	0	0
200 - 300	2350	64	2,937	435
200 - 300	223	80	.	.
200 - 300	2434	81	189	48
200 - 300	1324	82	1	0
200 - 300	1744	85	265	84
200 - 300	1619	97	5	1
200 - 300	1935	98	0	0
300 - 400	283	65	0	0
300 - 400	1382	66	2,729	311
300 - 400	333	83	429	124
300 - 400	1207	86	22,782	2,092
300 - 400	2232	87	10,934	1,226
300 - 400	1719	88	1,276	183
300 - 400	2421	99	402	73
400 - 500	2079	100	5,040	589
400 - 500	2487	67	316	36
400 - 500	65	68	170	21
400 - 500	288	89	.	.
400 - 500	2682	91	3,949	510
500 - 750	3476	101	1,474	132
500 - 750	1024	72	14	1
500 - 750	436	90	.	.
500 - 750	3114	92	65	6
750 -1000	1039	73	.	.
750 -1000	2687	93	.	.
Total			52,981	5,874
Upper 95% limit			141,911	14,426
Lower 95% limit			-35,949	-2,678
Percent within depth ranges				
<200 m			0.002378	0.005256
200 - 400 m			79.1745	77.93746
400 - 500 m			17.88392	19.68745
>500 m			2.930315	2.366982

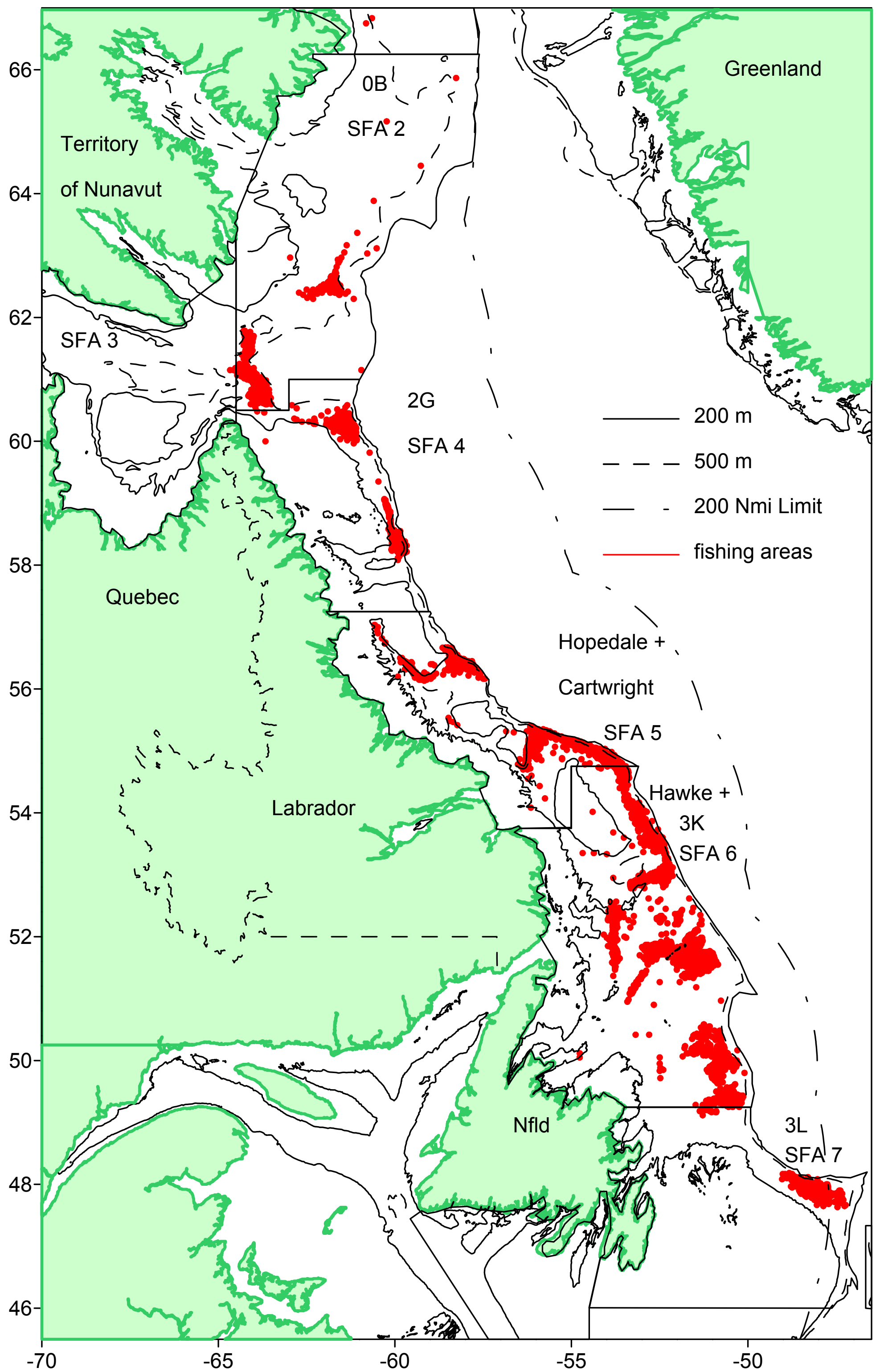


Figure 1. Shrimp fishing areas 2-7 with an overlay of the 2005 shrimp fishing locations.

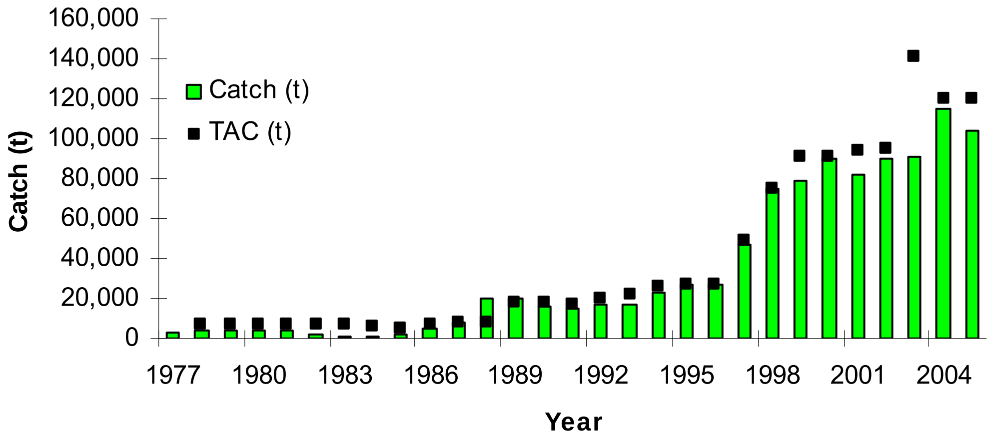


Figure 2. Shrimp fishing areas (SFA's 2 and 4-6) northern shrimp (*Pandalus borealis*) catches and quotas, 1977-2005.

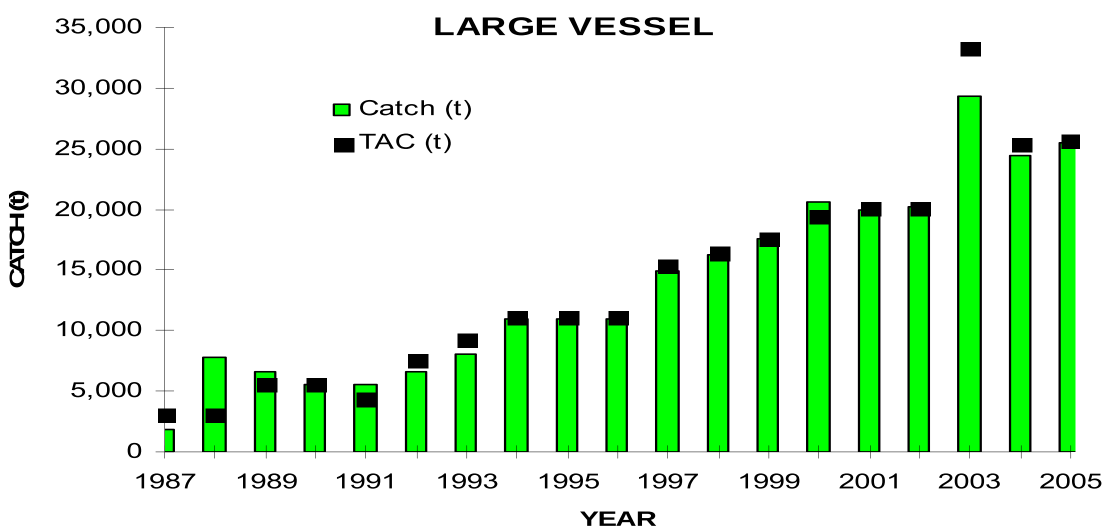


Figure 3. History of SFA 6 large vessel (>500 t) catches and quotas, 1977-2005. Note that beginning in 2003, TAC's have been allocated by management year (Apr. 1-Mar. 31). For the purposes of this report, the catches have been converted to calendar years for consistency.

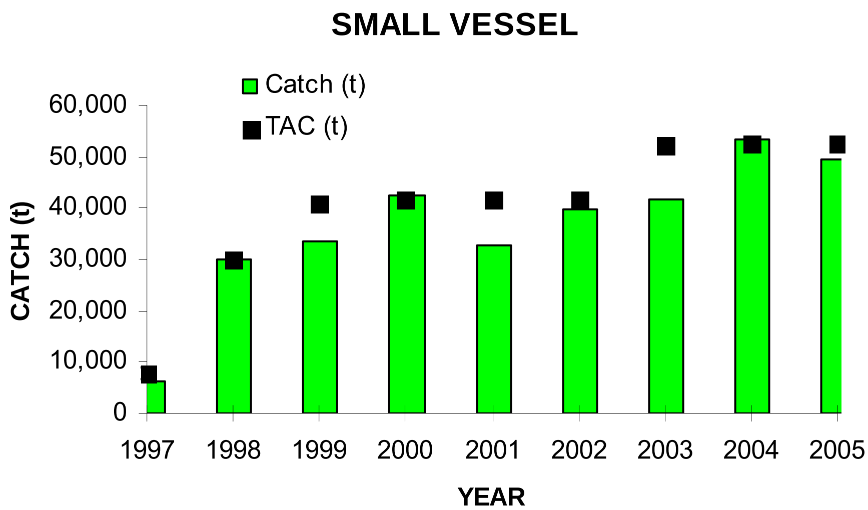


Figure 4. History of SFA 6 small vessel (<500 t; <100 ‘ LOA) catches and quotas, 1997-2005.

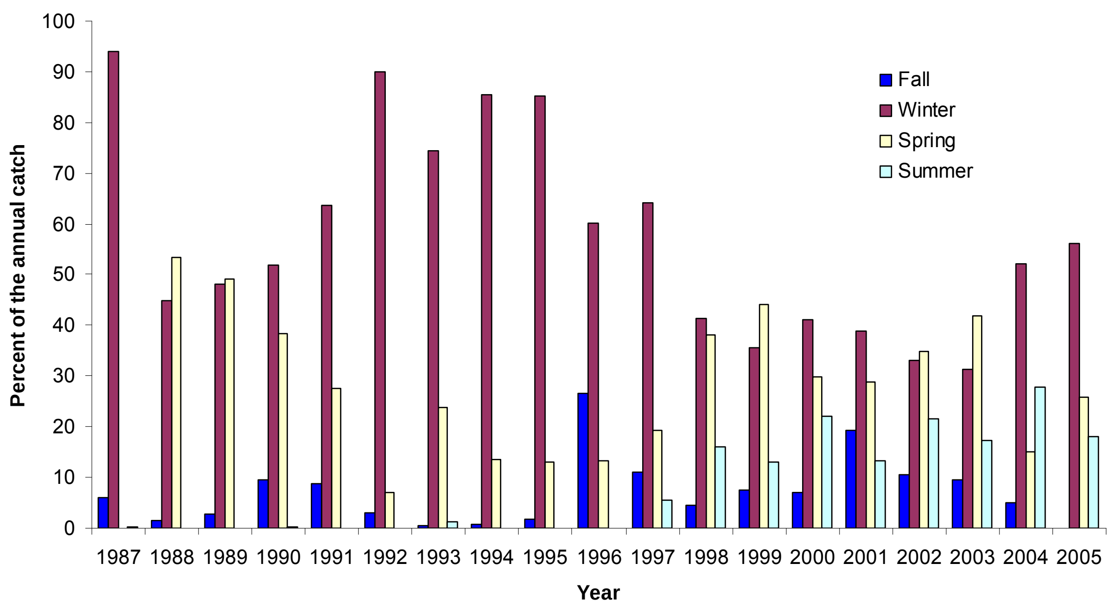


Figure 5. Seasonality of the large vessel (>500 t) fishery within Hawke Channel + 3K (SFA 6) as determined from percent annual catch by season.

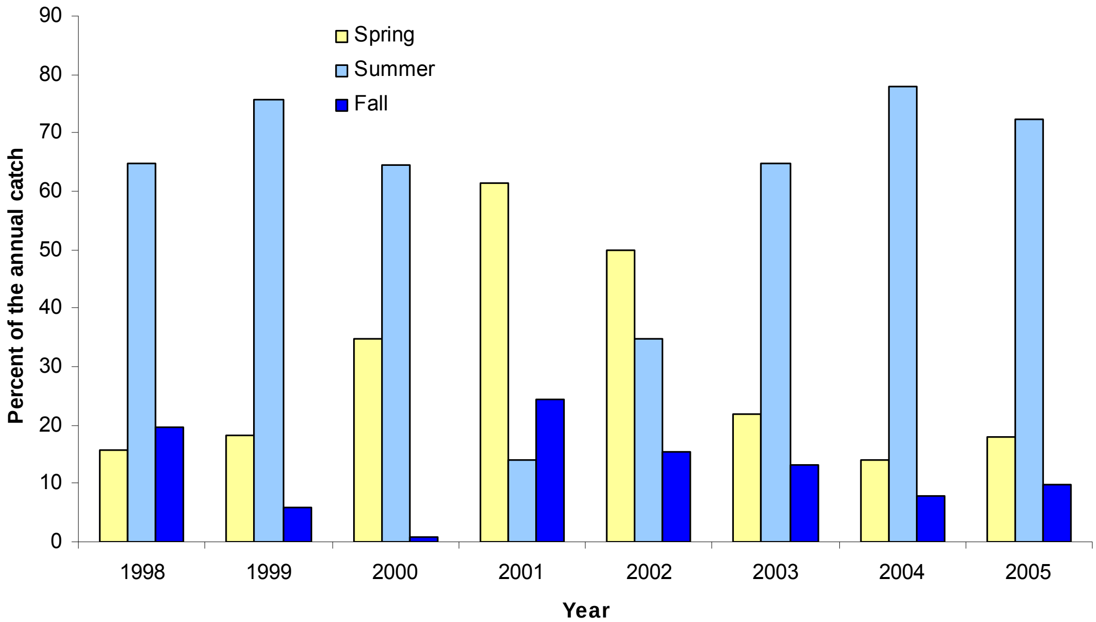


Figure 6. Seasonality of the small vessel (>500 t) fishery within Hawke Channel + 3K (SFA 6) as determined from percent annual catch by season.

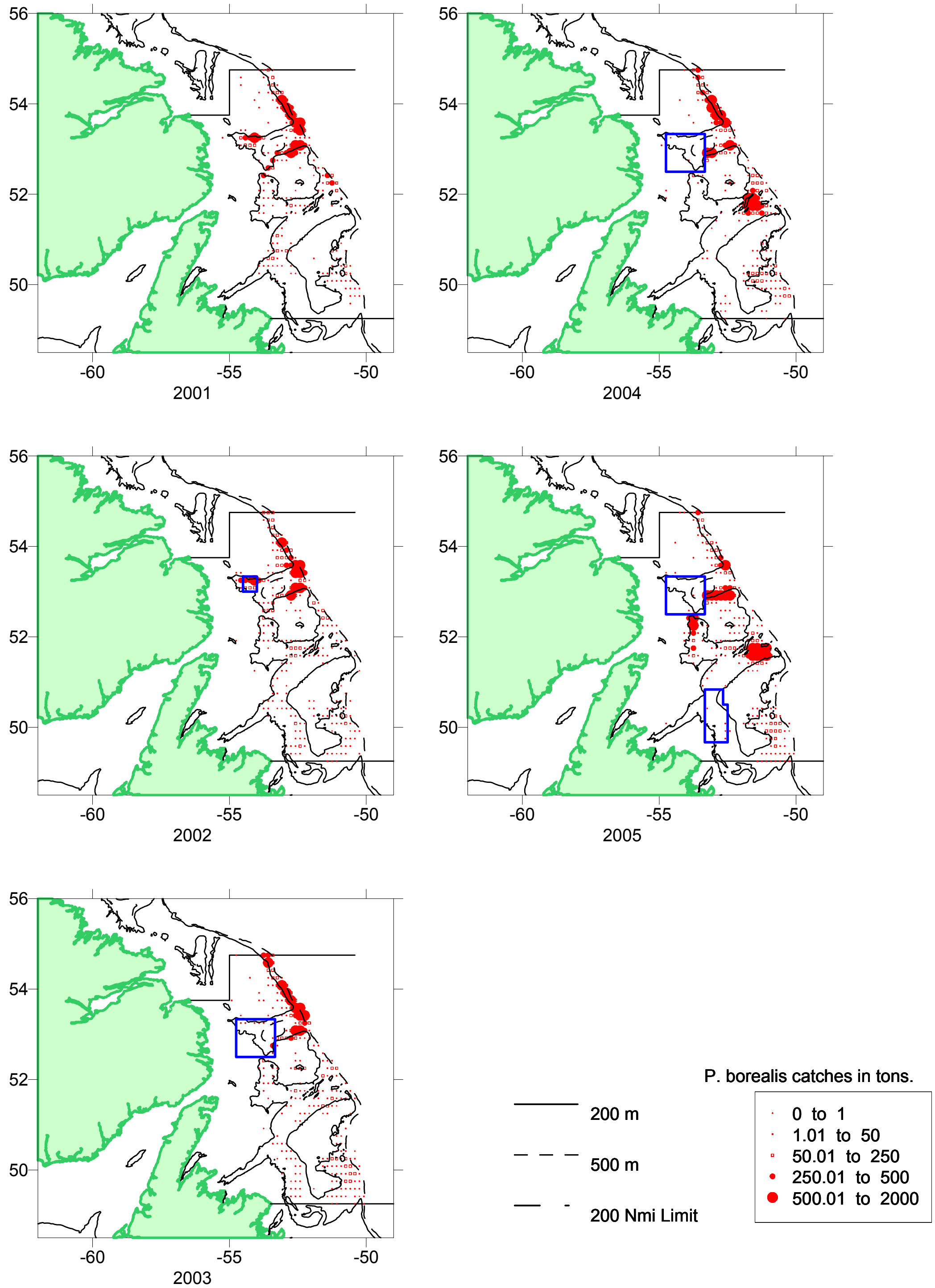


Figure 7. Distribution of large vessel (>500 t) shrimp catches in Hawke Channel + 3K (SFA 6). (Observer data aggregated into 10 min X 10 min cells). Please note that the blue boxes areas are closed to all but crab fishing.

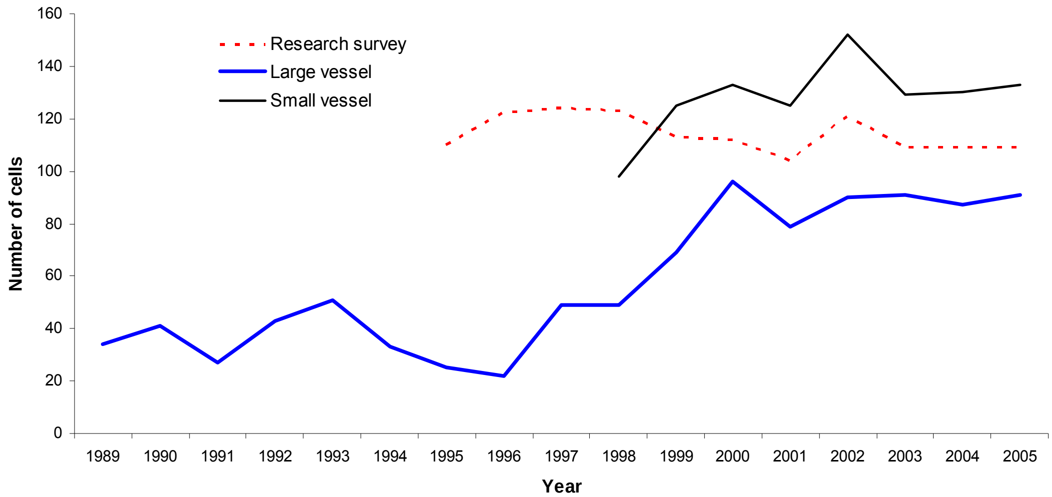


Figure 8. The number of 10 min. X 10 min. cells necessary to account for 95% of the Hawke Channel + 3K (SFA 6) research survey and fishery catches.

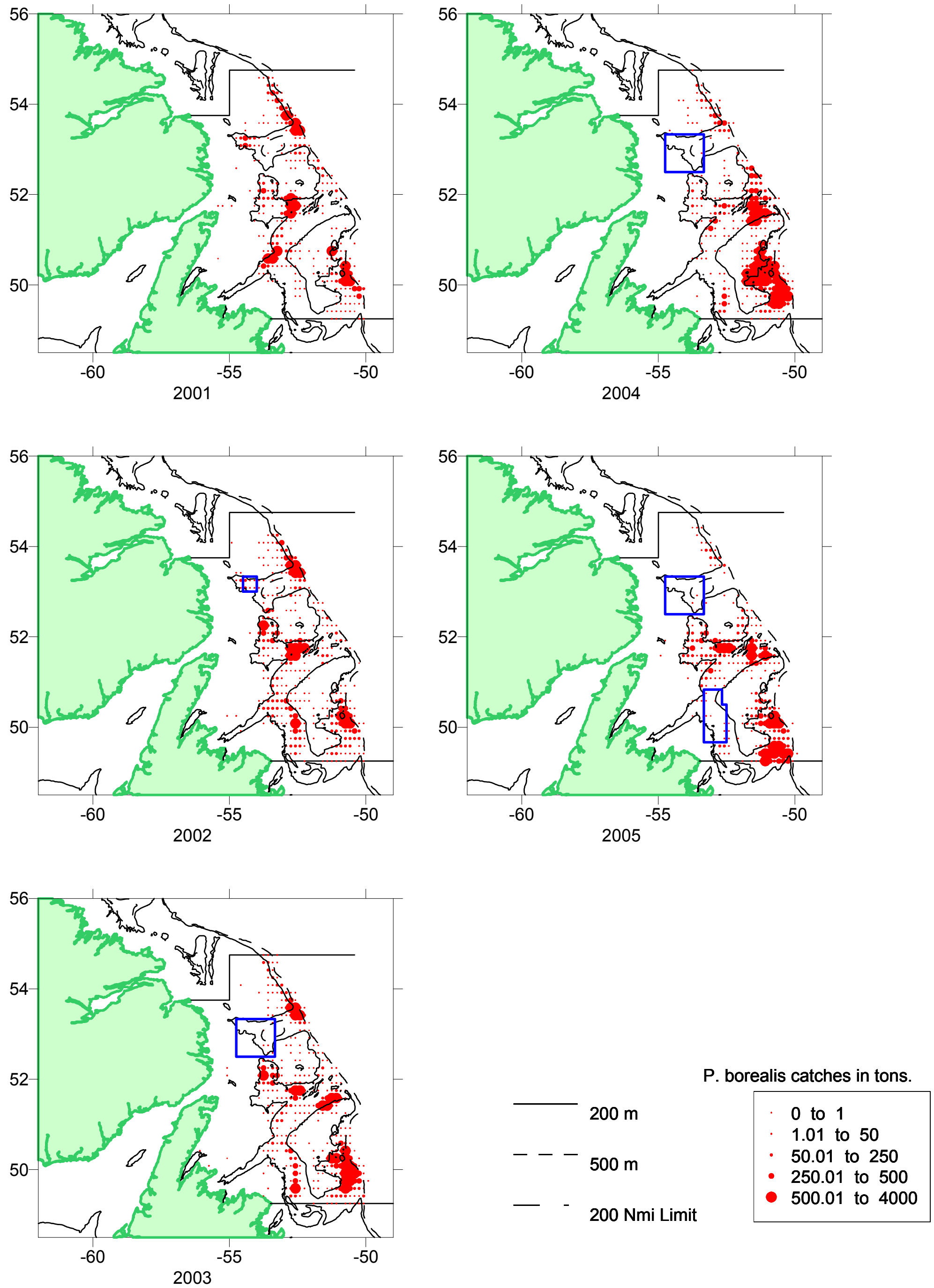


Figure 9. Distribution of small vessel (<500 t; <100' LOA) shrimp catches in Hawke Channel + 3K (SFA 6). (Observer data aggregated into 10 min X 10 min cells). Please note that the blue boxes areas are closed to all but crab fishing.

