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Northern shrimp (*Pandalus borealis*) off Labrador and northeastern Newfoundland as of March 2008

La crevette nordique (*pandalus borealis*) au large du Labrador et du nord-est de Terre-neuve en mars 2008

D. Orr, P.J. Veitch, K. Skanes, and D.J. Sullivan

Science Branch
Department of Fisheries and Oceans
P.O. Box 5667
St. John's NF A1C 5X1

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ABSTRACT

Updates of northern shrimp (*Pandalus borealis*) assessments were performed for NAFO Div. 2G, Hopedale + Cartwright Channels as well as Hawke Channel + Div. 3K, which correspond to shrimp fishing areas (SFA) 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. Fisheries independent data include an autumn multispecies research bottom trawl survey into SFA's 5 and 6 (1996 – 2007). The Northern Shrimp Research Foundation, in partnership with Fisheries and Oceans Canada, conducted a shrimp based research survey into Div. 2G (SFA 4) during each of the past three summers (2005–07). Surveys in SFA's 4-6 provide information on distribution, abundance, biomass, size/ sex composition and age structure of shrimp.

Catches increased from 22,000 t in 1994 to over 110,000 t by 2004-05 due mainly to increases in Total Allowable Catch (TAC). The TAC for the 2007-08 management year was set at 114,426 t and catches for that year equaled 114,000 t. Please note that due to a pilot bridging program that began in 2007, offshore licence holders may elect to fish up to 250 t of their total combined 2008-09 EAs in the period March 1-30 of 2008, or elect to fish up to 250 t of their 2007-08 EAs in the period April 1-30, 2009. Therefore it is possible for the total catch to exceed the TAC for any one year.

Annual catches within SFA 6 increased from 11,000 t during 1994-96 to 78,000 t by 2004-05. The TAC for the 2007-08 management year was set at 80,305 t (this TAC includes quota transfers and bridging). Catches for the 2007-08 management year equaled 80,733 t.

Spatial distribution of the SFA 6 fishery expanded between the mid 90's and 2000 increasing slightly thereafter. The 2007 large (>500 t) vessel Catch Per Unit Effort (CPUE) remained at a high level, while the small vessel (<=500 t; LOA<=100') CPUE increased significantly since 2003. Biomass and abundance indices from autumn multi-species surveys have generally increased since 1997. Recruitment indices in 2006 and 2007 (04 and 05 year-classes) were the highest in the time series. Female spawning stock indices increased from 181,700 t in 1997 to 462,500 t in 2006, remaining at a high level in 2007. 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 23,000 t in 2004-05 and 2006-07. In 2007-08 catches were 23,768 t against a TAC of 23,805 t. Since 1996, CPUE has fluctuated above the long-term average. Biomass and abundance indices after 2000 have been somewhat higher than before 2000. Recruitment in the short-term, while uncertain, 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.

Catches within SFA 4 increased from 4000 t in 1994 to 9,600 t by 2004-05. Approximately 10,200 t of shrimp were caught against a 10,348 t TAC during 2007-08. Since 2002, fishery catch rates have varied about the long-term average. The fishable biomass index ranged between 66,000 t and 111,000 t since 2005.

RÉSUMÉ

Une mise à jour de l'évaluation des stocks de crevettes nordiques (*Pandalus borealis*) a été réalisée dans la division 2G de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO), les chenaux Hopedale et Cartwright ainsi que le chenal Hawke et la division 3K, qui correspondent respectivement aux zones de pêche à la crevette (ZPC) 4, 5 et 6. Un examen des tendances sur le plan des prises commerciales, de l'effort, de la capture par unité d'effort, des modèles d'exploitation et de la composition des prises en fonction de la taille, du sexe et de l'âge ont permis, dans une certaine mesure, d'inférer l'état de la ressource dans chaque zone. Les données indépendantes de la pêche comprennent un relevé plurispécifique automnal de la recherche au chalut de fond dans les ZPC 5 et 6 (1996-2007). 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 la division 2G (ZPC 4) pendant les trois derniers étés (2005 à 2007). Les relevés dans les ZPC 4 à 6 ont fourni des données sur la répartition, l'abondance, la biomasse ainsi que sur la composition selon la taille et le sexe et la structure par âge des crevettes.

Les prises ont augmenté, passant de 22 000 t en 1994 à plus de 110 000 t en 2004-2005 en raison principalement de l'accroissement du total autorisé des captures (TAC). Le TAC pour l'année de gestion 2007-2008 a été fixé à 114 426 t et les captures pour l'année ont atteint 114 000 t. Veuillez noter qu'en vertu d'un programme pilote de transition lancé en 2007, les détenteurs de permis de pêche en haute mer peuvent choisir de prendre jusqu'à 250 t de leur AE 2008-2009 combiné total pendant la période du 1er au 30 mars 2008, ou de prendre jusqu'à 250 t de leur AE 2007-2008 pendant la période du 1er au 30 avril 2009. Il est donc possible que le total des captures dépasse le TAC donné pour l'une ou l'autre des années.