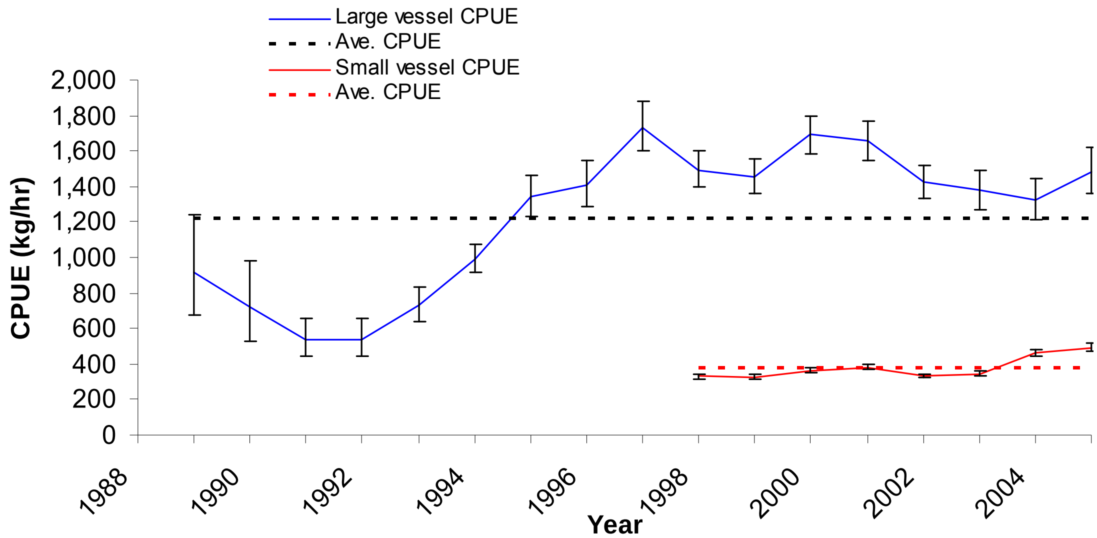


Figure 10. SFA 6 large and small vessel CPUE (error bars indicate 95% confidence intervals around point estimates).

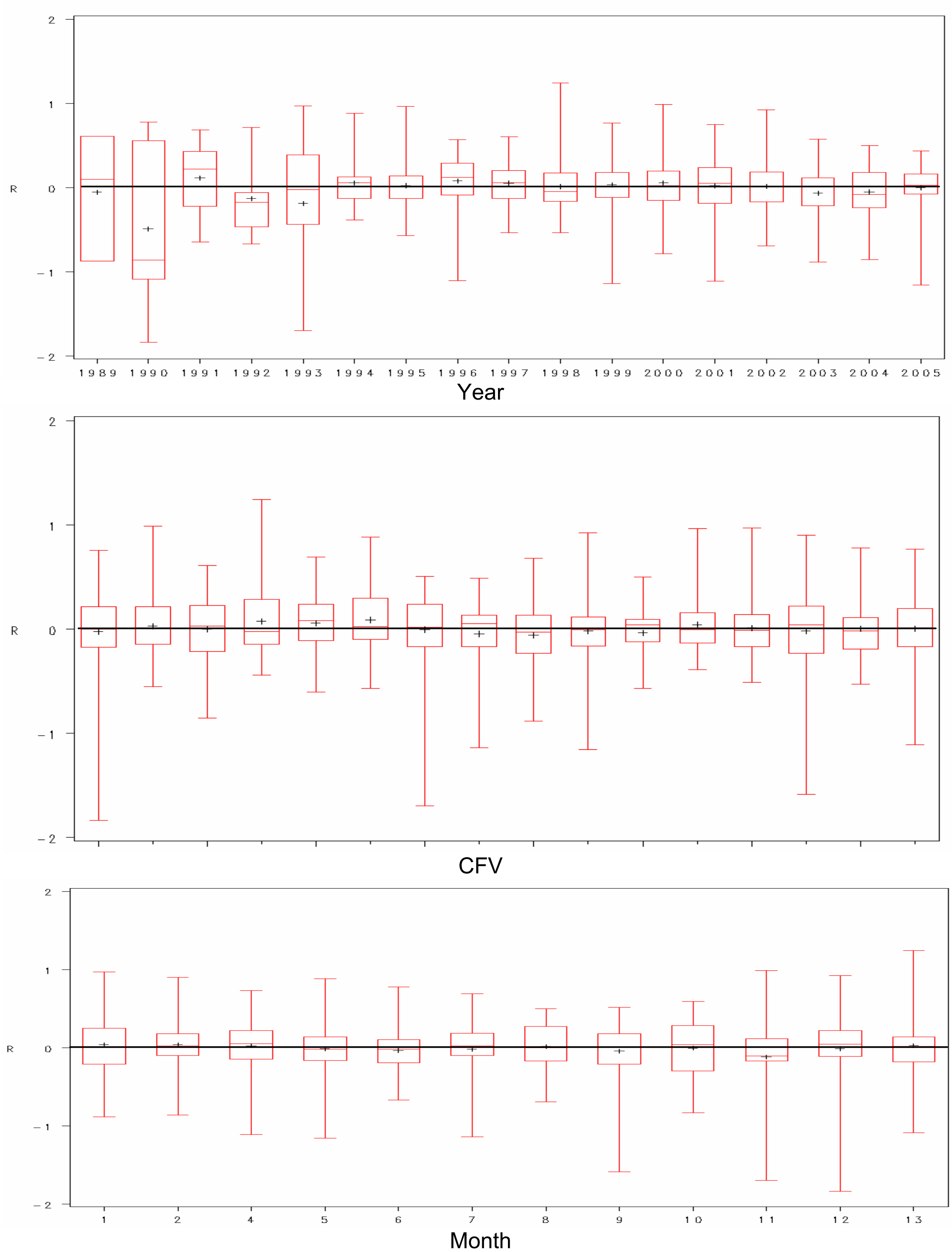


Figure 11. The distribution of residuals around estimated values for parameters used to model large vessel (>500 t) shrimp catch rates within Hawke Channel + 3K (SFA 6), 1989-2005.

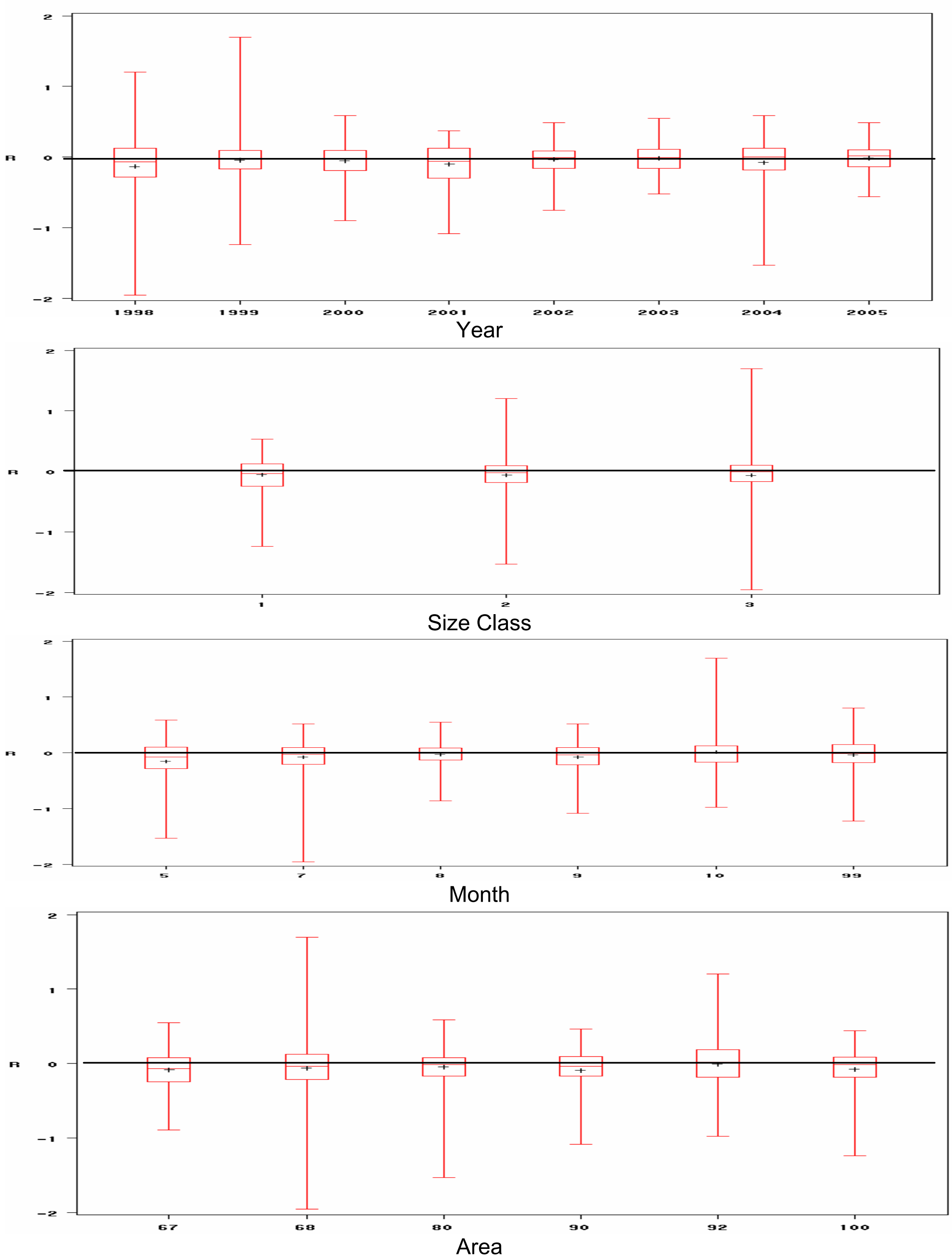


Figure 12. The distribution of residuals around estimated values for parameters used to model small vessel (<500 t; <100' LOA) shrimp catch rates in Hawke Channel + 3K (SFA 6), 1998-2005.

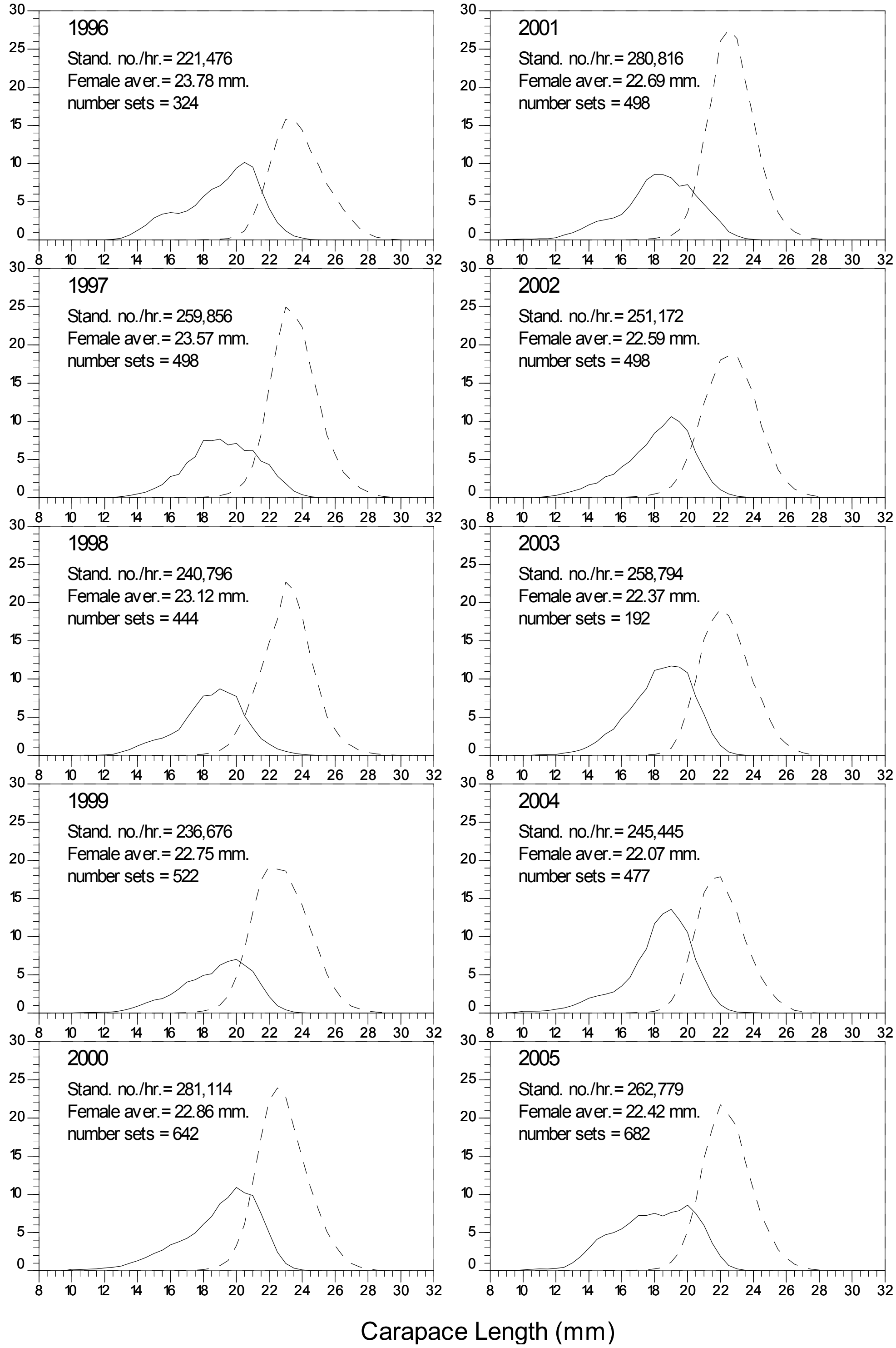


Figure 13. Observed northern shrimp length frequencies (000s per hour) from the Canadian large vessel (>500 t) fleet fishing shrimp within Hawke Channel + 3K (SFA 6) over the period 1996-2005. Solid lines = males; dotted lines = females.

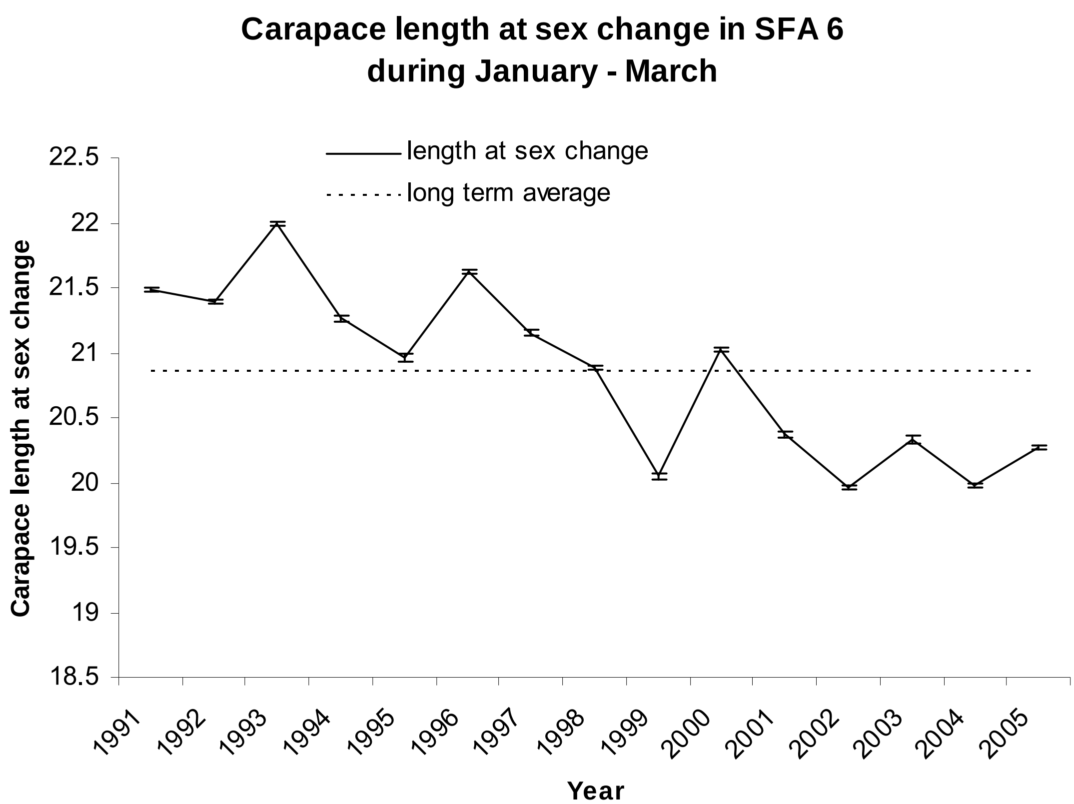


Figure 14. Length at sex change (L_{50}) values derived from observed large vessel (>500 t) commercial length frequencies (1991-2005) from vessels fishing in Hawke Channel + 3K (SFA 6). In order to reduce the influence of seasonality, data were restricted to January-March.

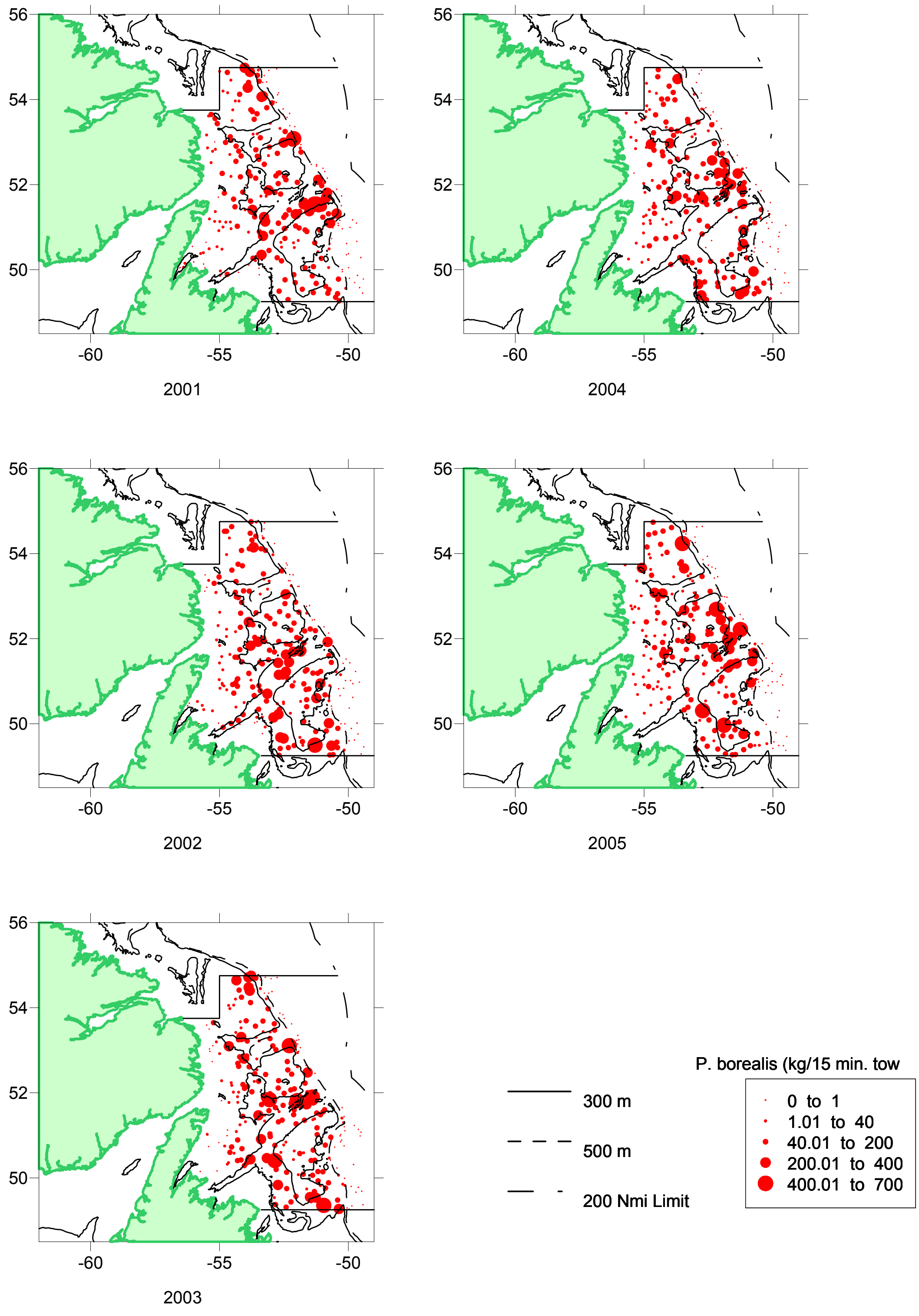


Figure 15. Distribution of Hawke Channel + 3K (SFA 6) northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from autumn research bottom trawl surveys conducted over the period 2001-05.