Les prises annuelles dans la ZPC 6 ont augmenté de 11 000 t en 1994-1996 à 78 000 t en 2004-2005. Le TAC de l'année de gestion 2007-2008 a été fixé à 80 305 t (comprenant les transferts de quota et les mesures de transition). Les prises de l'année de gestion 2007-2008 ont atteint 80 733 t.

La répartition spatiale de la pêche dans la ZPC 6 s'est élargie entre le milieu des années 1990 et 2000 en continuant d'augmenter légèrement par la suite. Les prises par unité d'effort des gros bateaux (>500 t) en 2007 sont demeurées à un niveau élevé, tandis que celles des petits bateaux (<=500 t; LHT<=100') ont connu une hausse considérable depuis 2003. Les indices de la biomasse et de l'abondance, tirés des relevés plurispécifiques d'automne, ont généralement augmenté depuis 1997. Les indices de recrutement en 2006 et 2007 (classes d'âge 04 et 05) ont été les plus élevés pour la série chronologique. Les indices du stock de génitrices ont augmenté, passant de 181 700 t en 1997 à 462 500 t en 2006 et sont restés élevés en 2007. 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 23 000 t en 2004-2005 et 2006-2007. En 2007-2008, les prises ont été

de 23 768 par rapport à un TAC de 23 805 t. 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 sont quelque peu supérieurs après 2000 par rapport à la situation d'avant 2000. Le recrutement à court terme, bien qu'incertain, 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.

Les prises dans la ZPC 4 sont passées de 4 000 t en 1994 à 9 600 t en 2004-2005. Environ 10 200 t de crevettes ont été prises par rapport à un TAC de 10 348 t en 2007-2008. Depuis 2002, le taux de prise a fluctué autour de la moyenne à long terme. Depuis 2005, l'indice de biomasse exploitable varie de 66 000 t à 111 000 t.

INTRODUCTION

The northern shrimp (*Pandalus* borealis) fishery 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 17,000 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 22,500 and 23,600 t in response to increased TAC's for several SFA's. Catches increased to 85,900 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 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 (January 1-December 31) year to a fiscal (April 1-March 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 4, 5 and 6, equaled 111,629 t. Without accounting for bridging and adjustments, this TAC was maintained throughout to the 2007-08 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. Small vessels must have a grate spacing no greater than 22 mm regardless of SFA being fished, while bar spacing on large vessels must not exceed 22 mm in SFA 6 but may be as large as 28 mm in SFA's 4 and 5. Observers are required on all trips by the large vessel fleet while a target of 10% coverage has been established for the small vessel fleet.

This research assessment, conducted during March 2008, included three shrimp fishing areas (SFA's): Hawke Channel + NAFO Div. 3K (SFA 6), Hopedale + Cartwright Channels (SFA 5) and Div. 2G (SFA 4).

MATERIAL AND METHODS

COMMERCIAL FISHERY DATA

Catch Rate Modeling

Large vessel (>500 t) CPUE was calculated by year for each SFA and was 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 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:

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

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;*
T_m is the effect of the m^{th} class of gear (whether single, double or triple);
e_{ijklm} 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 three years of experience were excluded from the analyses, as well, this ensured sufficient overlap in data between vessels. 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 2007 YEAR parameter estimate and those of previous years was inferred from the output statistics.

A similar model was developed for the small vessel (<=500 t; <=100') fleet fishing shrimp in SFA 6. However, these models made use of logbook data, because observers monitor less than 10% of fleet activities. The small vessel CPUE model included a vessel class size term. The vessels were divided into three size classes as follows: LOA<= 50'; 50'<LOA<=60' and 60'<LOA.

Spatial distribution of the northern shrimp fishery

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

3963.0 * arccos[sin(lat1/57.2958) * sin(lat2/57.2958) + cos(lat1/57.2958) * cos(lat2/57.2958) * cos(long2/57.2958 -long1/57.2958)

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

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

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

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

Carapace length distribution within the northern shrimp fishery

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. Please note that spatial expansion programs used by many

assessment biologists require that a minimum of 2 sets be placed in each stratum, therefore all strata have a minimum of 2 sets and the number of sets allocated by area may be much higher than 1 set per 230 sq. Nmi identified above. 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 the summers of 2005-07. The NSRF-DFO surveys were 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.

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.

Ageing

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

Estimation of exploitation rate indices

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, within set, abundances at length to weights using the length/weight model:

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

This length weight relationship was estimated from live males obtained within NAFO Div. 3K during autumn 2004. Whereas the male portions of the SFA's 4 and 5 fishable biomass were determined by converting abundances at length to biomass using the length/weight model:

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

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

The weights of fishable males were added to female (transitionals, primiparous, ovigerous and multiparous females) weights per set to obtain the weight of fishable animals per set. Ogmap calculations were then run using the weights per set to provide fishable biomass estimates with 95% confidence intervals. 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.