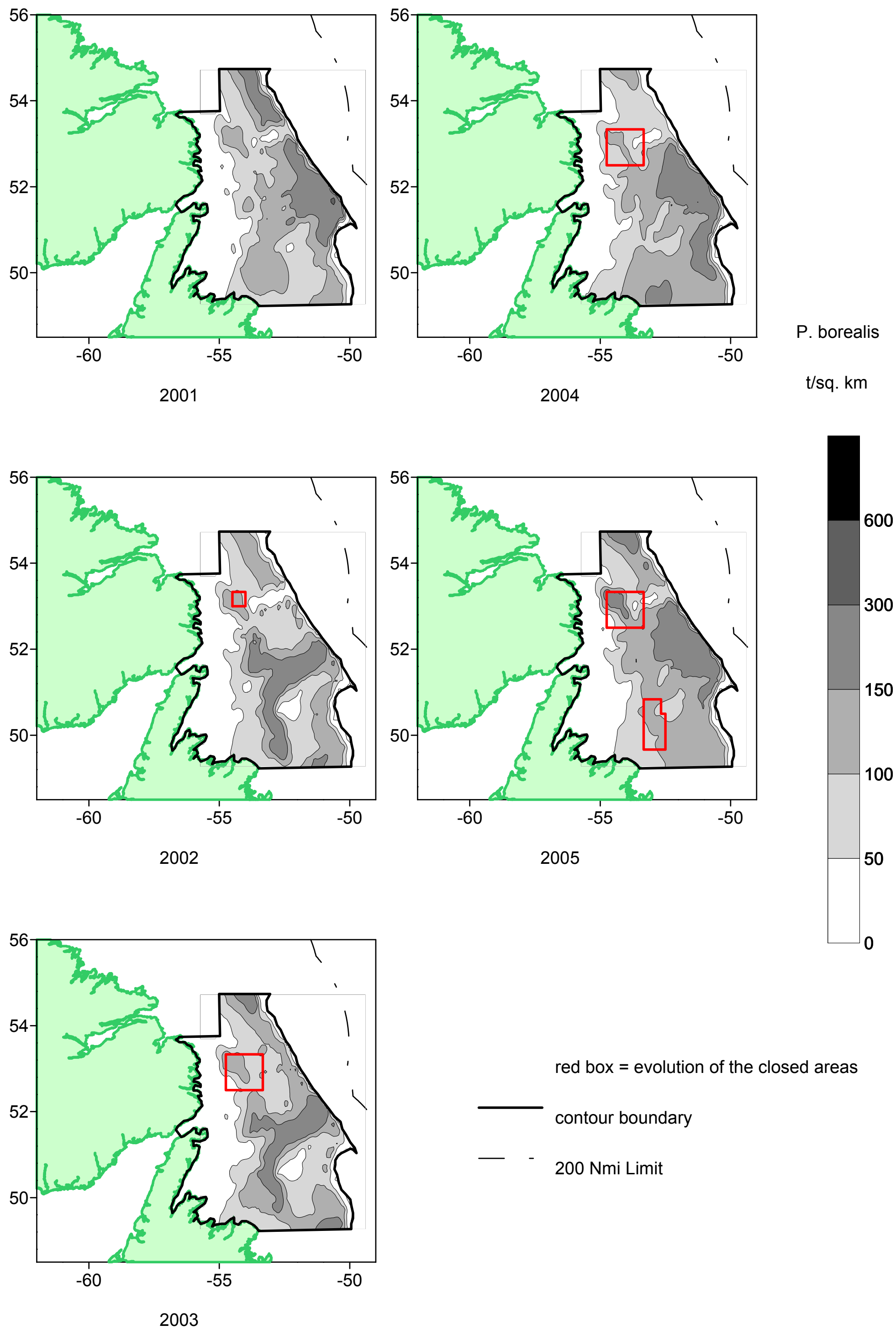


Figure 16. OGive MAPped (Ogmap) density (mass) contours of northern shrimp biomass within Hawke Channel + 3K (SFA 6) as determined from data collected during autumn research bottom trawl surveys conducted over the period 2001-05.

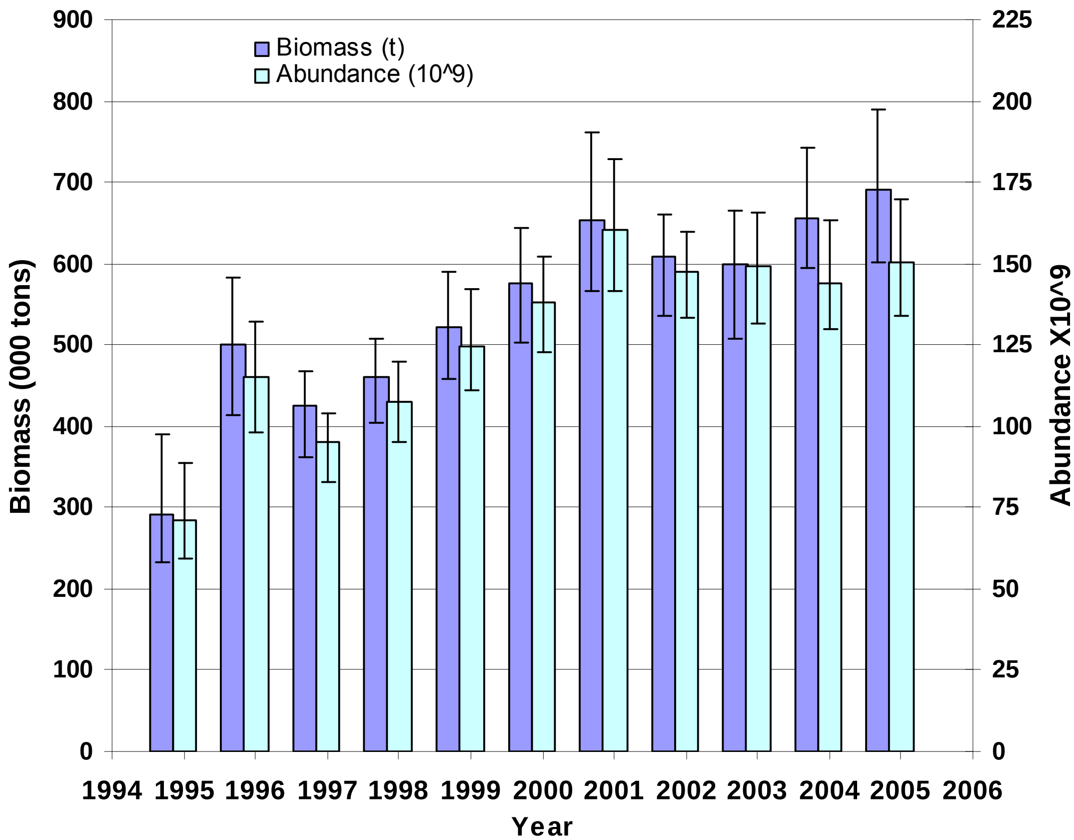


Figure 17. Autumn northern shrimp (*Pandalus borealis*) biomass and abundance indices within Hawke Channel + 3K (SFA 6), as determined using <u>OG</u>ive <u>MAP</u>ping calculations. Data were from annual Canadian multi-species bottom trawl surveys using a Campelen 1800 shrimp trawl.

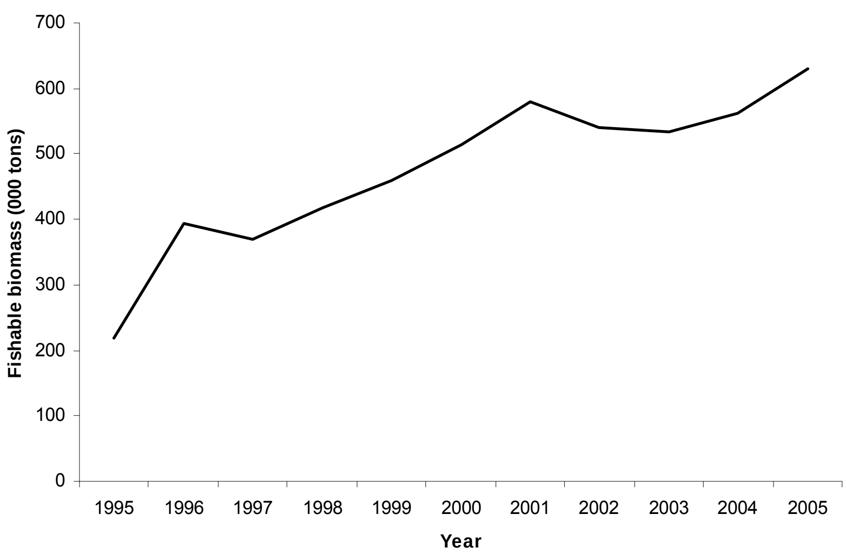


Figure 18. Fishable northern shrimp (*Pandalus borealis*) biomass (biomass of all males >17 mm carapace length + biomass of all females) within Hawke Channel + 3K (SFA 6).

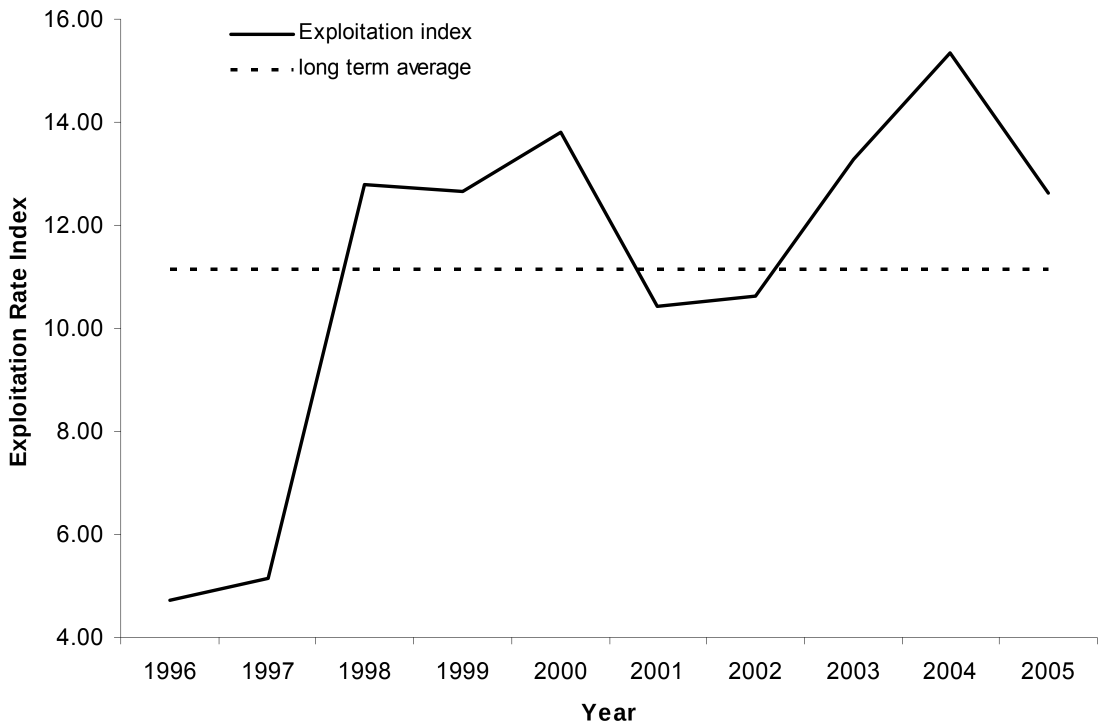


Figure 19. The exploitation rate index for northern shrimp harvested from Hawke Channel + 3K (SFA 6), 1996-2005. Exploitation was determined as a ratio of catch/ lower 95% confidence limit of the previous year's biomass estimate.

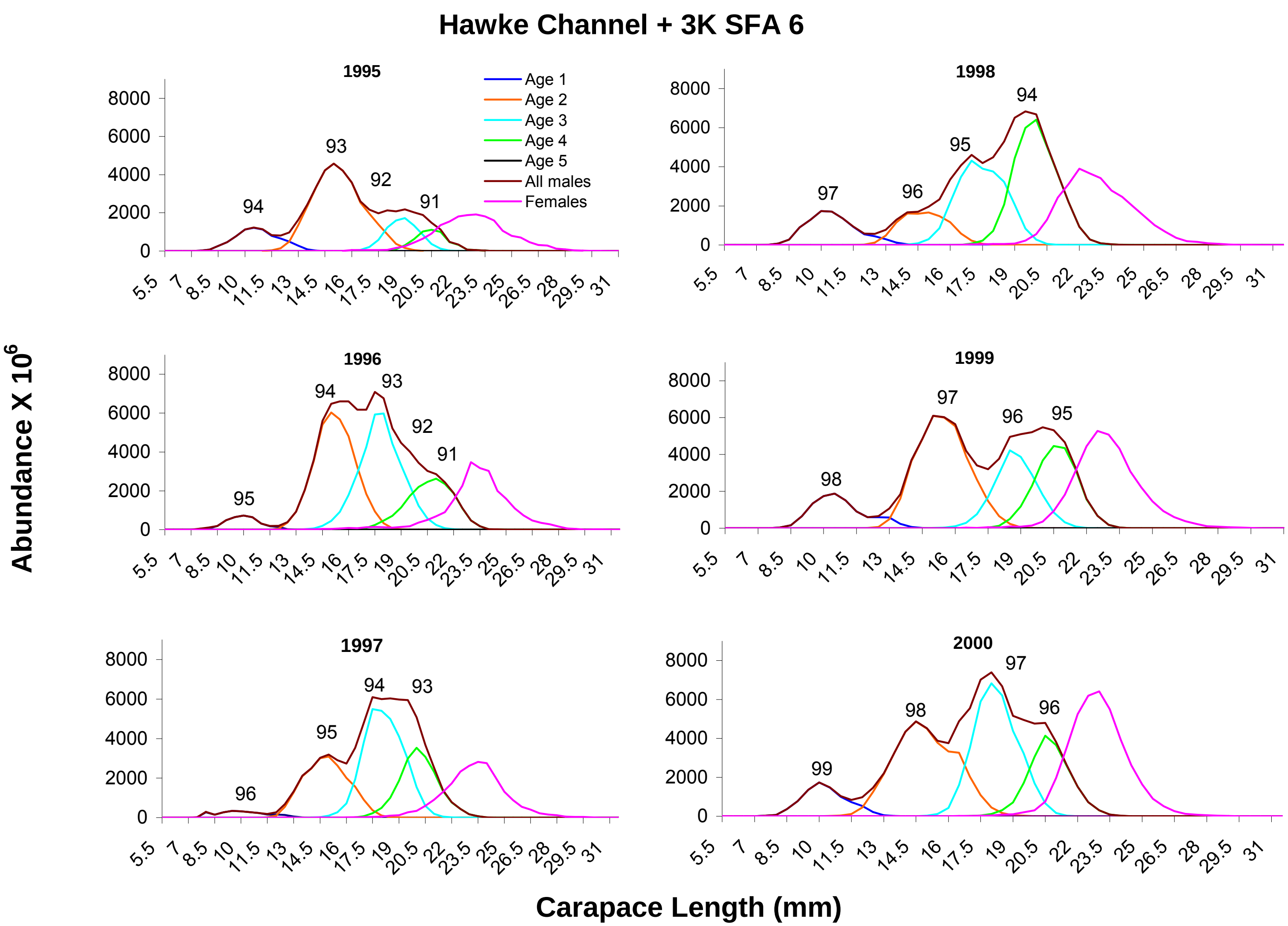


Figure 20. Abundance at length for Hawke Channel + 3K (SFA 6) northern shrimp (*Pandalus borealis*) estimated by OGive MAPping of autumn multi-species bottom trawl survey data 1995-2005.

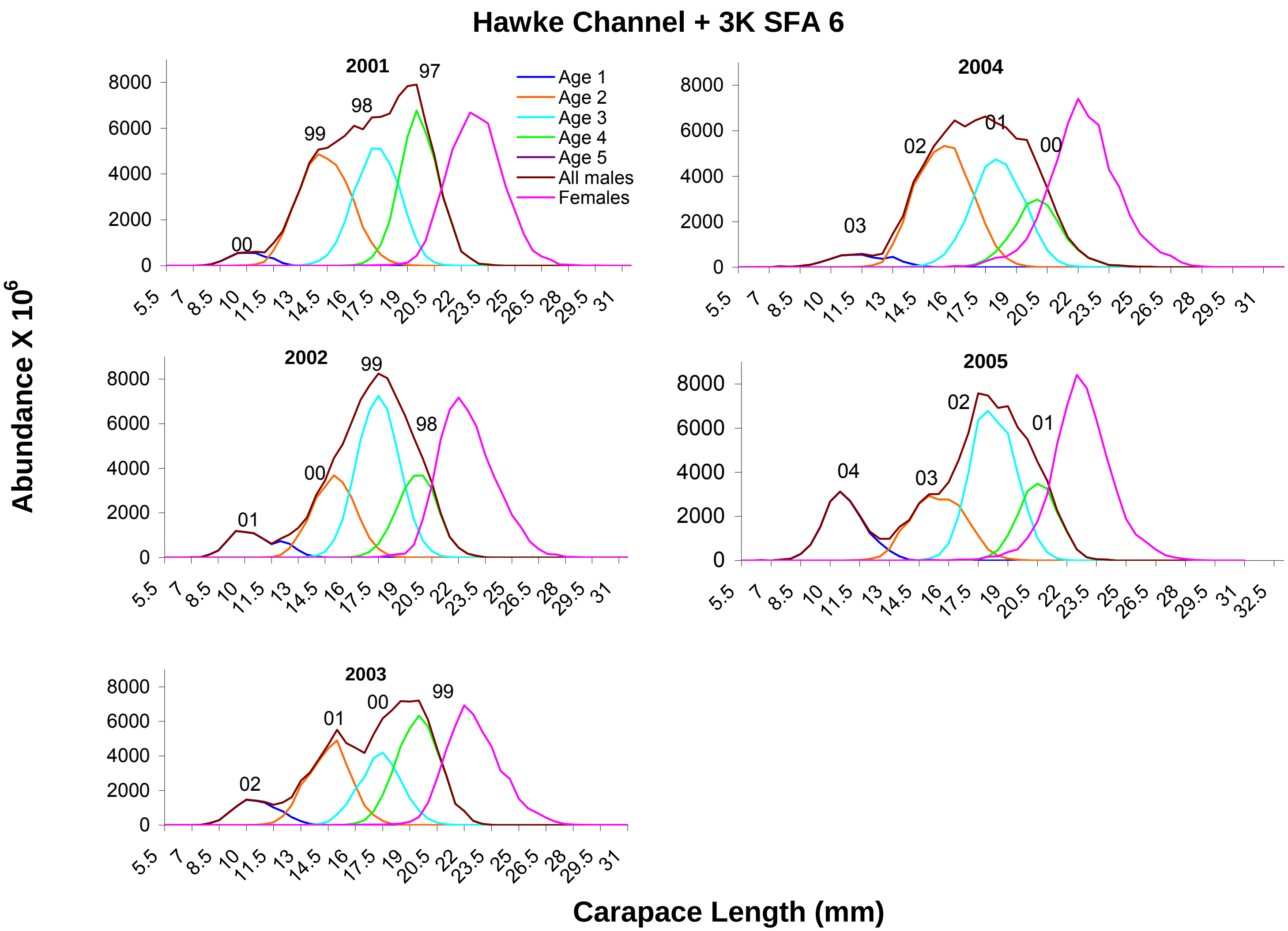
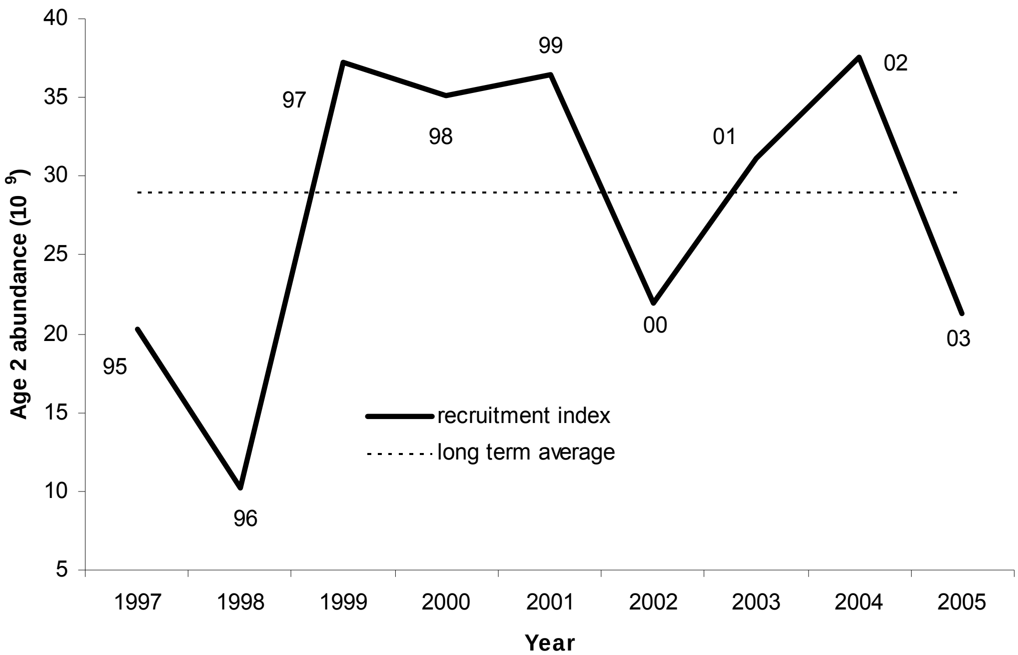
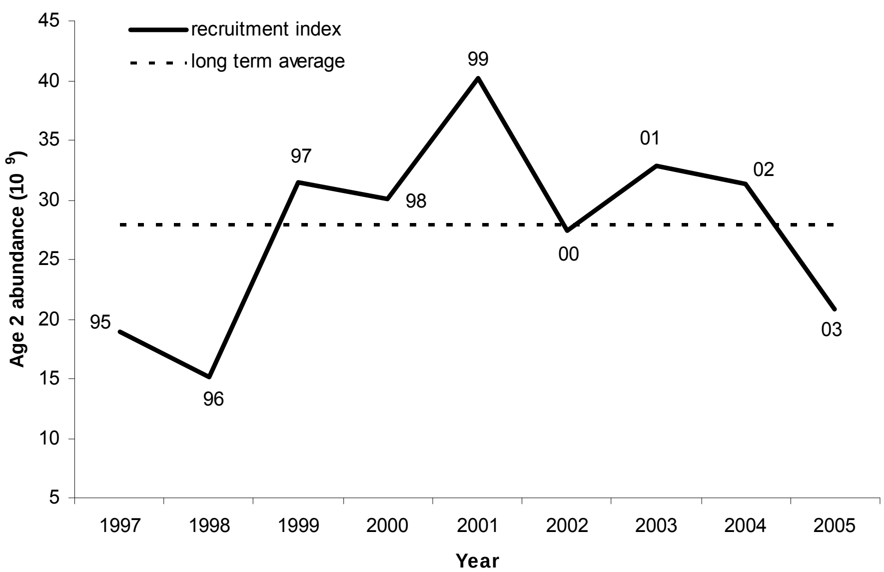


Figure 20. (Cont'd.) Abundance at length for Hawke Channel + 3K (SFA 6) northern shrimp (*Pandalus borealis*) estimated by OGive MAPping of autumn multi-species bottom trawl survey data 1995-2005 (continued).



A)



B)

Figure 21. SFA 6 research survey recruitment indices (age 2 abundance from modal analysis (A) and from abundances of all males with 11.5-16.0 mm carapace lengths (B)) over the period 1997-2005. The latter was presented in the Stock Advisory Report (2000/007).