Instantaneous mortality rate indices

The instantaneous rate of mortality (Z) was determined using various methods. First by estimating the four year running average abundance indices age 3+ and females from the autumn surveys. The running average for these shrimp was compared with the four year running average for age 4+ and female shrimp centred on the following year as follows:

$$N_1/N_o = e^{-Z}$$
$$Z = -\log_e(1-A)$$

Where N_o = four year running average index for autumn age 3+ shrimp
N_1 = four year running average index for autumn age 4+ and female shrimp the following year.
Z = instantaneous mortality rate
A = annual mortality rate (Ricker 1975)

The second method made use of the four year running average raw count of primiparous shrimp measured from the observer dataset compared to the four year running average count of multiparous shrimp centred on the following year.

A third method made use of mean length at age data to fit a growth curve as described by the von Bertalanffy equation

$$L_t = L_\infty \left[1 - e^{-K(t-t_0)}\right] \qquad (1)$$

where L_t is the length at age t and L_∞, K,and t_0 were the parameters of the von Bertalanffy equation. This method was applied to shrimp aged zero through to six where the mean length of a six year old shrimp came from 2007 fall survey data, and the mean length of age zero shrimp came from the 2001 fall survey data. By minimizing the sum of squares between observed and predicted values reasonable estimates of L_∞, K,and t_0 were determined.

von Bertalanffy growth parameters were then used to evaluate the length composition of the survey catches. It is reasonable to believe that the lower the mortality, the larger the mean size amongst the shrimp population should be. Note that the mean length of shrimp with lengths greater than any particular length, L_c, is given by

$$\bar{L} = L_c + \frac{K}{Z+K}\left(L_\infty - L_c\right) \qquad (2)$$

where Z is the instantaneous mortality and K and L_∞ are growth parameters. This equation was then used to find an equation for Z.

$$Z = \frac{K\left(L_\infty - \bar{L}\right)}{\bar{L} - L_c} \qquad (3)$$

If any previous information on aging, except for the von Bertalanffy growth parameters, is ignored, the entire length range of shrimp could be broken down into arbitrary ranges and a new approach to mortality could be investigated.

The length range of shrimp (from about 5 to 30 mm) was evaluated using 0.5 mm width classes. Mortality estimates were also calculated for females separately. The value of L_c was taken as the starting value of the size range and a weighted average was calculated for all shrimp larger than L_c.

As L_c increases (minimum length of each group), mean L increases and until a certain point in the size range, Z increases as well. This method allowed us to estimate Z by size.

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) was 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 21,000 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 t. 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 by 4% to 61,632 t. Approximately 63,000 t were taken, 20,600 t by large vessels and 42,600 t by small vessels. The 2001 TAC remained at 61,632 t, of which 19,900 t were taken by the large vessel fleet while only 32,600 t were taken by the small vessel fleet (Tables 1-3 and 5; Figs. 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, Department of Fisheries and Aquaculture, NL. 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 7,653 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 remained the same through to the 2007-08 management year and the total catch of 80,700 t was taken. Both large and small vessels primarily fish during the first six months of the year (Fig. 5 and 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 and 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 the entrance to 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 closed 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 Fig. 7 and 8. Figure 8 presents a quantification of area towed by large vessels, while Fig. 9 and 10 present the evolution of small vessel catches and area towed over the period 2004–07. 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.

Percent total area within SFA 6 necessary for the large (>500 t) vessel fleet to obtain 95% of their catch has increased from 2–8% over the period 1998–2007. A similar index for the small vessel fleet increased from 11–19% between 1998 and 2007 while the DFO survey index varied between 10 and 15% over the same period (Fig. 11). In general, the spatial indices of bottom contact tracked the respective catch indices over the study period.

Catch Per Unit Effort (CPUE)

Annual CPUE's for large vessels, gear (single + double trawl), year, month, area, observer data, no windows, (history >3 years) increased steadily from 1992 to 1995 and have since fluctuated at a high level (Tables 3 and 4; Fig. 12). The model accounts for approximately 64% of the variance in the data. Figure 13 clearly indicates that there are no trends in the scatter of residuals around the parameter estimates.

The model indicated that 1995, 1996 and 1998-2005 catch rates were similar to the 2007 catch rate ($P>0.05$). The 1997 and 2006 values were significantly higher than the 2007 value while all other values were significantly lower than the 2007 estimate ($P<0.05$). The fact that the CPUE increased significantly over the 1992–95 period and thereafter remained high 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 (Figs. 7-12).