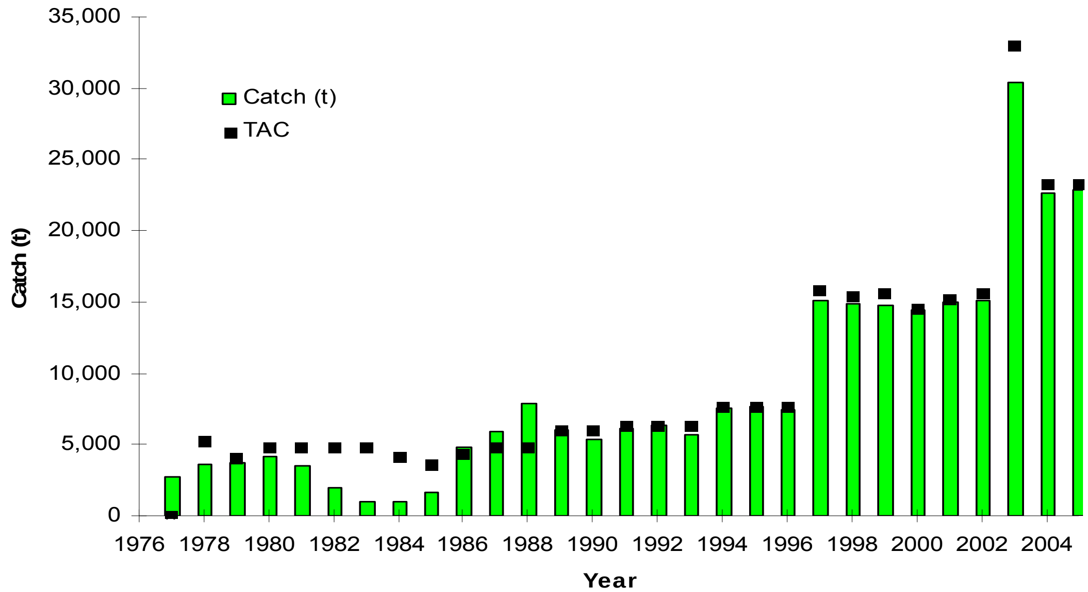


Figure 22. Total northern shrimp (*Pandalus borealis*) catches and quotas within Hopedale + Cartwright Channels (SFA 5), 1977-2005.

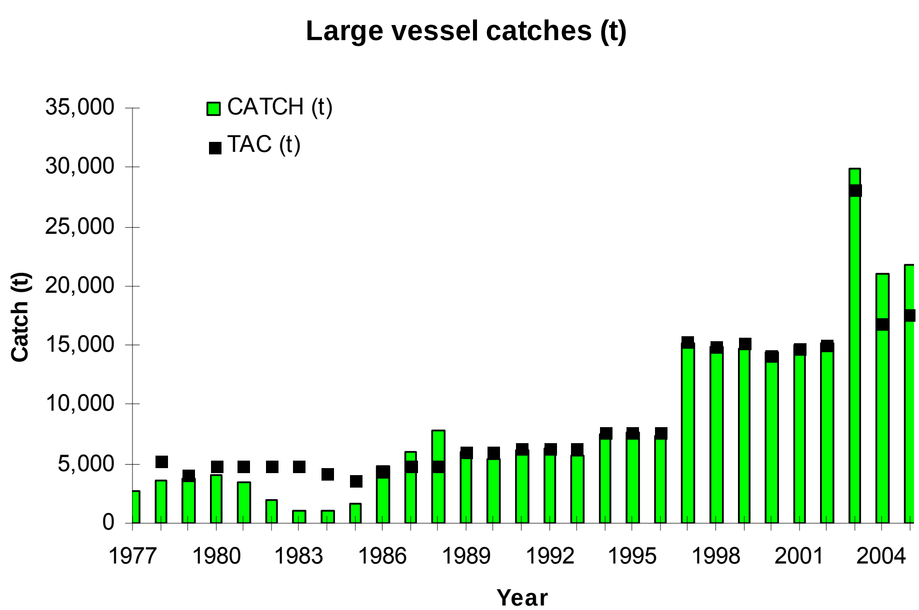


Figure 23. Large vessel (>500 t) northern shrimp (*Pandalus borealis*) catches and quotas within Hopedale and Cartwright Channels (SFA 5), 1977-2005. Note that beginning in 2003, TAC's have been allocated by management year (Apr. 1-Mar. 31). For consistency, the catches have been converted to calendar years. The large vessel catches appear to exceed the large vessel quotas because of quota transfers. As illustrated in Fig. 22, the total quotas for all fleets should be met in 2005.

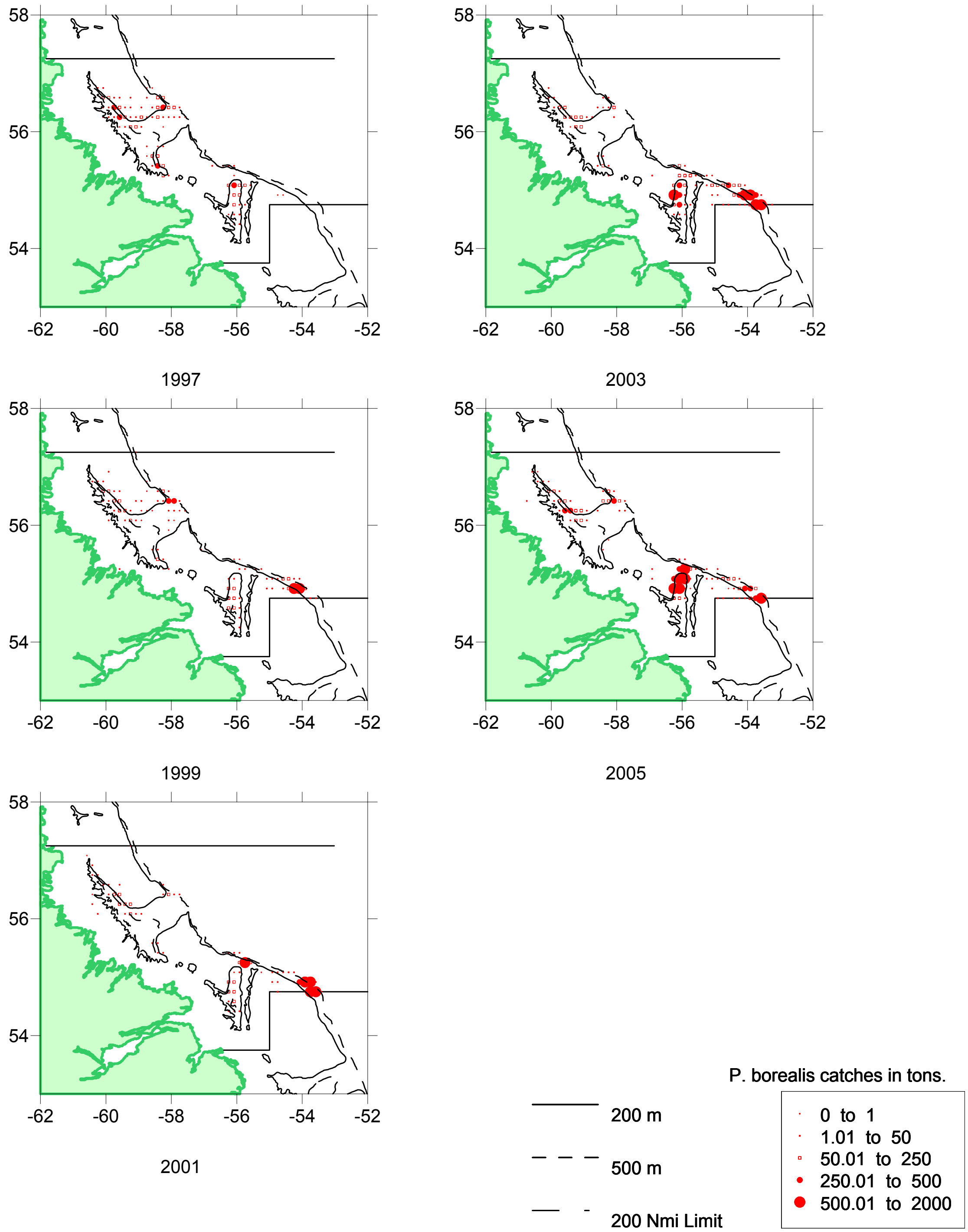


Figure 24. Distribution of large vessel (>500 t) shrimp catches in Hopedale and Cartwright Channels (SFA 5). (Observer data aggregated into 10 min X 10 min cells).

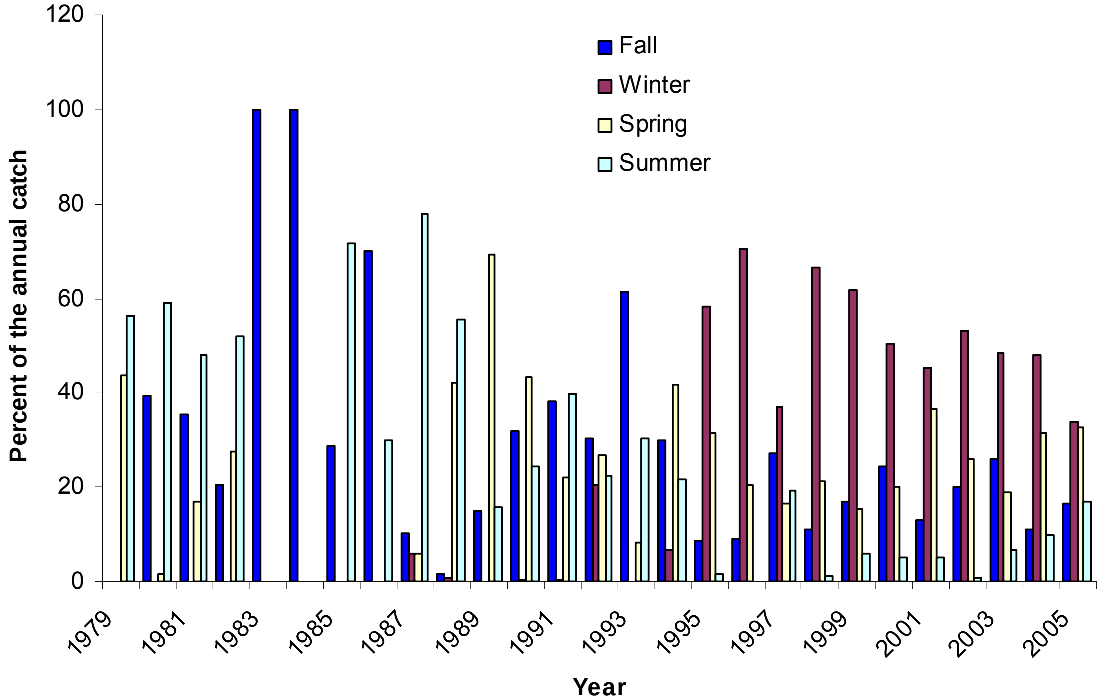


Figure 25. Seasonality of the large vessel (>500 t) fishery within Hopedale and Cartwright Channels (SFA 5) as determined from percent annual catch by season.

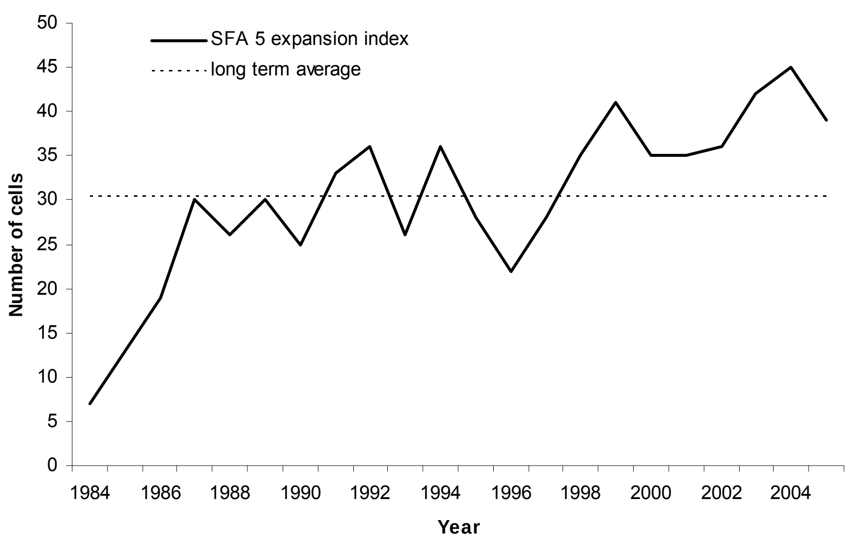
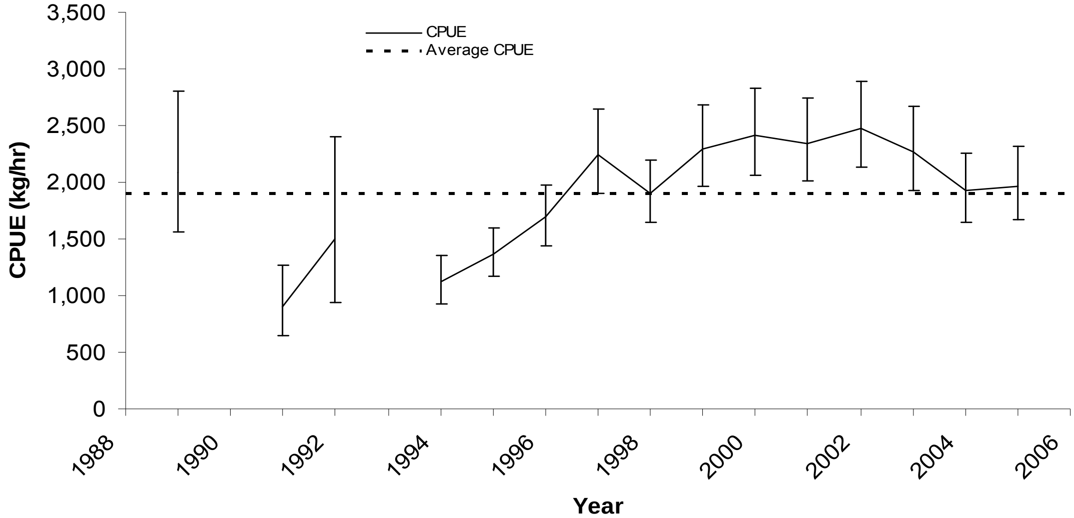
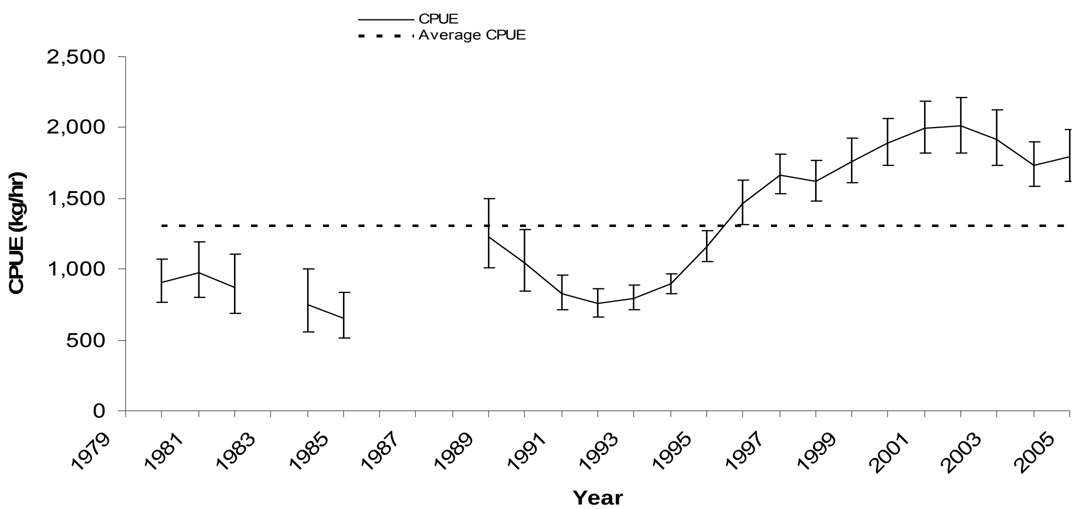


Figure 26. The number of 10 min. X 10 min. cells necessary to account for 95% of the Hopedale and Cartwright Channels (SFA 5) large vessel catches.



A).



B)

Figure 27. SFA 5 large vessel CPUE (error bars indicate 95% confidence intervals around point estimates). Model A was presented in the Stock Advisory Report (2006/077) and was constrained only to data from January-June as the fishery has switched from a summer fall fishery to a winter spring fishery (Fig. 25). Model B model includes all months and was presented at the March 2006 RAP; it will be described in the remainder of this report when referring to the SFA 5 catch rate indices.

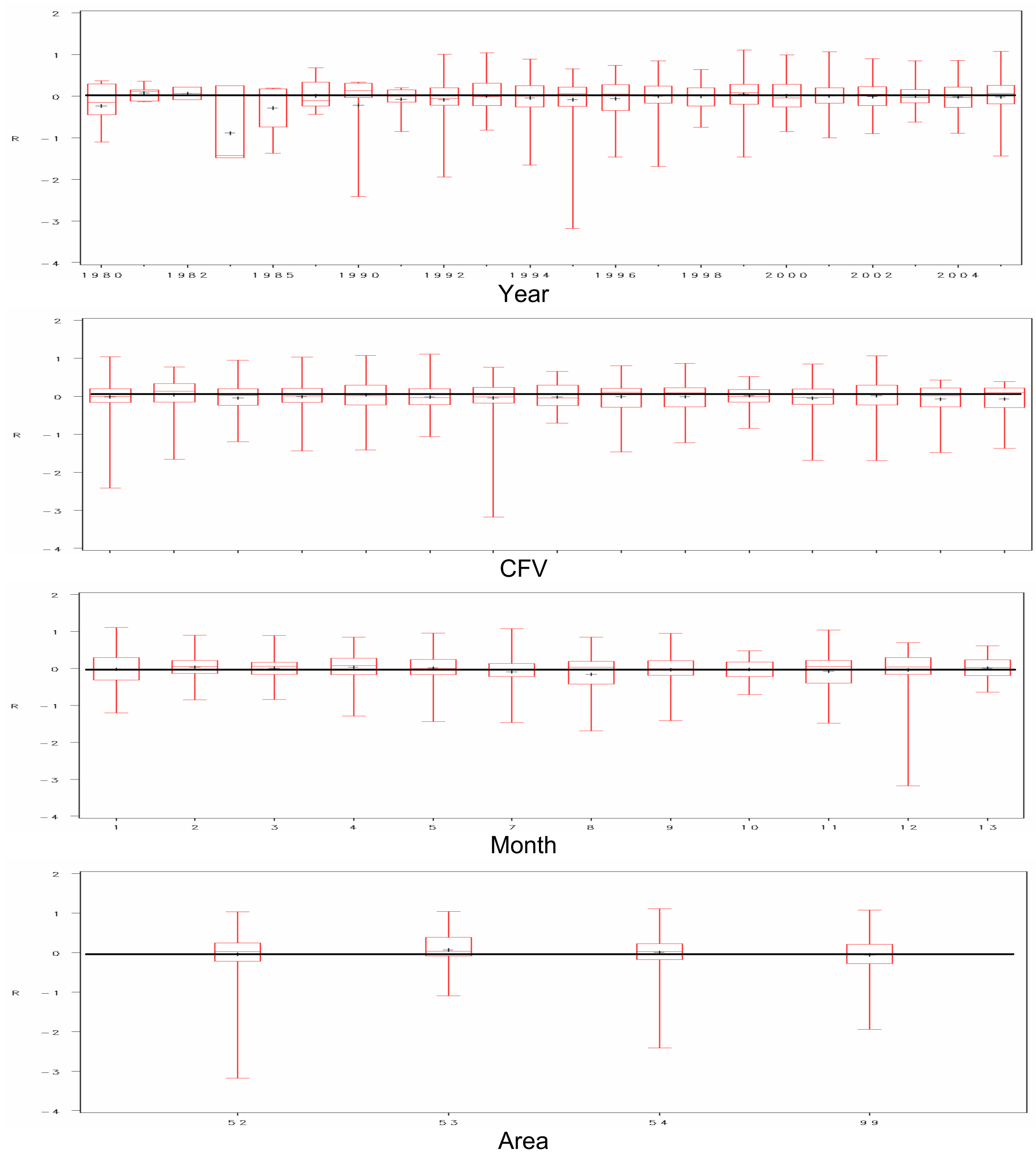


Figure 28. The distribution of residuals around estimated values for parameters used to model large vessel (>500 t) shrimp catch rates in Hopedale and Cartwright Channels (SFA 5), 1989-2005.

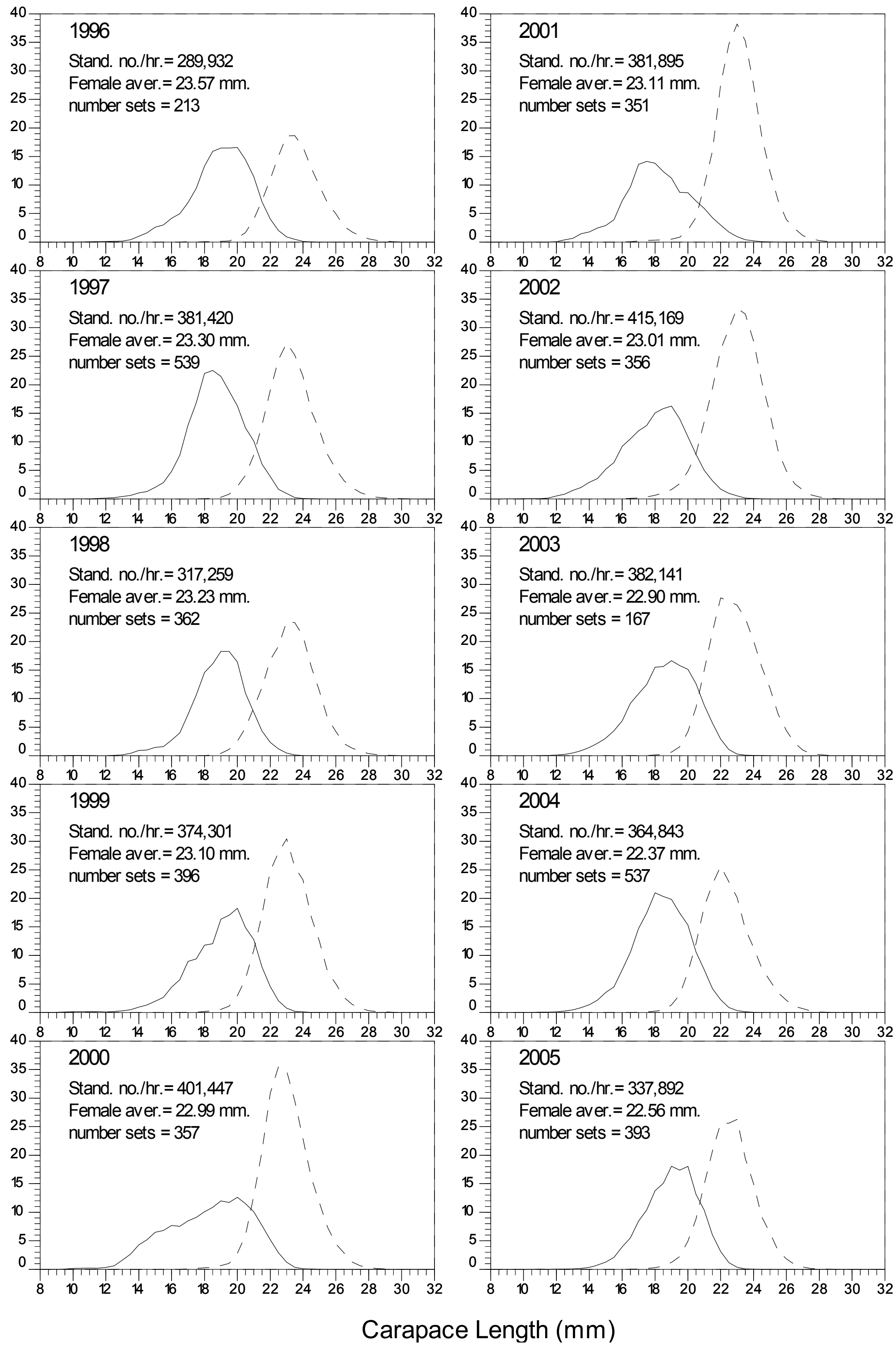


Figure 29. Observed northern shrimp length frequencies (000s per hour) from the Canadian large vessel (>500 t) fleet fishing shrimp within Hopedale and Cartwright Channels (SFA 5) over the period 1996-2005. Solid lines = males; dotted lines = females.