Tables 5 and 6 and Fig. 12 provide the small vessel CPUE model output while Fig. 14 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 76% of the variation in explanatory parameters. The 2007 catch rate estimate was similar to the 2006 value while all other estimates were significantly ($P<0.05$) lower (Tables 5 and 6; Fig. 12).

Size Composition

Several length frequency observations were taken from large and small vessel catches (Figs. 15 and 16). Catch at length from samples taken by observers on large vessels consisted of a broad size range of males and females believed to represent more than two year-classes. The male modes overlapped to the extent that it was not possible to complete modal 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 14 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 for large vessels had been maintained at over 240,000 animals per hour. The within year frequency weighted average carapace lengths for males ranged between 17.75 mm and 19.75 mm, while the weighted average carapace lengths for females ranged between 22.14 mm and 23.12 mm. There were no trends in the average size of either males or females.

RESEARCH SURVEY DATA

Stock Size

Inshore strata along the northeast Newfoundland coast were not sampled during either 1995 or 1999. Due to weather conditions, it was not possible to survey the 3K inshore strata during 2007. Therefore, for comparative purposes, the analyses were confined to the offshore strata. 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 2007 fall multi-species research survey indicate that shrimp continue to be widely distributed and abundant throughout Hawke Channel + Div. 3K (Fig. 11 and 17). Indices from autumn multi-species surveys have generally increased since 1997 (Tables 7-12). The total biomass in 2007 was 776,200 t (178 billion animals).

Confidence intervals are relatively tight suggesting a relatively uniform distribution throughout the survey area (Table 7; Fig. 17 and 18). This is in agreement with the aerial index used to track changes in the commercial fishing and research survey data (Fig. 11). This is further confirmed by Tables 8–12 which provide various presentations of stratified analyses by stratum and depth to determine whether the stock is expanding or contracting into certain areas. All of these tables indicate that most of the shrimp have consistently been found in 200–500 m depths. The meeting agreed that there was no sign of contraction into certain strata or depths. This provides further evidence that the resource is presently healthy.

The female stock increased from an estimated 182,000 t in 1997 to 462,000 t in 2006. Female spawning stock biomass was 427,000 t in 2007, the second highest level in the survey time series (Table 13; Fig. 19). Similarly, fishable biomass has been increasing almost continuously throughout the time series and was 616,000 t in 2007, also the second highest in the survey time series (Table 14; Fig. 19).

Recruitment has fluctuated about the mean between 1996 and 2005. The 2006 and 2007 recruitment indices were the highest in the time series (Table 15; Fig. 20).

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, total biomass and fishable biomass. In general, exploitation has been low even though catches have increased over time because the stock parameters also increased (Table 16). Fig. 21 presents the exploitation rate index determined as catch/ previous year's fishable biomass index. The 2007 exploitation rate index ($catch_{year}$/$fishable\ biomass_{previous\ year}$), was 10.82%.

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 1996-2007 surveys are compared in Fig. 22. 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, as well, there is an accumulation of animals at each length class due to varying but generally reduced growth rates as males become older. Table 17 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. 22), 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 17). 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.

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 17; Fig. 22). Shrimp aged 2-4 dominated the male component of the length frequencies in 2007 (2005, 2004 and 2003 year-classes) survey with carapace length frequency modes at 13.79, 16.67 and 19.80 mm respectively.

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 (Tables 13 and 17; Fig. 22).

Survival and Mortality Rate Indices

Based upon age 3+ males and females at time zero against age 4+ males and females during the next year, the median survival, annual mortality, and instantaneous mortality rates were 0.76, 0.24 and 0.27 respectively (Table 18). These values appear reasonable as they do not imply excessively high densities of shrimp necessary to maintain the populations determined from research surveys. As well, these values are similar to those found for the Gulf of St. Lawrence *P. borealis* (Frechette and LaBonte 1981).

The second method required analysis of the observer dataset. Figure 23 provides the percent overigerous animals by Julian day. The period between which 50% of the animals had hatched their eggs (April 22) and when 50% had spawned (August 30) was used as the date range when obtaining counts of primiparous and multiparous animals. When abundances of primiparous females at time zero were compared with abundances of multiparous females the next year, median survival, annual mortality, and instantaneous mortality rates were 0.45, 0.55 and 0.81 respectively (Table 19). The indices produced using this method is not reasonable as it would require a massive biomass of shrimp to sustain the present resource if only 45% of the animals survived from one year to the next.

The third mortality estimation method used the length based parameters presented in Fig. 24. Observed lengths yielded L_{∞}, K,and t_0 values of 30.7986, 0.2187 and -1.0659 respectively. Table 20 compares observed and predicted carapace lengths at age using these parameters. Survival and mortality indices derived using this method is presented in Tables 21 and 22. Median survival, annual mortality and instantaneous mortality for all shrimp (males and females over the entire length range) were 0.65, 0.35 and 0.43 respectively. The median survival, annual mortality and instantaneous mortality for female shrimp were 0.72, 0.28 and 0.33 respectively (Table 21). These values are similar to those derived from the number of age 4+ and females that survived to the next year. Figure 25 presents the changes in instantaneous mortality by size for all shrimp and females only while Fig. 26 presents changes in instantaneous mortality over time. Using this method, instantaneous mortality of males and female shrimp, within SFA 6, has been fairly stable over time.

Status of the shrimp resource

Current status remains positive. The resource continues to be distributed over a broad area as inferred from the spatial distribution of commercial effort and survey catches (Fig. 1, 7-11 and 17). Biomass and abundance indices from fall multi-species surveys have generally increased since 1997 (Tables 7-12; Fig.18). Recruitment and female biomass are expected to support the fishery over the next four years. At the current TAC the 2008-09 exploitation rate index is expected to be 11-15% (based on 2007-08 TAC and 2007 fishable biomass confidence intervals). Any modest change in TAC is expected to have a proportional change in the exploitation rate index. Appendix 1 provides the stock status performance report for SFA 6.

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 1989-93 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 9,787 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 to 2007-08 seasons. The history of the total fishery within SFA 5 is presented in Tables 1 and 2, as well as Fig. 27. Approximately 22,700 t were taken each year between 2004-05 to 2006-07 while 23,800 t of shrimp were taken in the 2007-08 management year from a quota of 23,805 t (Tables 1, 2 and 23; Fig. 27). 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. 28); however, as illustrated in Fig. 27 the total combined fleet quotas have rarely been exceeded since 1986.

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. 29). Figure 30 quantifies the amount of bottom contact per 10 min X 10 min cell. The area fished has generally been increasing throughout history of the fishery (Fig. 31). Since 1995, the seasonality of the fishery switched from a summer-fall to a winter-spring operation (Fig. 32).

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 24; Fig. 33). 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 78% of the variance in data. The scatter of residuals around parameter estimates is provided in Fig. 34. 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 1998, 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. 33). The 1997-2006 catch rates were statistically similar (P>0.05) to 2007 (Table 24). A high CPUE over a relatively broad area (Fig. 29-31) is an indication that the stock is healthy.

Stock Composition

Due to the overlap of modes, it was not possible to complete modal 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. 35). Catch rates have been maintained at more than 270,000 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 23.22 mm. There were no trends in the average size of either males or females.

Recruitment of males with 16-22 mm carapace lengths 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 1999, 1998 and 1997 year-classes (16 mm, 18 mm and 20 mm respectively). The 2000-03 year-classes were of weak to moderate strength and it was not possible to detect these year-classes in subsequent commercial length frequencies. The 2004 year-class was relatively strong and could be seen as 16 mm animals in the 2007 distribution.

RESEARCH SURVEY DATA

Stock Size

Annual multi-species surveys were conducted throughout the entire of SFA 5 Cartwright + Hopedale Channels) between 1996 and 1999. Since then, SFA 5 was surveyed in its entirety in only three (2001, 2004, 2006) of the last eight years. However, the lower part of SFA 5 (Cartwright Channel) has been surveyed during all years since 1996. Trends in total biomass and abundance indices and biological characteristics from SFA 5 and Cartwright Channel were broadly consistent with at least 76% of the variance accounted for in linear regressions between SFA 5 and Cartwright Channel estimates (Tables 25-27; Figs. 36-39).

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 is 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, 2004 and 2006 survey indices within Cartwright showed similar trends to those within the whole of SFA 5. 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 within Cartwright Channel increased from 43,300 t (9 billion animals) during 1998 to 141,300 t (29 billion animals) during 2005 and decreasing in 2006 to 80,000 t (20 billion animals) but then increasing again to 85,600 t (24 billion animals) in 2007 (Table 25; Fig. 37A). The lower 95% confidence limit of the biomass estimates averaged 71,400 t (17 billion animals) over the period 2003-07.

Biomass within the entire of SFA 5 increased from 86,100 t (17 billion animals) during 1998 to 247,800 t (62 billion animals) during 2001 and then decreased to 183,000 t (39 billion animals) during 2004 and remaining near that level in 2006. The lower 95% confidence limit of the biomass estimates averaged 137,800 t (30 billion animals) over the period 2003–06.

A comparison between Figs. 7-11 and 17 with 29-31 and 36 demonstrates that the distribution of animals is more widespread and evenly dispersed within SFA 6 than it is in 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 (Tables 25-27; Fig. 37). The SFA 5 fishery takes place in areas of high research catches (Figs. 29-31 and 36). The aerial index used in tracking the fishery (percent of the total available area accounting for 95% of the catch; Fig. 11 and 31) is higher in latter years in both SFA's 5 and 6 suggesting that the resource is healthy in both SFA's.