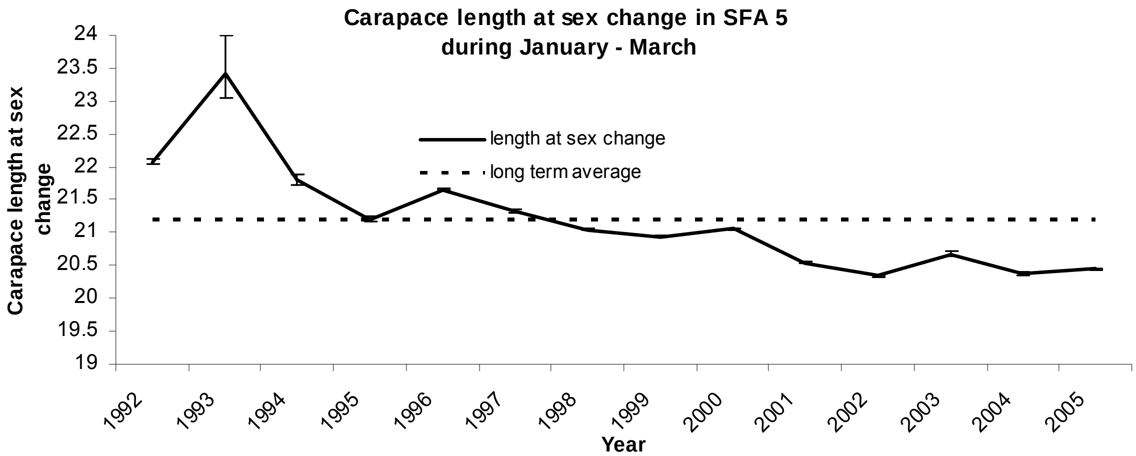


Figure 30. Length at sex change (L_{50}) values derived from observed large vessel (>500 t) commercial length frequencies (1992-2005). In order to reduce the influence of seasonality, data were restricted to the January-March.

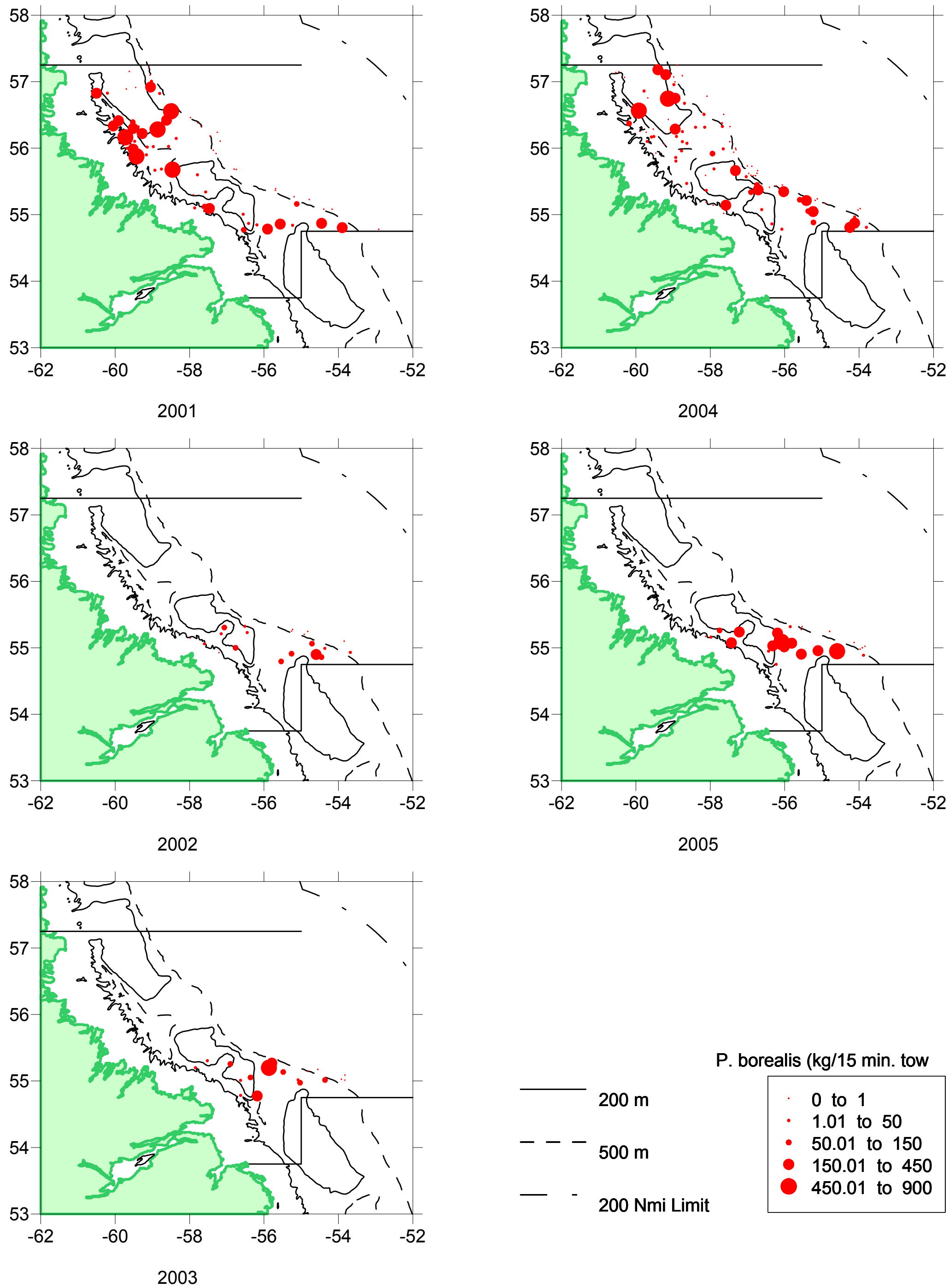


Figure 31. Distribution of Hopedale and Cartwright Channels (SFA 5) northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from autumn bottom trawl surveys conducted over the 2001-05.

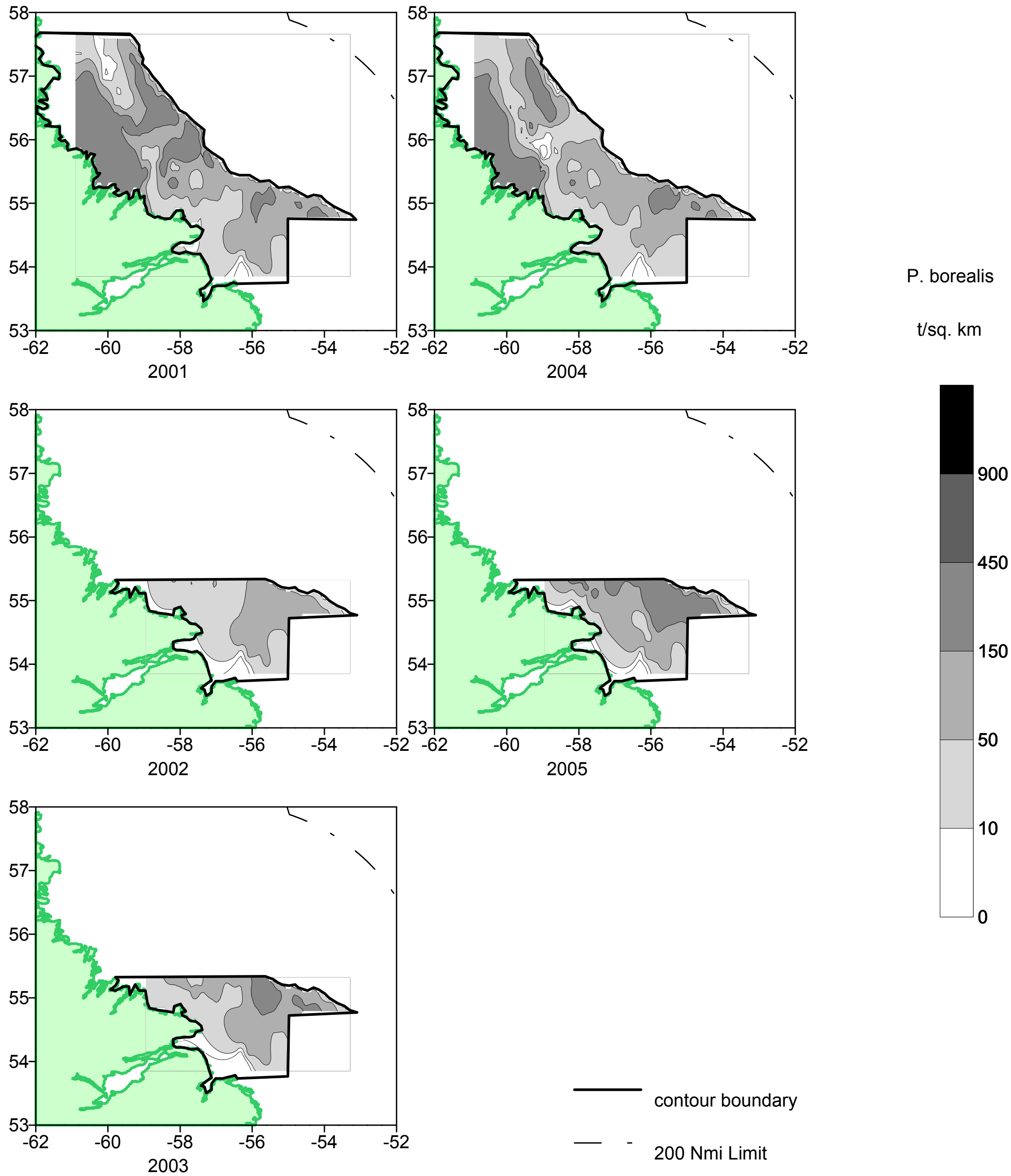
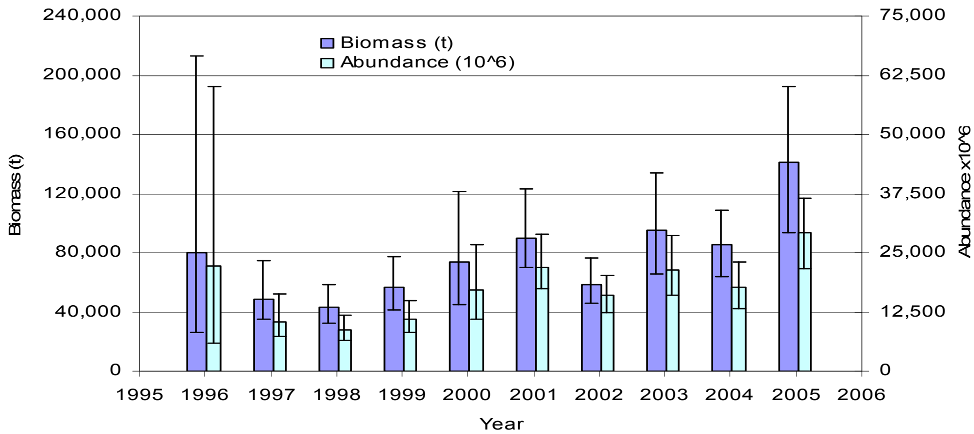
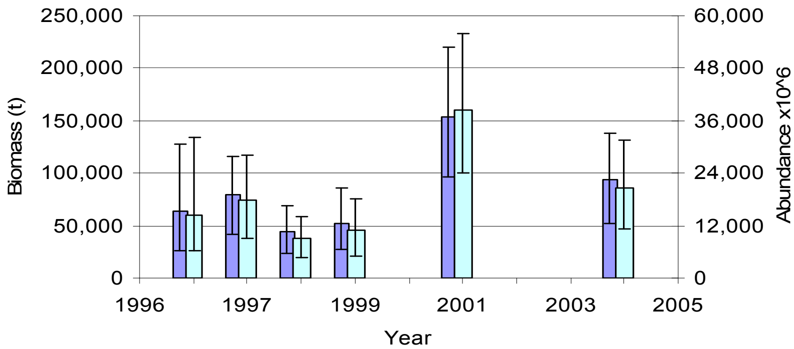


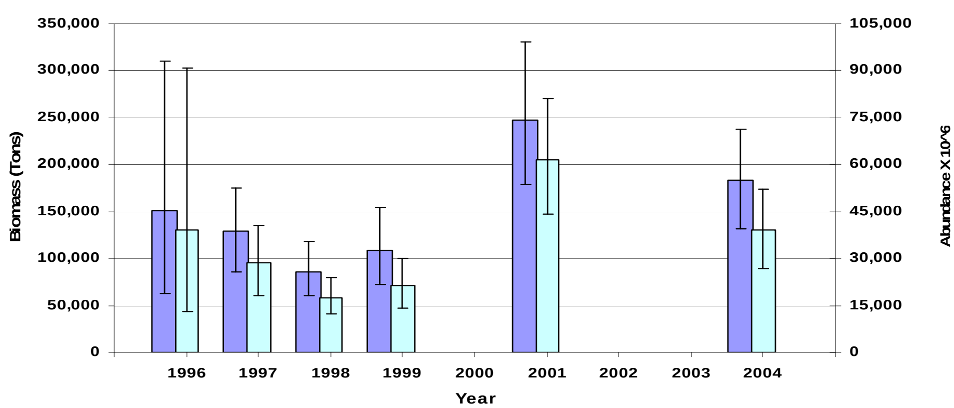
Figure 32. OGive MAPped (Ogmap) density (mass) contours of northern shrimp biomass within Hopedale and Cartwright Channels (SFA 5) as determined from data collected during autumn research bottom trawl surveys conducted over the period 2001-05.



A) Cartwright Channel

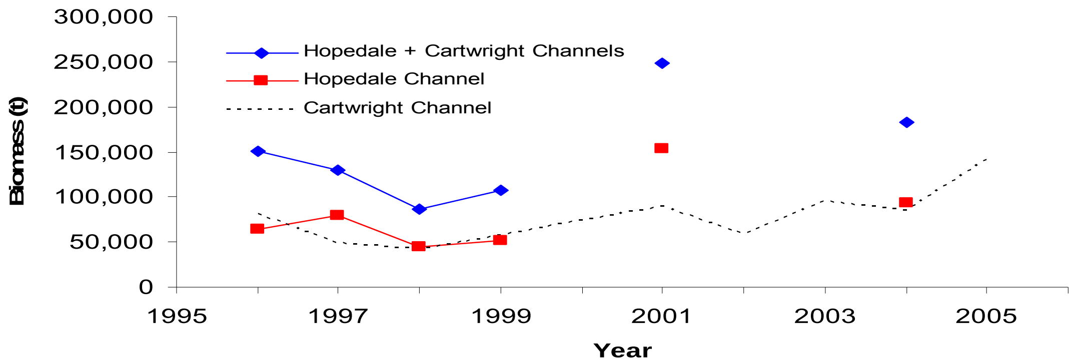


B) Hopedale Channel



C) Hopedale and Cartwright Channels (SFA 5)

Figure 33. Autumn northern shrimp (*Pandalus borealis*) biomass and abundance indices within A) Cartwright Channel, B) Hopedale Channel and C) the entire of SFA 5, as determined using Ogmap calculations. Data were from annual Canadian multi-species bottom trawl surveys using a Campelen 1800 shrimp trawl.



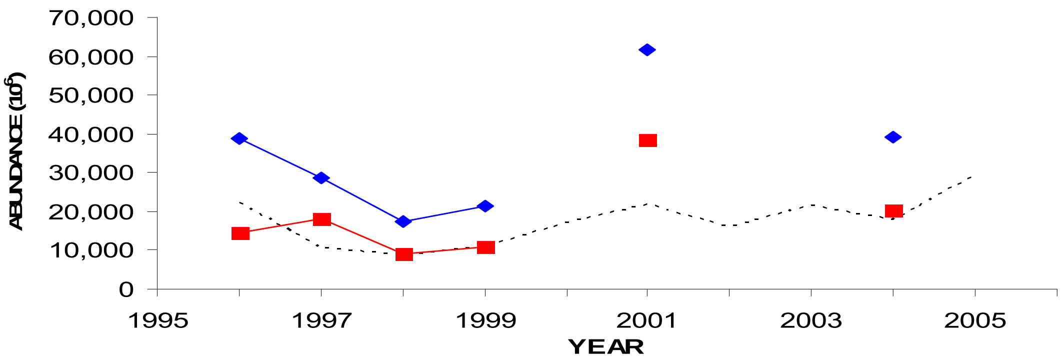


Figure 34. An overlay of Cartwright Channel indices (biomass and abundance) with those from Hopedale Channel and the entire of SFA 5 with the goal of determining whether Cartwright Channel indices can be used as a proxy for indices within the entire of SFA 5.

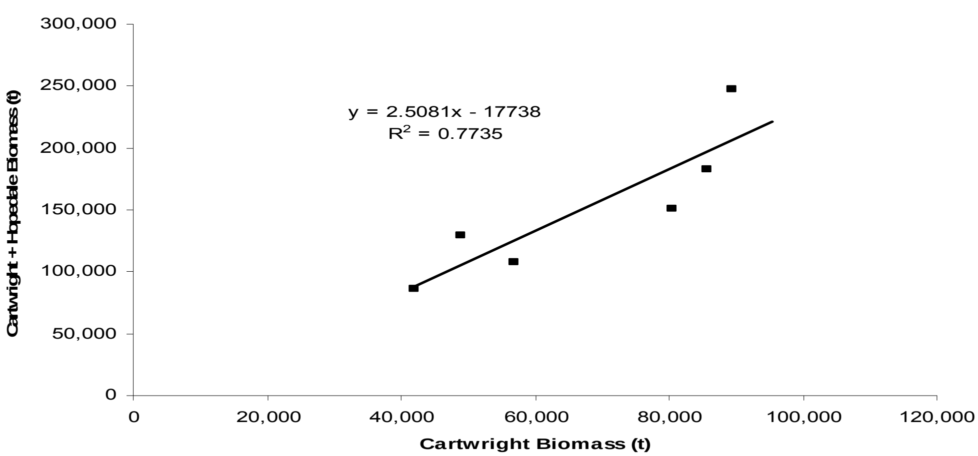


Figure 35. A preliminary relationship between Cartwright Channel biomass indices and biomass indices within the entire of SFA 5.

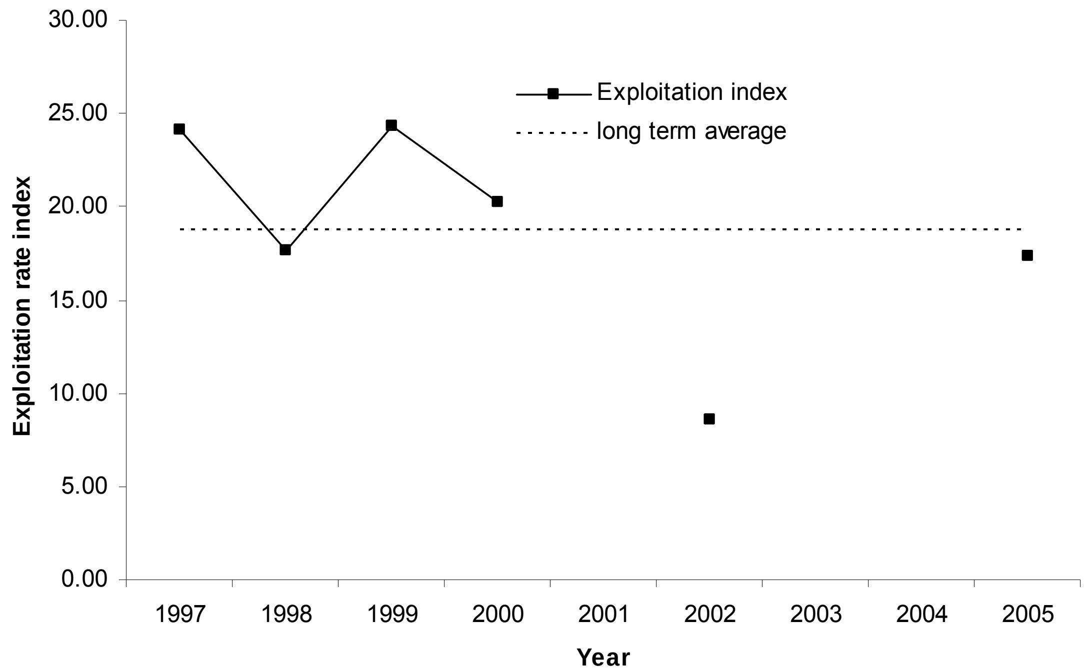


Figure 36. The exploitation rate index for northern shrimp harvested from the entire of SFA 5, 1997-2005. Exploitation was determined as a ratio of catch/ lower 95% confidence limit of the previous year's biomass estimate.

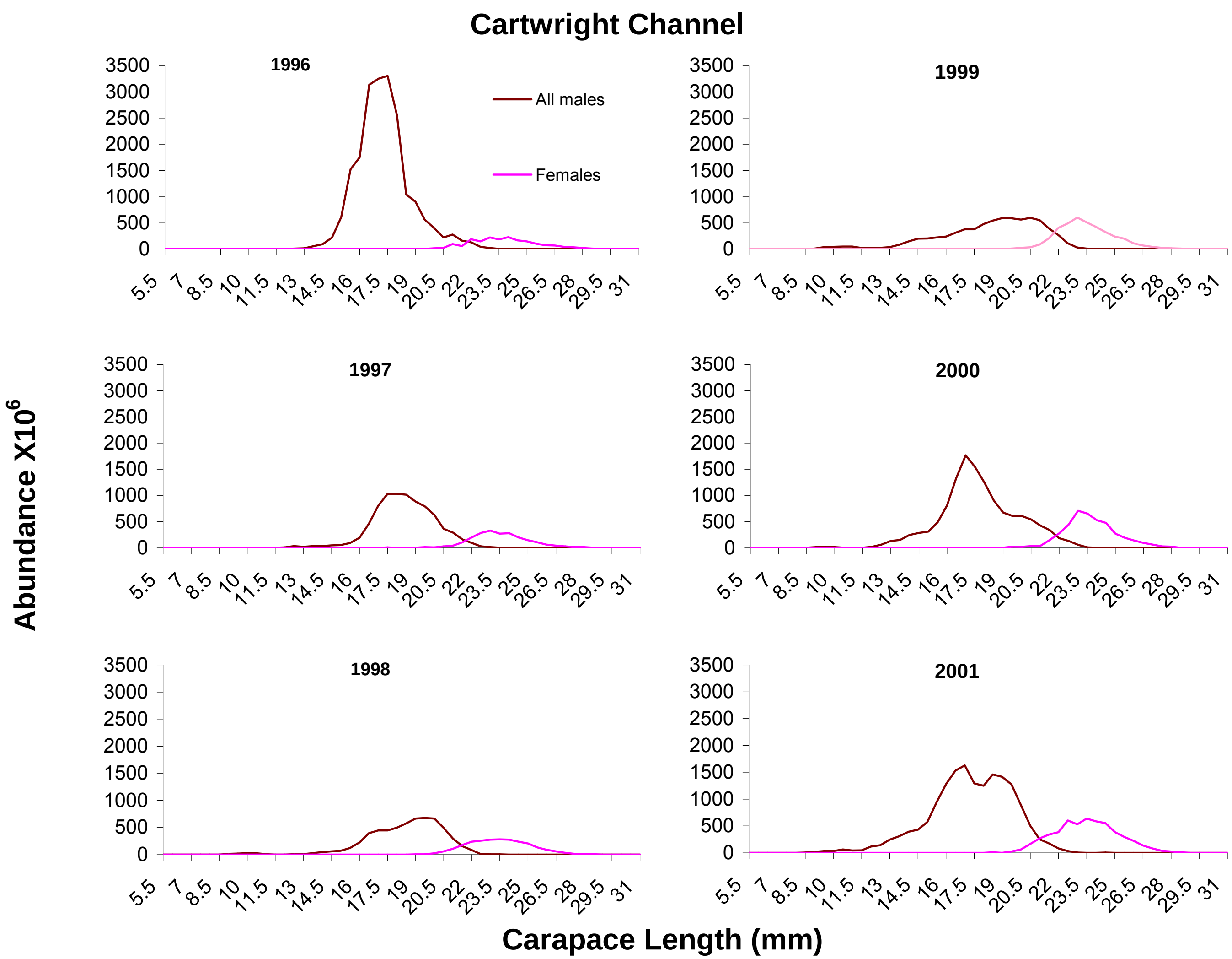


Figure 37. Abundance at length for Cartwright Channel northern shrimp (*Pandalus borealis*) estimated by Ogmap calculations of autumn multi-species bottom trawl survey data 1995-2005.