Tables 28–32 summarize the biomass by depth over the entire survey time series. Unfortunately, the autumn multi species covered the entire of SFA 5 during only 1996–99 and in three (2001, 2004, 2006) of the last eight years; therefore, it is not appropriate to compare across all years. The comparison between years in which there was a complete survey indicates that in general, the biomass was higher in most strata down to 750 m after 2000 than before 2000 (Tables 28-32). As with similar tables for SFA 6 (Tables 7-12), there is no indication that shrimp distributions are contracting.

In general, the female spawning stock biomass index, within Cartwright Channel, increased from 16,000 t in 1996 to 76,000 t in 2005 before declining to 33,000 t in 2006 and remaining near that level in 2007 (Table 33; Fig. 40A). The lower 95% confidence limit of the Cartwright Channel female spawning stock biomass index averaged 28,400 t between 2003–07 (Table 33).

The female spawning stock biomass index for the entire of SFA 5 increased from 33,000 t in 1996 to 95,000 t in 2001 and then decreased to 86,000 t in 2004 remaining near that level in 2006 (Table 34).

Trends in female spawning stock biomass from SFA 5 and Cartwright Channel were broadly consistent with 93% of the variance accounted for in a linear regression

between SFA 5 and Cartwright Channel female spawning stock biomass estimates (Tables 33 and 34; Fig. 40).

Recruitment indices within the Cartwright Channel and the entire of SFA 5 appear to follow similar trajectories (Tables 35, 36; Fig. 41). Recruitment oscillated along the long term mean. The indices, within the entire of SFA 5, were high during 1996, decreased over the next three years before increasing to 14.3 billion animals in 2001 but then decreasing to 4.5 billion in 2005. Subsequent to 2005 the recruitment indices have been increasing and are now about average for the entire of SFA 5 (7.6 billion animals) in 2006. Recruitment indices increased to the highest recorded level in Cartwright Channel (9.9 billion animals) in 2007. Seventy four percent of the variance is accounted for in the relationship between SFA 5 and Cartwright Channel recruitment indices (Fig. 41C).

There is no clear trend in the fishable biomass indices within Cartwright Channel, with the exception that for the most part, fishable biomass indices are higher after 2000 than before 2000 (Table 37; Fig. 42A). Similarly, fishable biomass indices within the entire of SFA 5 are higher after 2000 than before 2000 (Table 38; Fig. 42B). Fishable biomass indices were estimated to be 61,400 t and 151,700 t in Cartwright Channel and the entire of SFA 5 respectively during 2006. Fishable biomass decreased slightly to 58,300 t in Cartwright Channel during 2007. Approximately 81% of the variance in the relationship between SFA 5 and Cartwright Channel fishable biomass indices is accounted for in a linear relationship (Fig. 42C).

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, total biomass and fishable biomass. In general, exploitation has been low even though catches have increased over time because the stock parameters also increased (Table 39). Figure 43 presents the exploitation rate index determined as catch/ previous year's fishable biomass index. The 2007 exploitation rate index, for SFA 5 ($catch_{year}$/fishable $biomass_{previous\ year}$), was 15.67%.

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

Figure 44 provides the Cartwright Channel length frequency distributions over the period 1996-2007. Modes were found near 10, 14, 16, 18 and 20 mm along the male length frequencies (Table 40; Fig. 44). It is noteworthy that there is one additional mode that was not present among the Hawke Channel + 3K (SFA 6) male distributions (Table 17; Fig. 22). The third and fourth modes in the Cartwright Channel length frequencies are to the left of the respective Hawke Channel + 3K modes and there is a fifth mode among the Cartwright males that was not present among the more southern males. This is evidence that the Cartwright Channel animals are slower growing than they are in southern areas.

It is worth noting that the 2004 year-class can be tracked at 10.45 mm, 13.82 mm and 16.06 mm modes during 2005, 2006 and 2007 respectively. This strong mode is similar to the age 1 mode found in the autumn 2005 Hawke Channel + 3K (SFA 6) (Fig. 22) and 2005 NAFO Div. 3LNO length frequencies (Orr et al. 2006). The 2004 year-class appeared strong in the 2006 recruitment index (abundance of males with 11.5–16 mm carapace lengths) from SFA 6 (Fig. 20) and NAFO Div. 3LNO (Orr et al. 2006), as well as from Cartwright Channel (Fig. 41A); however, it appeared to be of average strength in the entire SFA 5 (Fig. 41B).

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 (Tables 33, 34 and 40) relative to values before 2000.

Status of the shrimp resource

Current status remains positive. The resource continues to be distributed over a broad area (Figs. 29-31, 36 and 37). Survey indices after 2000 are somewhat higher than before 2000 (Tables 25–38; Figs. 37, 40 and 42). Recruitment in the short-term, while uncertain appears average (Table 36; Fig. 41). Longer-term prospects are unknown. Appendix 2 provides the stock status performance report for SFA 5 .