Cartwright Channel

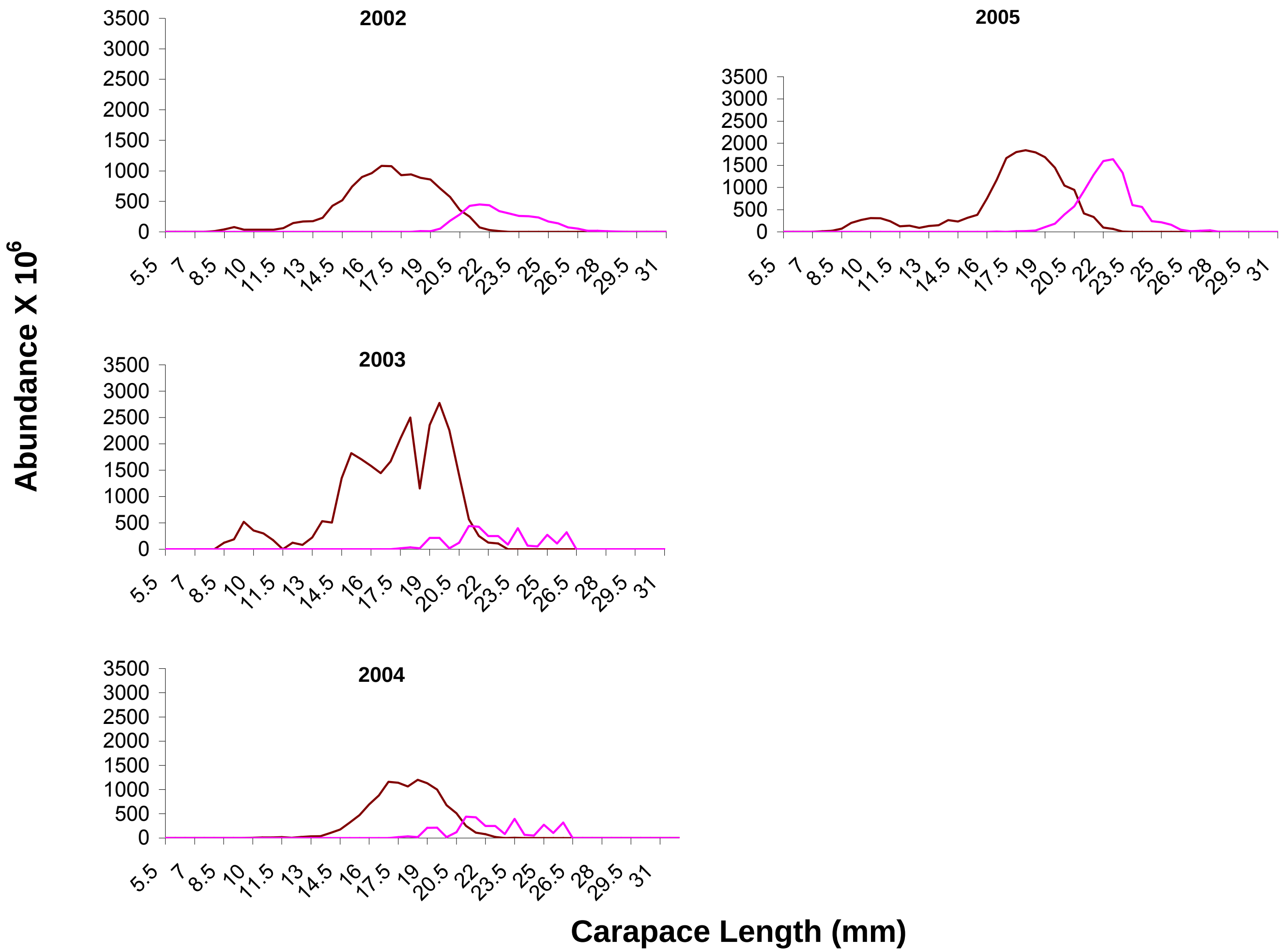


Figure 37. (Cont'd.) Abundance at length for Cartwright Channel northern shrimp (*Pandalus borealis*) estimated by Ogmap calculations of autumn multi-species bottom trawl survey data 1995-2005.

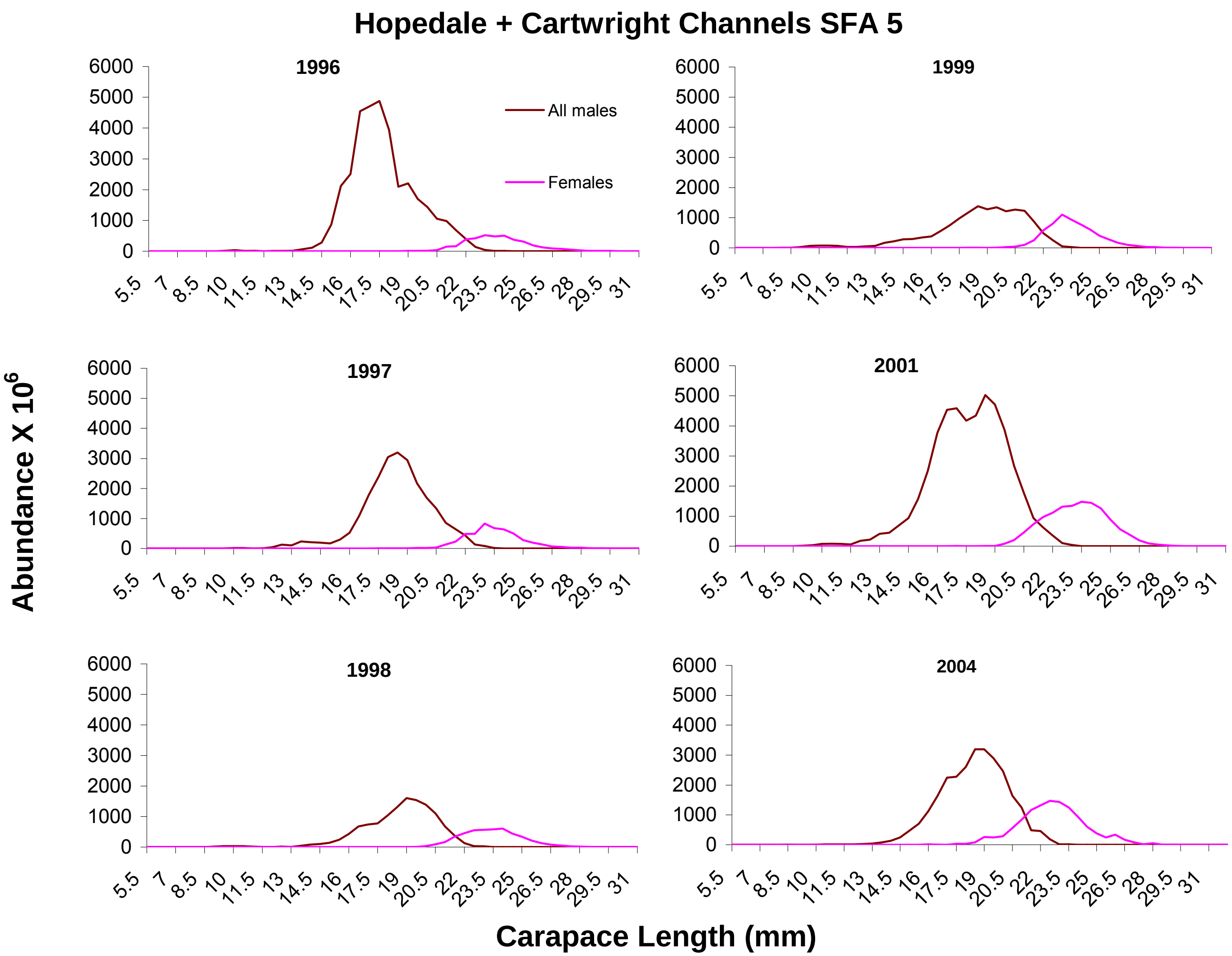


Figure 38. Abundance at length for Hopedale and Cartwright Channels (SFA 5) northern shrimp (*Pandalus borealis*) estimated by Ogmap calculations of autumn multi-species bottom trawl survey data 1995-2005.

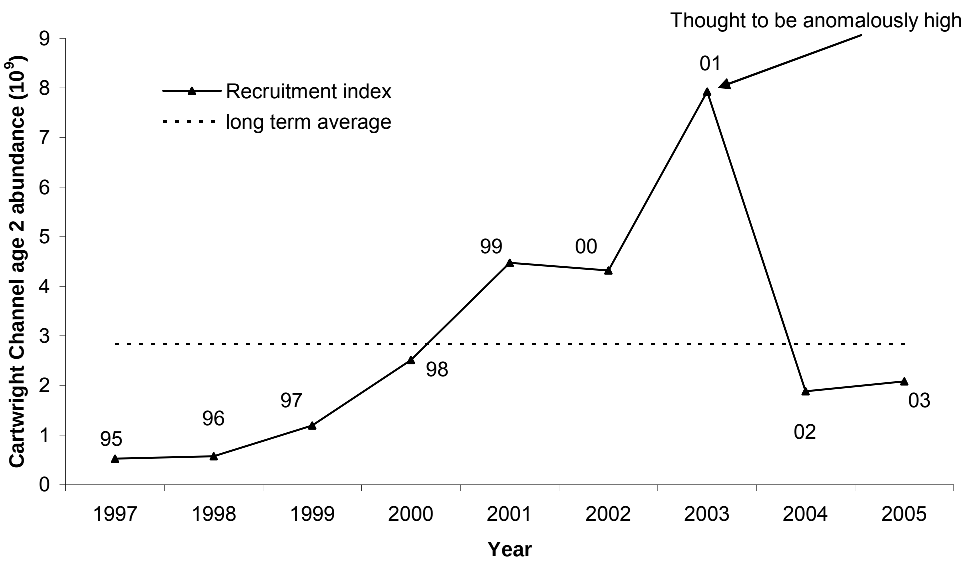


Figure 39. Cartwright Channel research survey recruitment index (abundance of age 2 males with 11.5-16 mm carapace lengths) over the period 1997-2005.

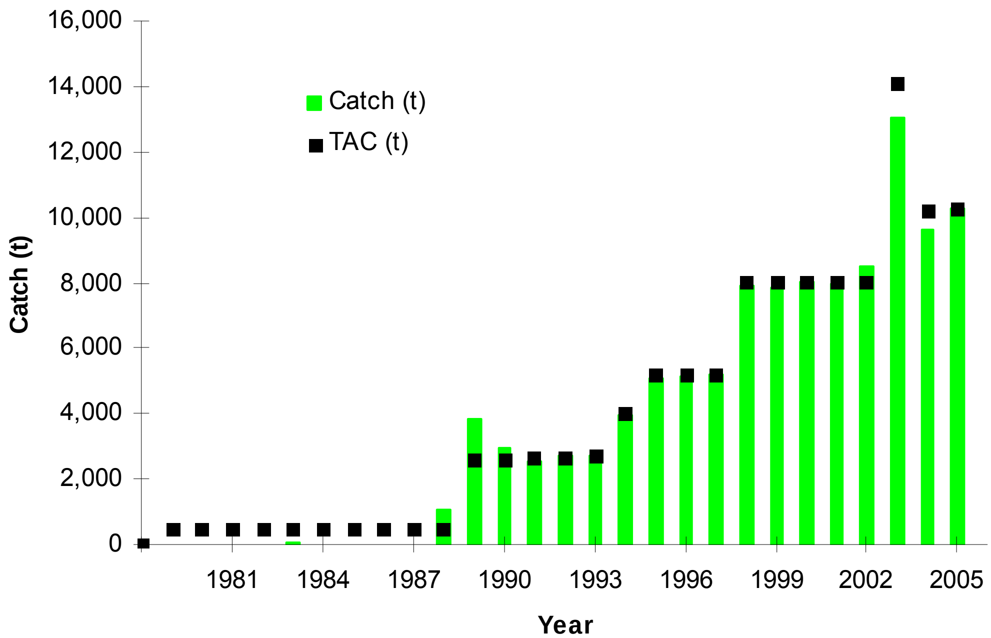


Figure 40. Large vessel (>500 t) northern shrimp (*Pandalus borealis*) catches and quotas within NAFO Division 2G (SFA 4), 1979-2005. Note that beginning in 2003, TAC's have been allocated by management year (Apr. 1-Mar. 31.). For consistency, the catches have been converted to calendar years.

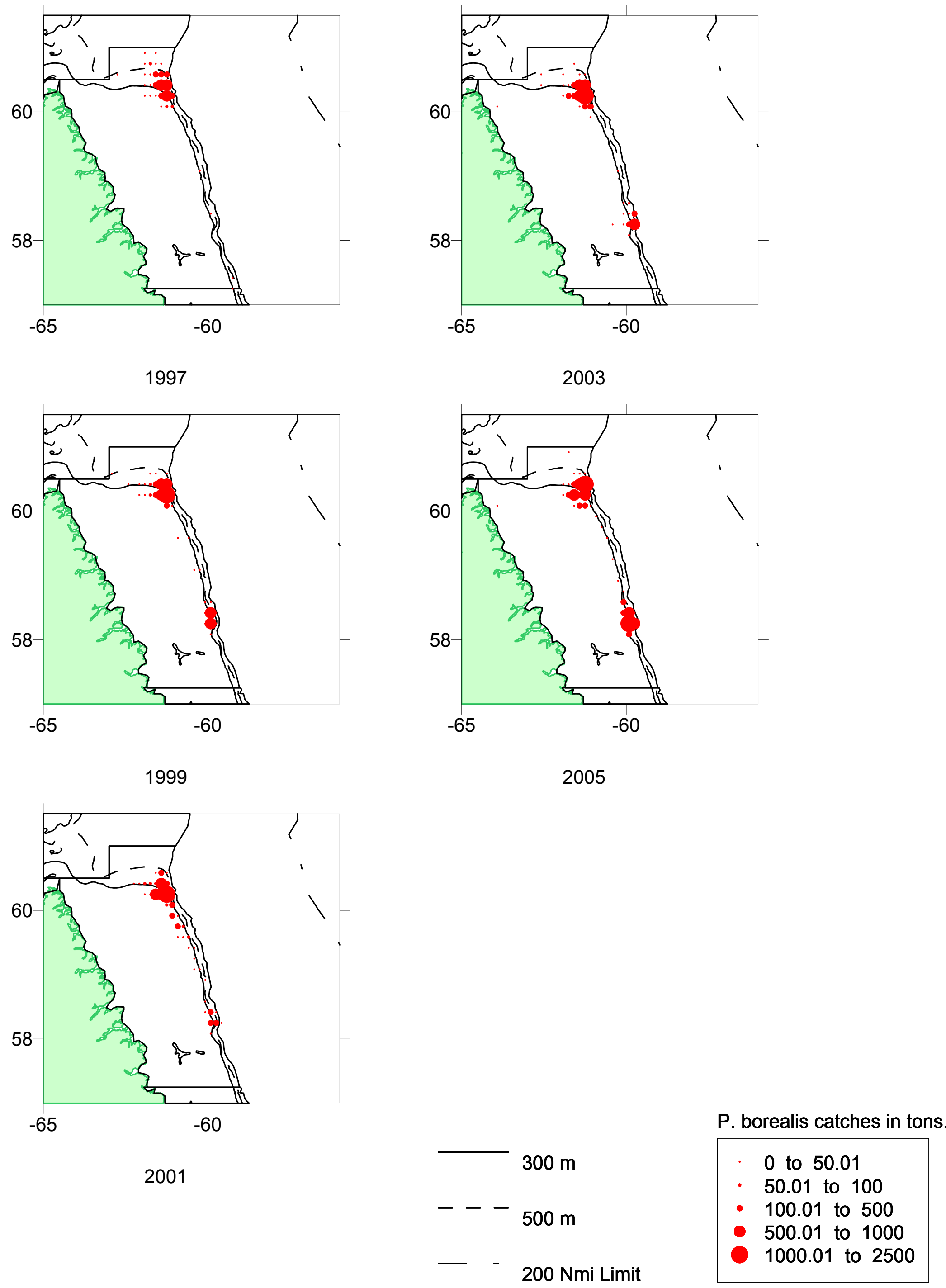


Figure 41. Distribution of large vessel (>500 t) shrimp catches in NAFO Division 2G (SFA 4). (Observer data aggregated into 10 min X 10 min cells).

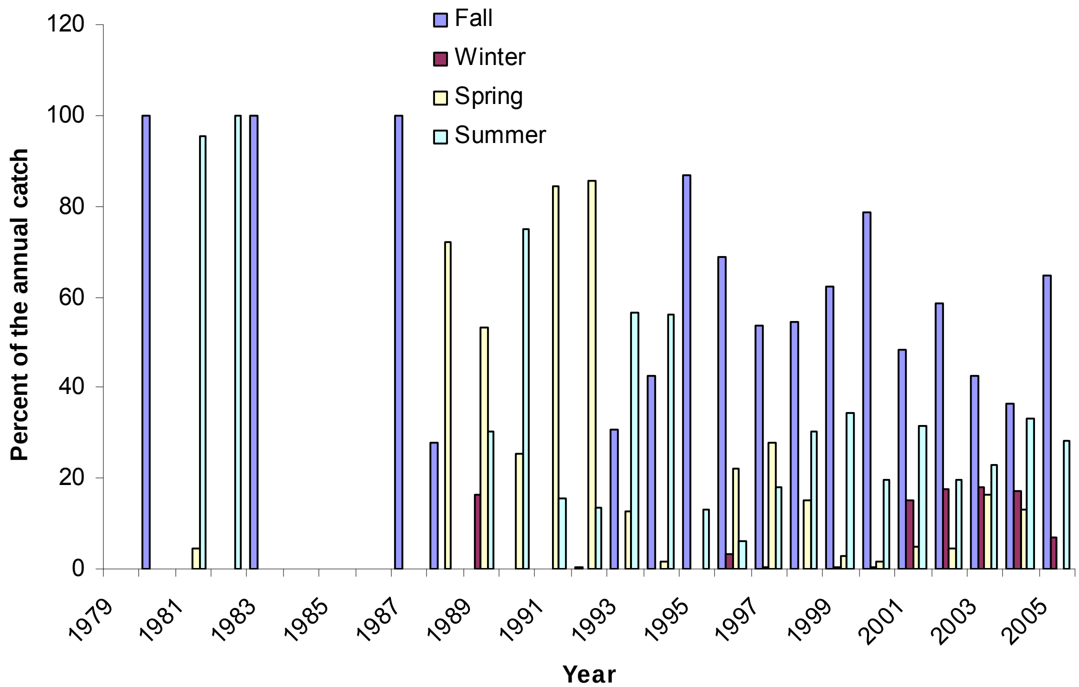


Figure 42. Seasonality of the large vessel (>500 t) fishery within NAFO Division 2G (SFA 4) as determined from percent annual catch by season.

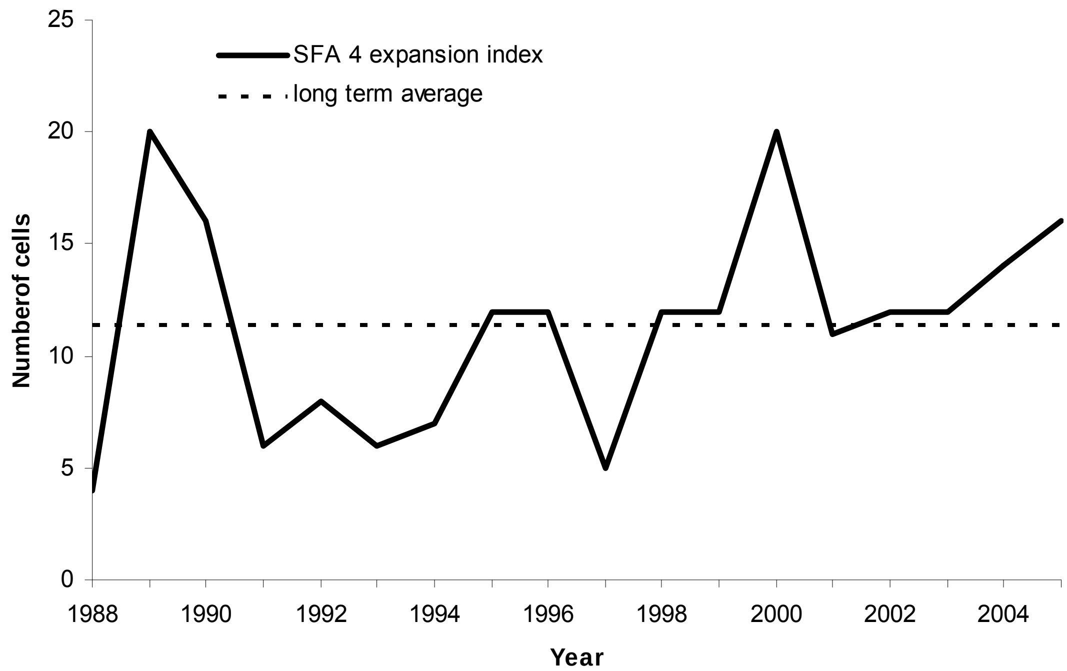


Figure 43. The number of 10 min. X 10 min. cells necessary to account for 95% of the NAFO Division 2G (SFA 4) large vessel catches.