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

FISHERY DATA

Catch and Effort

Total allowable catches increased from 2,580 t in 1989 to 5,200 t in 1995 and 8,632 t in 1998 (Table 1; Fig. 45). The 1998 TAC allocated 2,184 t to the area south of 60^{o}N to promote spatial expansion of the fishery. The 2003 TAC was increased to 10,320 t. In 2003 the management year changed to April 1–March 31, and an additional interim quota of 2,802 t was set for the period January 1–March 31, 2004. Thus the 2003-04 management period was 15 months and had a 13,057 t TAC. The 2003-04 management year TAC (10,320 t) was maintained through to 2007-08. Preliminary data indicate that 10,300 t were taken during the 2007-08 management year.

The large vessel fleet fishes along the northeastern shelf edge in depths as great as 700 m, in Ogak Channel and to a lesser degree along the southern shelf edge (Fig. 46 and 47). Percent total area within SFA 4 necessary for the large (>500 t) vessel fleet to obtain 95% of their catch has increased from 1–6% over the period 1980-2007 and has generally been showing an upward trend since 1997 (Fig. 48) indicating an expansion of the fishery.

The seasonality of the fishery has changed greatly over the years as ice conditions changed. Over the history it has most often been a spring-fall fishery; however, in recent years an increasing percentage of fishing during the winter (Fig. 49).

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 61% of the variation in the parameters and showed that the annual, standardized catch rates for 1991-93, 1998-2000, 2002 and 2004-06 were similar ($P > 0.05$) to the 2007 estimate. Model CPUE has varied along the mean since 1991 (Tables 41 and 42; Fig. 50). Anecdotal information from the large vessel fleet indicates that the CPUE may be biased downward due to exploratory fishing along the shelf edge. The scatter of residuals around the parameter estimates is provided in Fig. 51. 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 1998-2007 period showed variable size distributions between years (Fig. 52). Catch at length from the observer large vessel dataset consisted of a broad size range of males and females believed to represent more than two year-classes. As with the more southern shrimp fishing areas, the modes were highly overlapping, therefore it was not possible to age either males or females using modal analysis. Catch rates for large vessels had been maintained at over 240,000 animals per hour. The within year frequency weighted average carapace lengths for males ranged between 19.54 mm and 21.10 mm while the weighted average carapace lengths for females ranged between 23.37 mm and 24.65 mm. There were no trends in average size of either males or females.

RESEARCH SURVEY DATA

Stock Size

Since 2005, three annual July shrimp surveys have been conducted in NAFO Division 2G. These surveys have been conducted jointly by the Northern Shrimp Research Foundation and DFO 2G (Figs. 53-55). Total biomass increased from 69,100 t (14 billion animals) in 2005 to 128,200 t (23 billion animals) in 2007 (Table 43; Fig. 56).

Most shrimp were found in 200-400 m depths (Tables 44–47; Figs. 53-55) and as in the more southern SFA's there was no trend toward concentration in any one depth zone.

Recruitment increased from 1 billion animals in 2005 to 2.2 billion in 2006 then decreasing slightly to 2.1 billion animals in 2007 (Table 48; Fig. 57). As one moves north from 3L toward 2G, the recruitment signal becomes less clear, because the abundances of animals decrease from south to north resulting in relatively high numbers of small animals filtering through the 40 mm mesh ahead of the codend. For this reason, a small mesh (12.7 mm knot to knot) juvenile shrimp net is attached slightly ahead of the codend. Figure 58 clearly indicates modes from 0-group (8 mm carapace length) and one year (12 mm carapace length) old animals may be tracked from one year to the next in the juvenile shrimp net samples. These modes are not evident in the codend samples. The first clear mode, found in the codend, is at 15 mm and is thought to be from three year old animals. It is hoped that over time, information gathered from the juvenile

shrimp net samples can be used as an aid in ageing the SFA 4 shrimp. Additionally, it is hoped that the juvenile shrimp net samples will provide a reliable recruitment index.

Female spawning stock biomass increased from 33,100 t in 2005 to 77,600 t in 2007 (Table 49; Fig. 59).

Fishable biomass increased from 66,200 t in 2005 to 111,300 t in 2007 (Table 50; Fig. 60).

Exploitation Rates

Exploitation rate indices were determined using ratios of catch divided by the within year's survey index. The within year survey indices as used as the denominators for this set of exploitation rate indices because the survey is conducted during the middle of the fishing season as opposed to the more southern surveys conducted near the end of the fishing season. In this case, the survey indices included the lower 95% confidence interval of the biomass estimate, total biomass and fishable biomass. In general, exploitation has been low even though catches have increased over time because the stock parameters also increased (Table 51). Figure 61 presents the exploitation rate index determined as catch/ previous year's fishable biomass index. The 2007 exploitation rate index, for SFA 5 ($catch_{year}$/fishable $biomass_{year}$), was 9.22%.