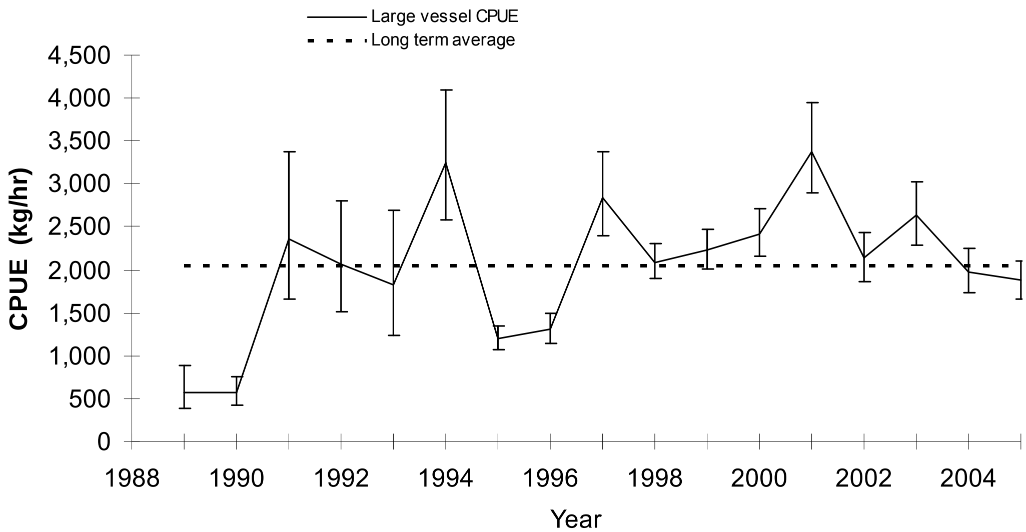


Figure 44. SFA 4 large vessel CPUE (error bars indicate 95% confidence intervals around point estimates). This model was constrained to data from only May-December as the fishery mainly takes place from the spring until late fall.

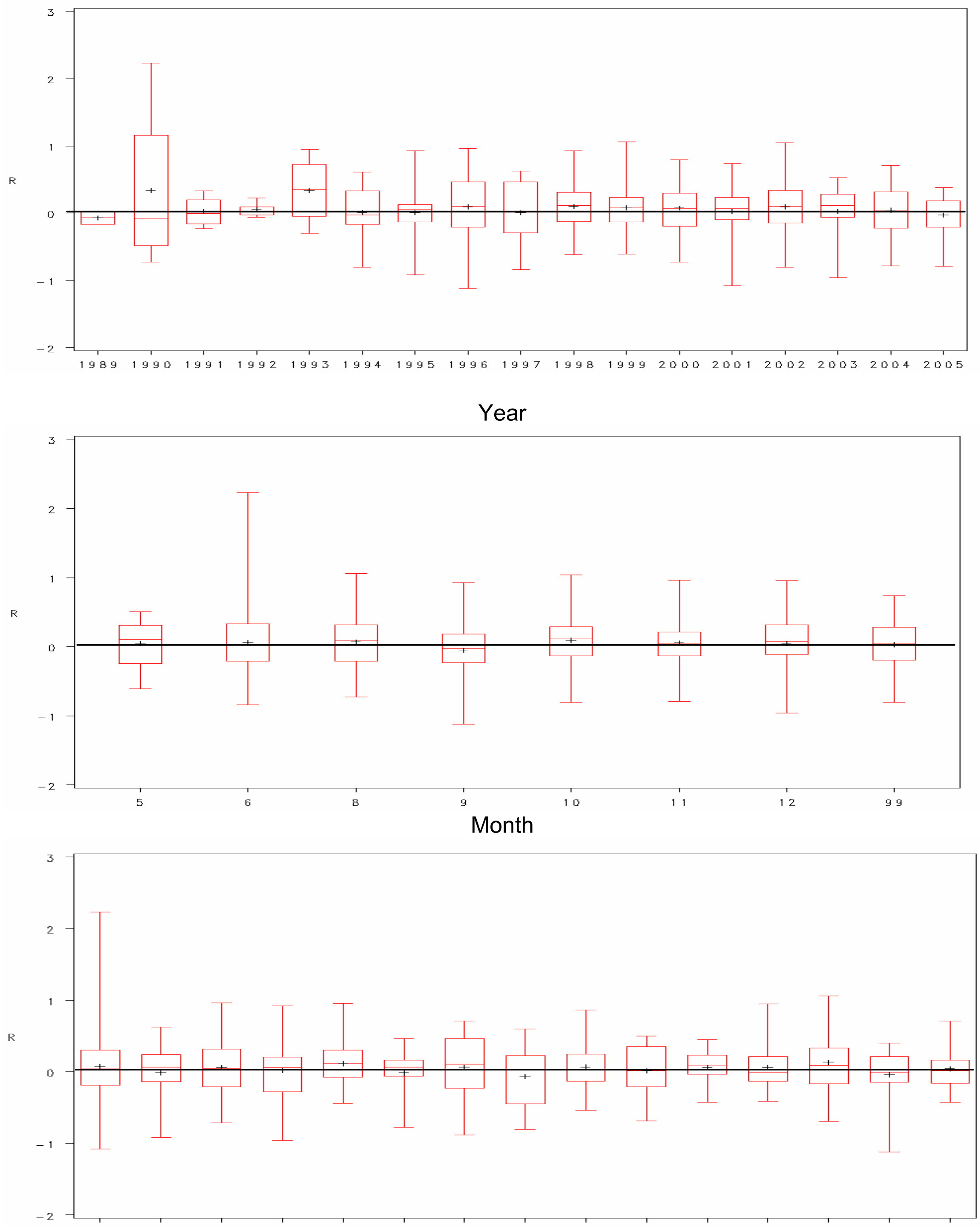


Figure 45. The distribution of residuals around estimated values for parameters used to model large vessel (>500 t) shrimp catch rates in NAFO Division 2G (SFA 4), 1989-2005.

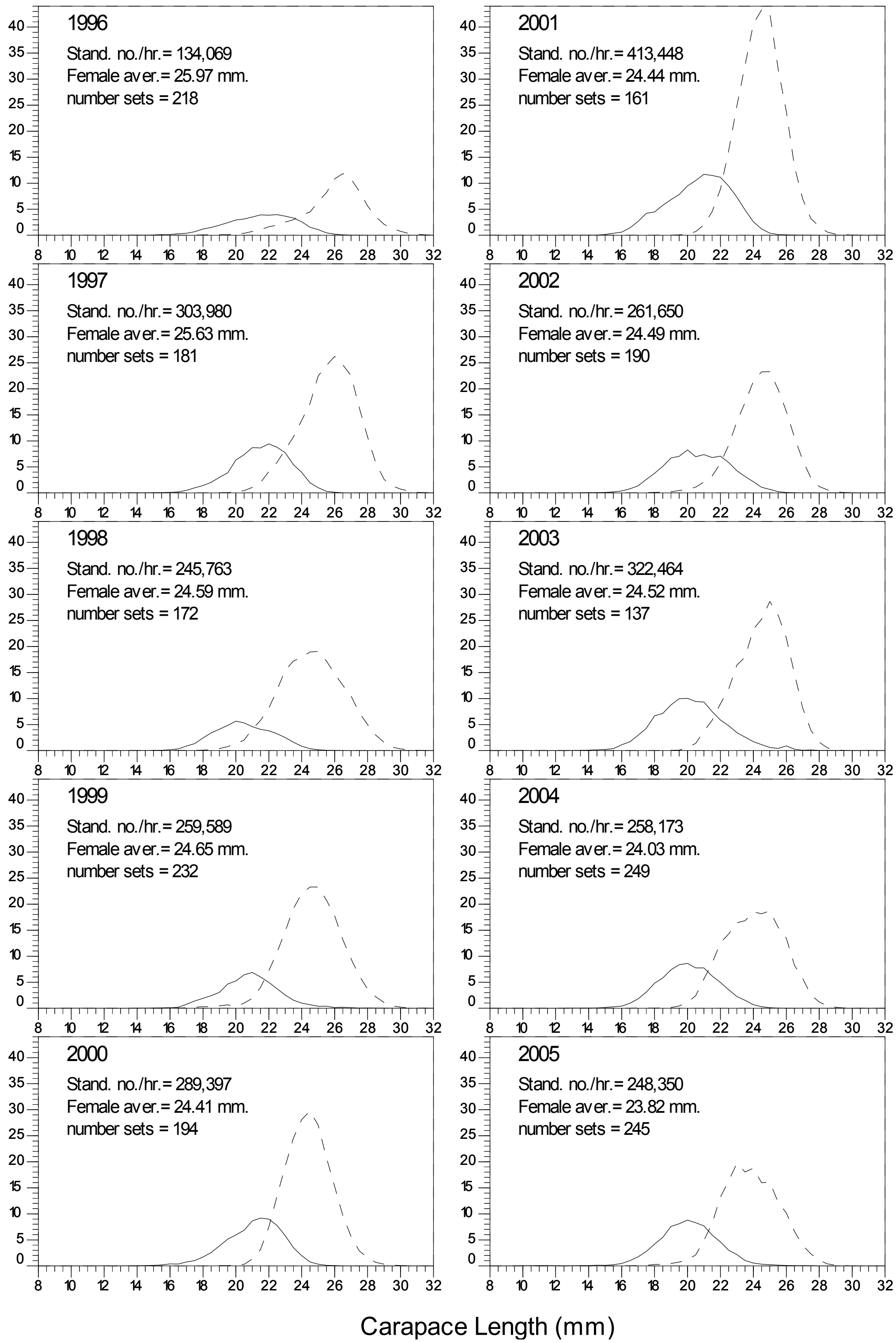


Figure 46. Observed northern shrimp length frequencies (000s per hour) from the Canadian large vessel (>500 t) fleet fishing for shrimp in NAFO Division 2G SFA 4) over the period 1996-2005. Solid lines = males; dotted lines = females.

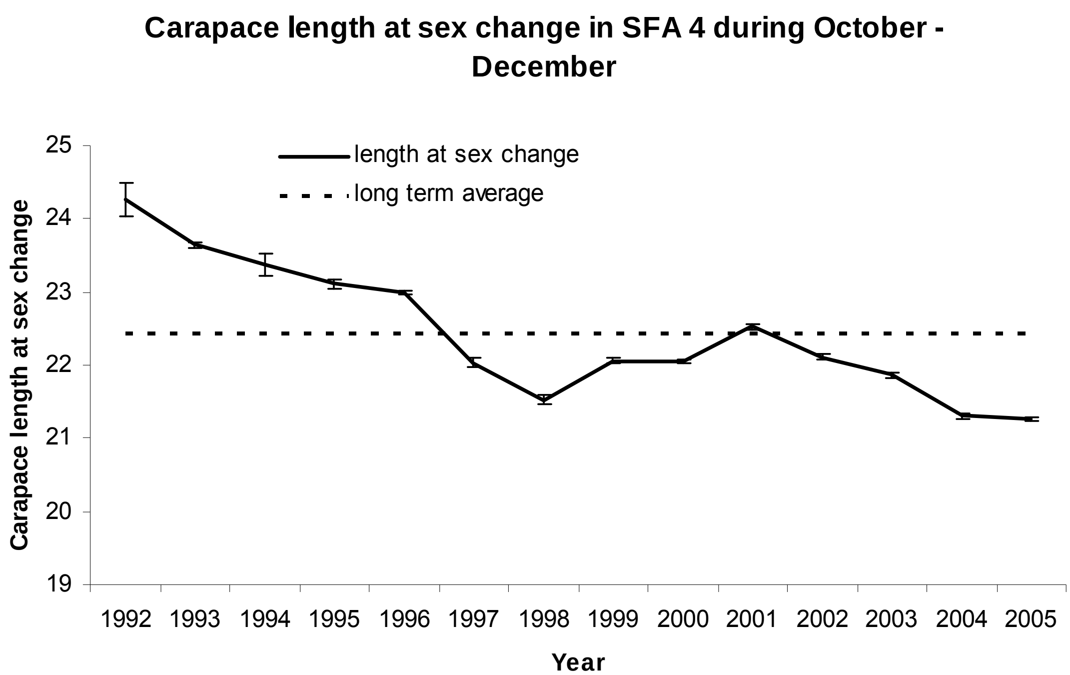


Figure 47. Length at sex change (L_{50}) values derived from observed large vessel (>500 t) commercial length frequencies (1992-2005) taken from SFA 4. In order to reduce the influence of seasonality, data were restricted to
October-December.

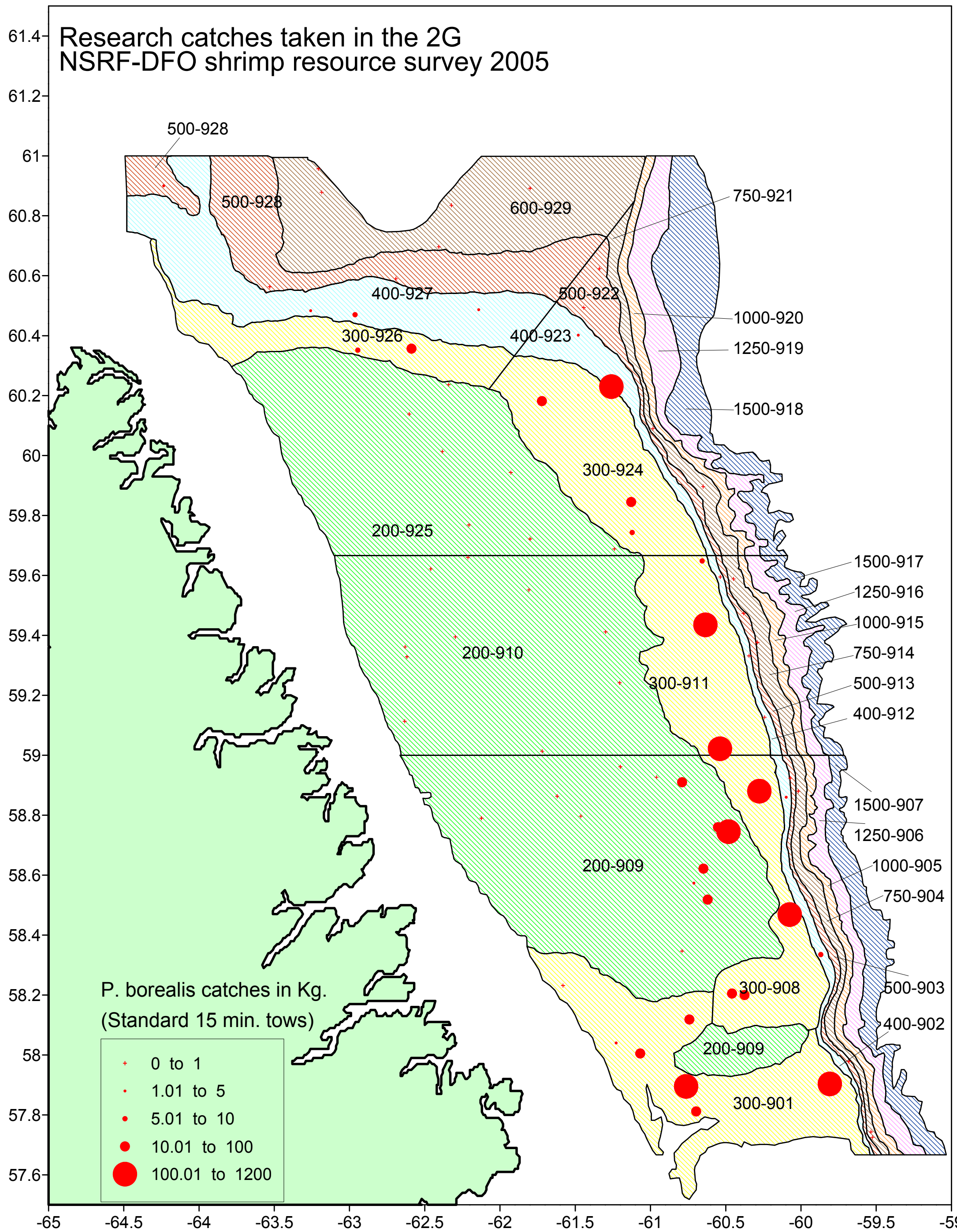


Figure 48. Distribution of NAFO Division 2G (SFA 4) northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from 2005 NSRF-DFO joint bottom trawl survey.

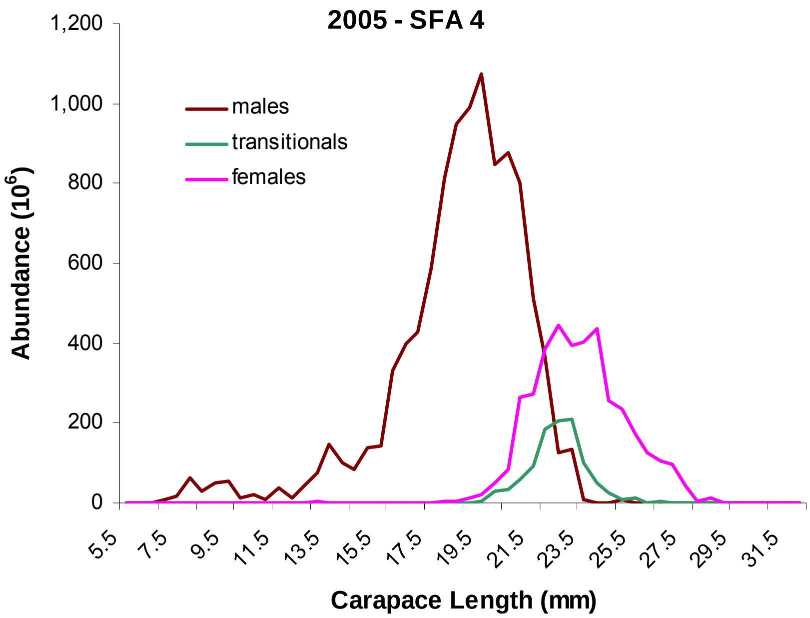


Figure 49. Abundance at length for NAFO Division 2G (SFA 2) northern shrimp (*Pandalus borealis*) estimated using stratified areal expansion alculations (Cochran 1977) of July 2005 NSRF-DFO bottom trawl survey data.

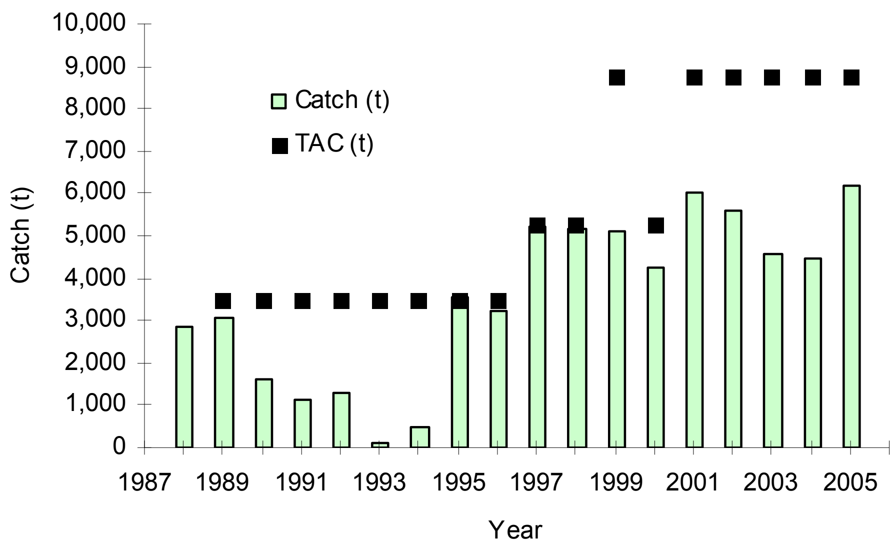


Figure 50. Large vessel (>500 t) northern shrimp (*Pandalus borealis*) catches and quotas within NAFO Division 0B (SFA 2), 1988-2005. Note that beginning in 2003, TAC's have been allocated by management year (Apr.1-Mar. 31.). For the purposes of this report, the catches since 2002 have been converted to calendar years for consistency.

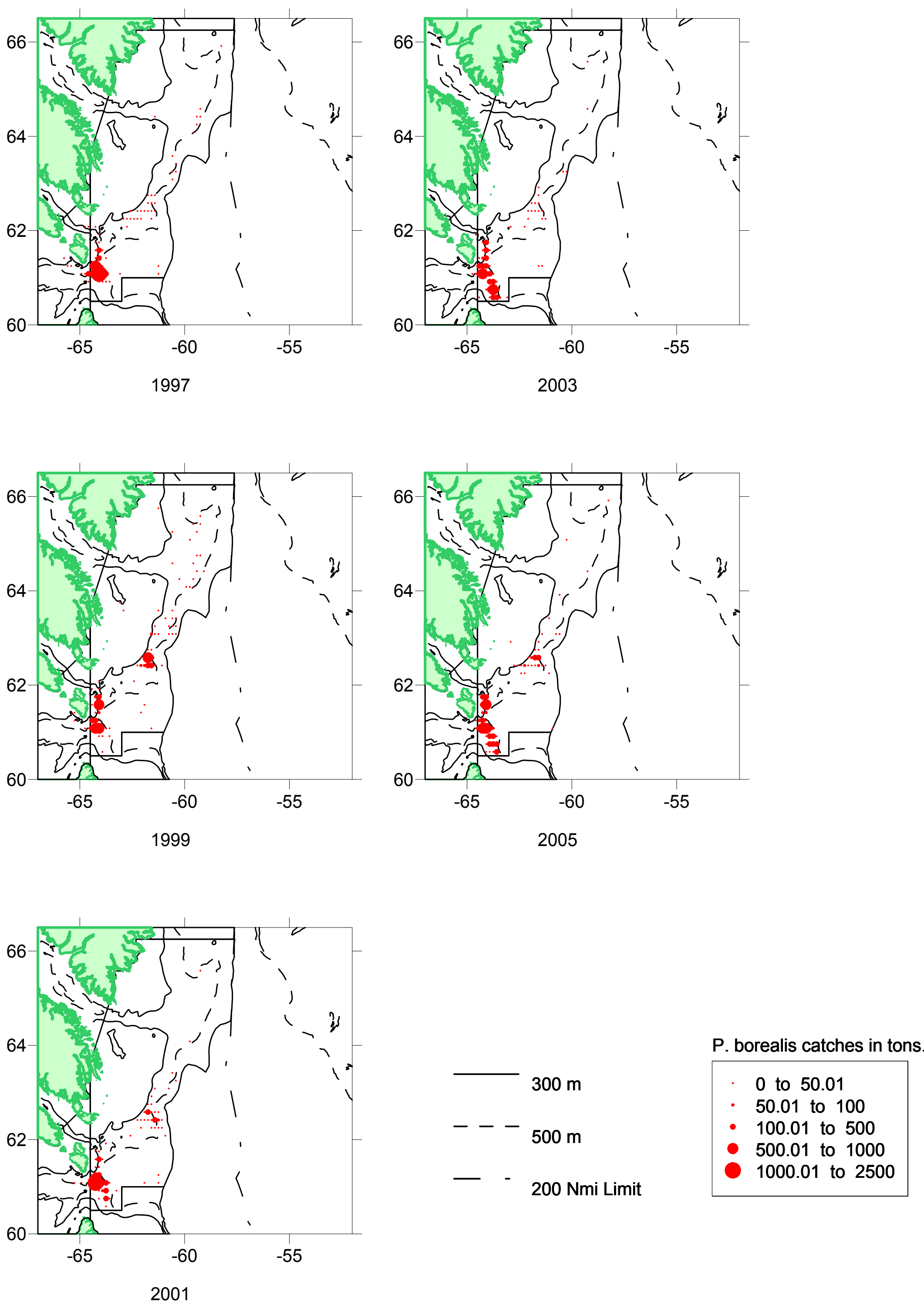


Figure 51. Distribution of large vessel (>500 t) shrimp catches in NAFO Division 0B (SFA 2). For the purposes of this report, the data are from shrimp fished in SFA 2 and those portions of SFA's 3 & 4 north of 60°30N and west of 63°00W. (Observer data aggregated into 10 min X 10 min cells).

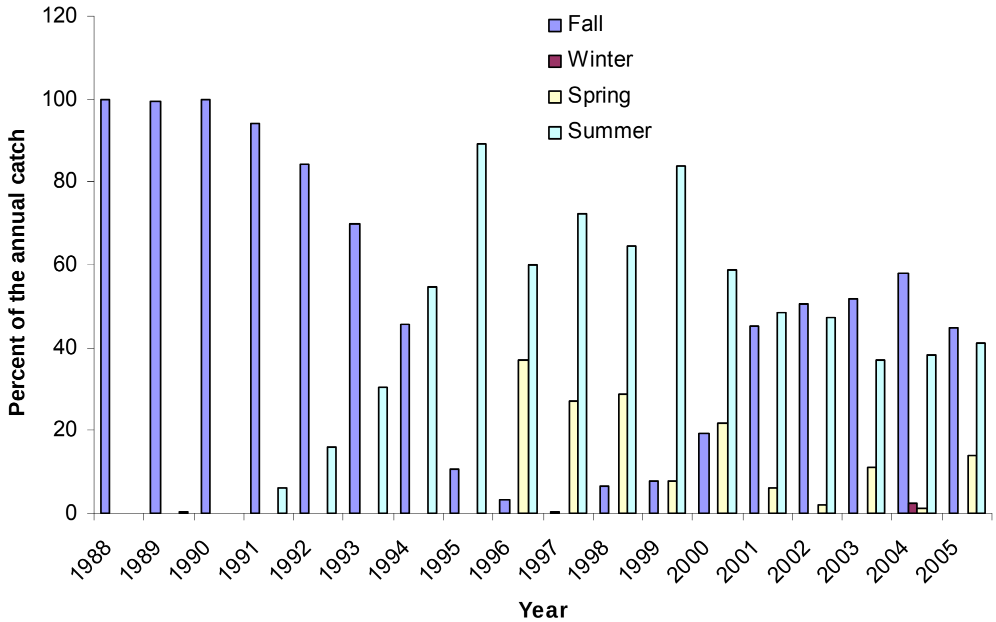


Figure 52. Seasonality of the large vessel (>500 t) fishery within NAFO Division 0B (SFA 2) as determined from percent annual catch by season. For the purposes of this report, the data are from shrimp fished in SFA 2 and those portions of SFA's 3 and 4 north of 60°30N and west of 63°00W.

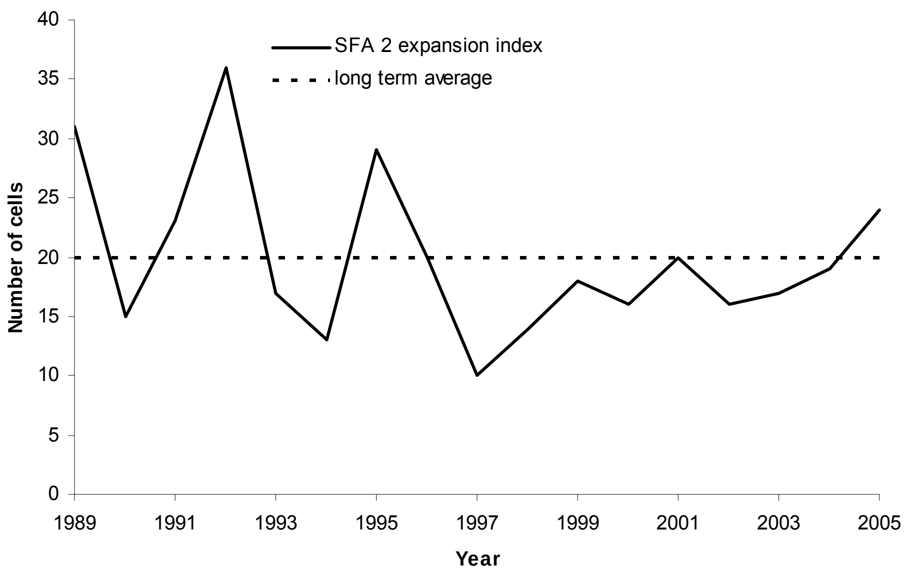
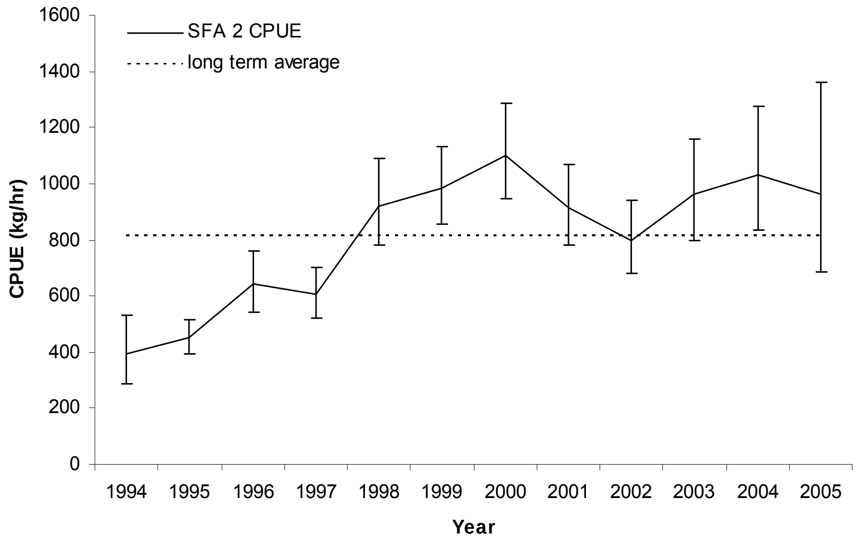
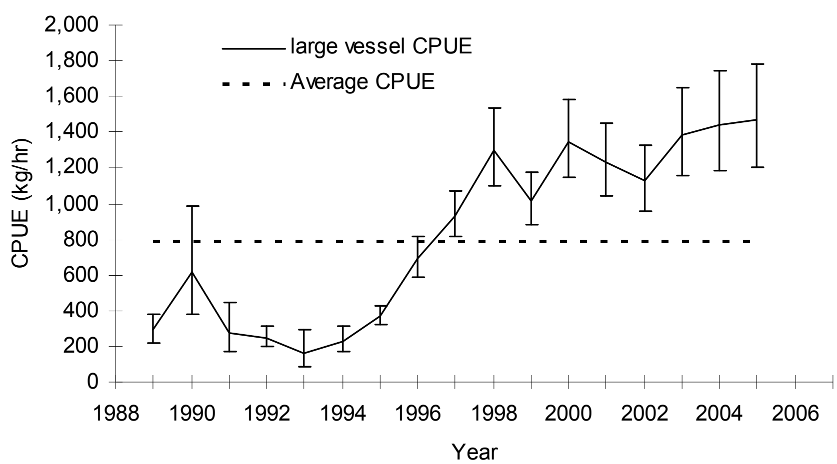


Figure 53. The number of 10 min. X 10 min. cells necessary to account for 95% of the NAFO Division 0B (SFA 2) large vessel catches. For the purposes of this report, the data are from shrimp fished in SFA 2 and those portions of SFA's 3 & 4 north of 60°30N and west of 63°00W.



A)



B)

Figure 54. SFA 2 large vessel CPUE (error bars indicate 95% confidence intervals around point estimates). Model A was presented in the Stock Advisory Report (2006/007) and was constrained to only Canadian vessels, charter vessels or exploratory licenced vessels. Model B includes all vessels that fished for a minimum of four years. Both models were presented in the March 2006 RAP, however only the latter will be described in the remainder of this report.

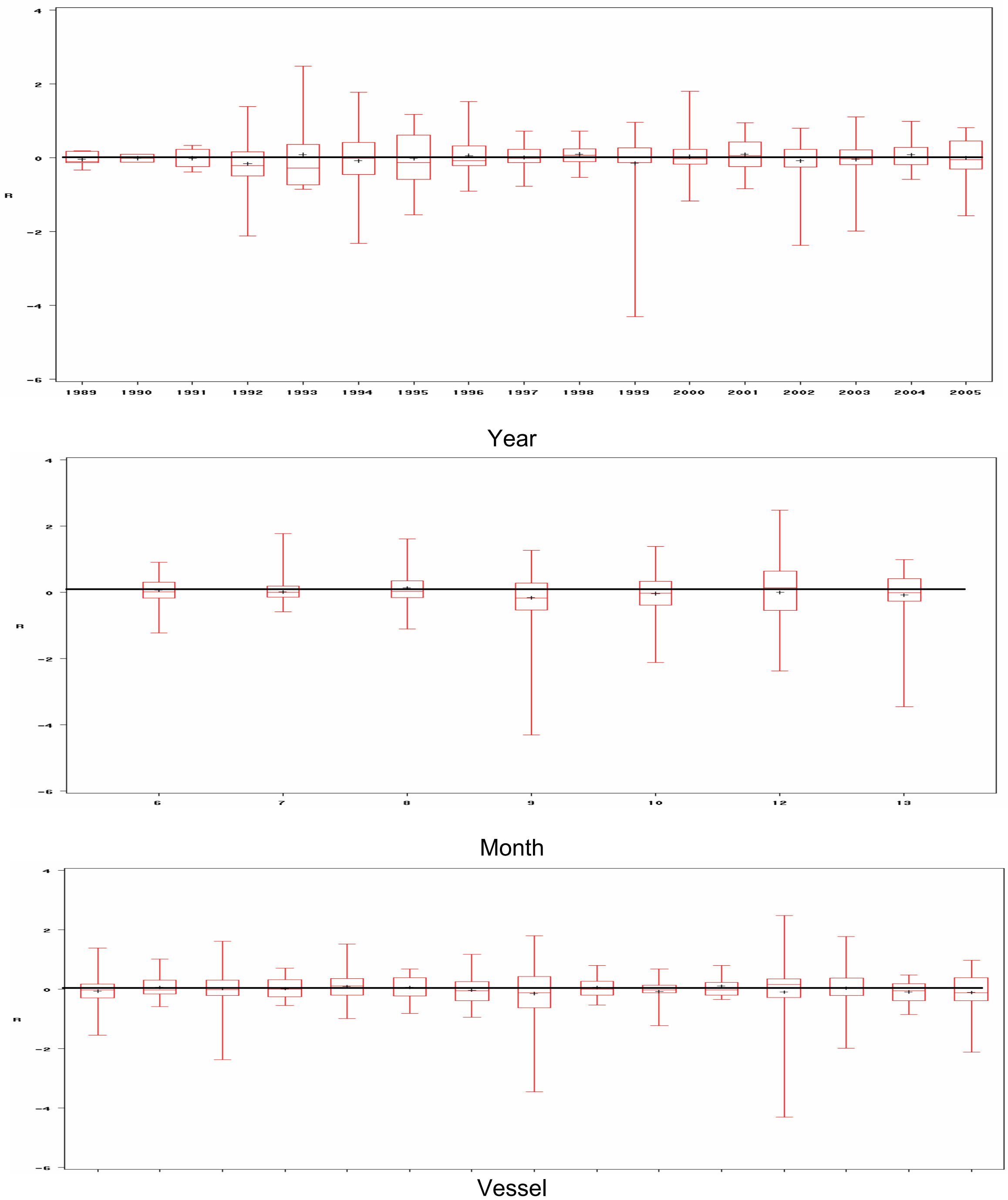


Figure 55. The distribution of residuals around estimated values for parameters used to model large vessel (>500 t) shrimp catch rates in NAFO Division 0B (SFA 2), 1989-2005.

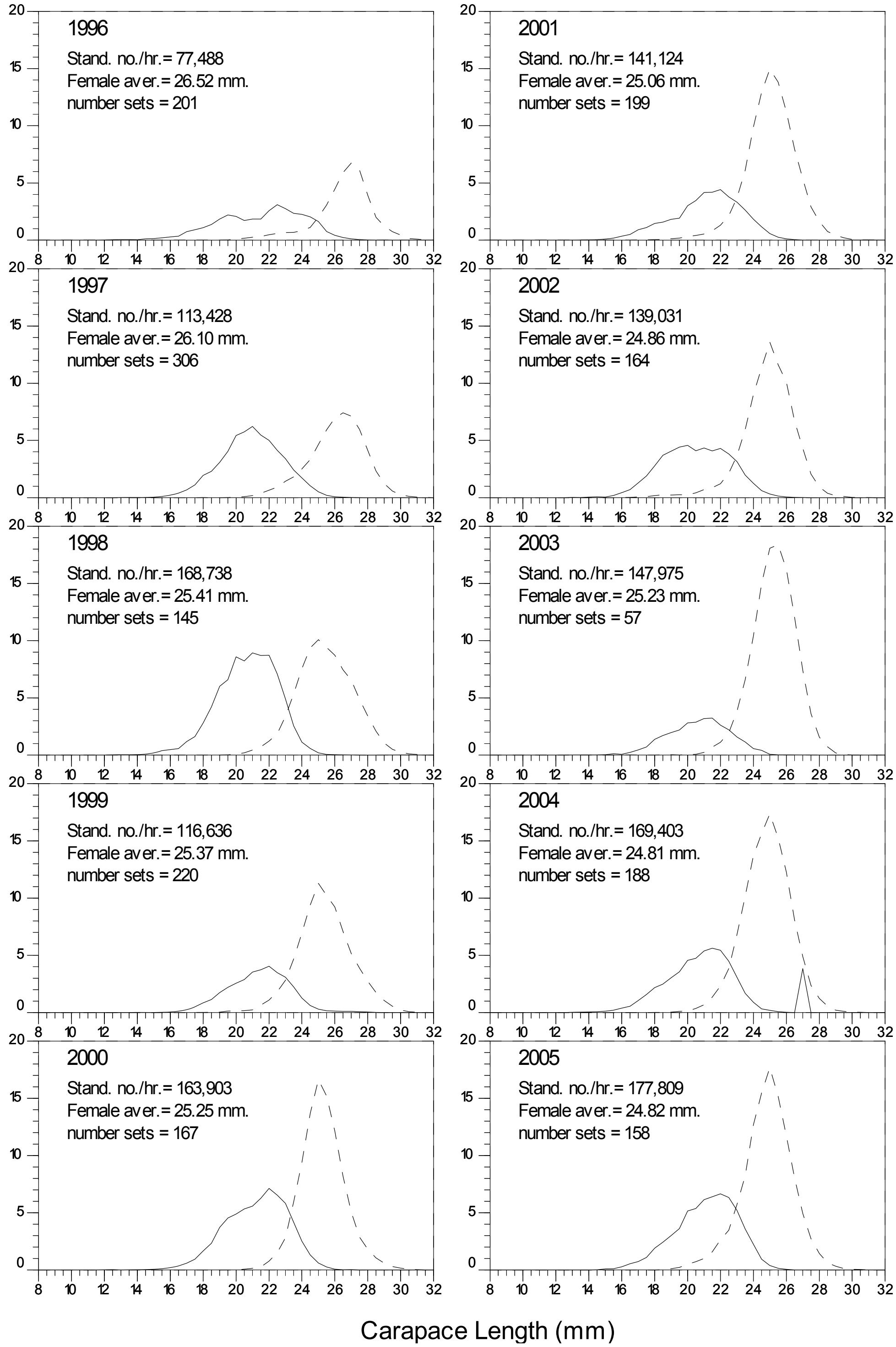


Figure 56. Observed northern shrimp length frequencies (000s per hour) from the Canadian large vessel (>500 t) fleet fishing shrimp in NAFO Division 0B (SFA 2) over the period 1996-2005. For the purposes of this report, the data are from shrimp fished in SFA 2 and those portions of SFA's 3 and 4 north of 60°30N and west of 63°00W. Solid lines = males; dotted lines = females.

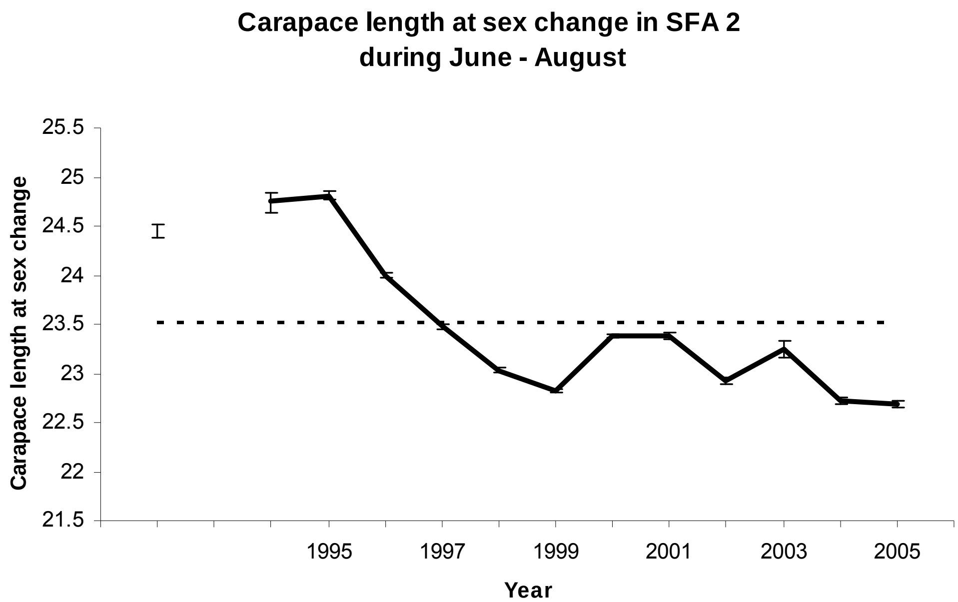


Figure 57. Length at sex change (L_{50}) values derived from observed large vessel (>500 t) commercial length frequencies (1992-2005) taken from SFA 2. In order to reduce the influence of seasonality, data were restricted to June-August. For the purposes of this report, the data are from shrimp fished in SFA 2 and those portions of SFA's 3 and 4 north of 60°30N and west of 63°00W.

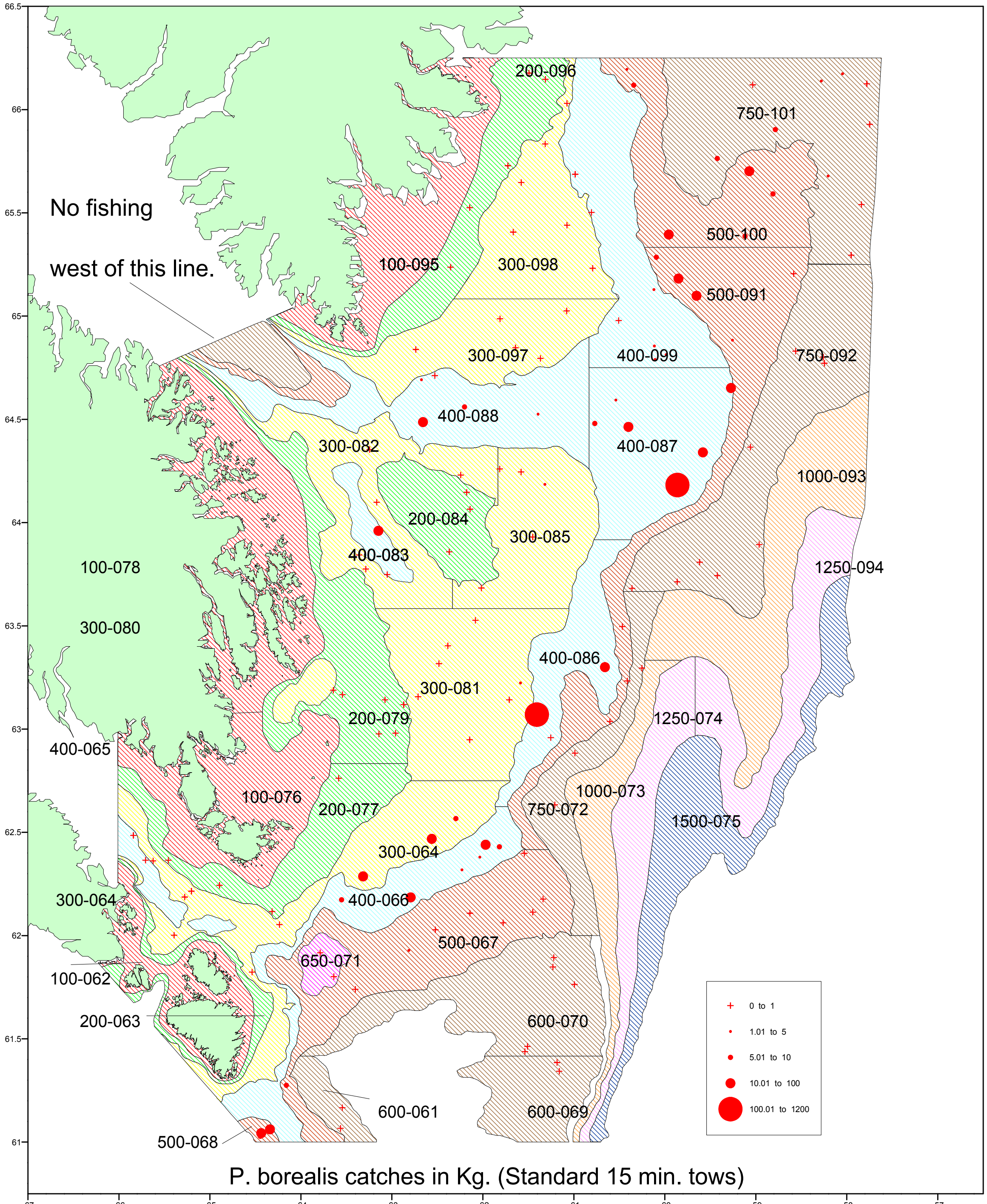


Figure 58. Distribution of NAFO Division 0B (SFA 2) northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from 2005 NSRF-DFO joint bottom trawl survey.

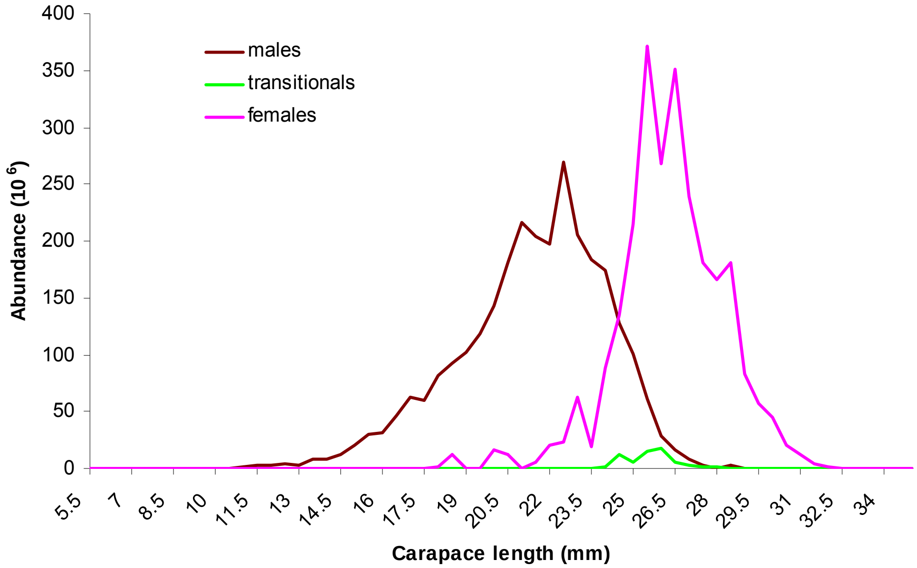


Figure 59. Abundance at length for NAFO Division 0B (SFA 2) northern shrimp (*Pandalus borealis*) estimated using stratified areal expansion calculations Cochran 1977) of July 2005 NSRF-DFO bottom trawl survey data.