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

NAFO Div. 2G length frequencies were often jagged making it difficult to age the shrimp using modal analysis. However, a mode at 19 mm and 21 mm were present in the male length frequencies meaning that the male shrimp were most likely from more than one year-class. Similarly, the female length frequencies were broad implying more than one year-class was present.

All of the survey indices have been increasing, confirming that the stock appears healthy with no indication that the present fishery has an impact upon this portion of the shrimp stock.

RESOURCE STATUS

Current status appears positive from fishery and exploitation indices. The fishable biomass remains between 66,200 t and 111,300 t (Table 50; Fig. 60) and spawning stock appears healthy, as evidenced in continued high catch rates of large female shrimp (Table 49; Figs. 52 and 59). Catch rates have remained near the long term mean over the entire fishery time series (Tables 41 and 42; Fig. 50) with anecdotal information, provided by the large vessel industry, indicating that the CPUE data may be low due to exploratory fishing along the shelf edge (Figs. 46 and 47).

Sources of Uncertainty within the SFA 4-6 Assessments

It is important to note that there is uncertainty around the 2002-05 autumn DFO surveys (SFA's 5 and 6) because, due to vessel problems, they were finished in January or early February rather than during December as planned.

Various methods were explored to determine shrimp mortality rates; however, further work must be completed before mortality estimates become available.

Additionally, there are several sources of uncertainty within the Cartwright channel and SFA 5 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 is 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, 2004 and 2006 survey indices within Cartwright showed similar trends to those within the whole of SFA 5. 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. Thus, the lack of complete research surveys in SFA 5 is a substantial source of uncertainty for this area.

The joint NSRF-DFO survey into SFA 4 is only three years in length, therefore it is difficult to assess trends in stock size.

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

Area closures in good shrimp fishing areas may affect catch rate models as indicators of stock size.

REFERENCES

Allen, J.A. 1959. On the biology of *Pandalus borealis* Kroyer, with reference to apopulation off the Northumberland coast. J. Mar. Biol. Ass. 38: 89–220.

Brodie, W. 1996. A description of the1995 fall groundfish survey in Division 2J3KLMNO. NAFO SCR. Doc. 96/27, Ser. No. N2700. 7p.

Frechette, J., and LaBonte, S.S.M. 1981. Biomass estimate, year-class abundance and mortality rates of *Pandalus borealis* in the northwest Gulf of St. Lawrence. *In* Proceedings of the international Pandalid shrimp symposium. Edited by T. Frady. Kodiak, Alaska, Feb. 13-15., 1979, Univ. Alaska, Sea Grant Rep. 81-3. p. 307-330. Cited in Shumway, S.E., Perkins, H.C., Schick, D.F., and Stickney,

A.P. 1985. Synopsis of biological data on the Pink Shrimp, *Pandalus borealis* Kroyer, 1838. FAO Fisheries Synopsis No. 144. 57pp.

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

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

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

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

Formula used to account for changes in cell size due to latitude. (On line available). http://www.meridianworlddata.com/Distance-Calculation.asp

Golden Software Inc. 2002. Surfer Version 8.0. Golden Software Inc. Golden Colorado. U.S.A

Parsons, D.G., Veitch, P.J., Orr, D., and Evans, G.T. 2000. Assessment of northern shrimp (*Pandalus borealis*) off Baffin Island, Labrador and northeastern Newfoundland. DFO Can. Sci. Advis. Sec. Doc. 2000/069. 65p.

Rasmussen, B. 1953. On the geographical variation in growth and sexual development of the deep sea prawn (*Pandalus borealis*, Kr.). Norweg. Fish. Mar. Invest. Rep. 10 (3): 1-160.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191. Ottawa. 382p.

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

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

Table 1. Quotas (t) Northern shrimp (*Pandalus borealis*) by Shrimp Fishing Area (SFA), 1978 - 2007

YEAR	DIV2G	HOPE	CART	HAWKE	DIV3K	TOTAL
	SFA4	SFA5		SFA6		
1978	500	4,500	800	800	500	7,100
1979	500	3,200	800	1,750	500	6,750
1980	500	4,000	800	850	500	6,650
1981	500	4,000	800	850	500	6,650
1982	500	4,000	800	850	500	6,650
1983	500	4,000	800	850	500	6,650
1984	500	3,500	700	850	500	6,050
1985	500	2,800	770	850	500	5,420
1986	500	3,400	1,000	850	1,200	6,950
1987	500	4,000	800	1,500	1,500	8,300
1988	500	4,000	800	1,500	1,500	8,300
1989	2,580	4,400	1,600	2,000	3,600	14,180
1990	2,580	4,400	1,600	2,000	3,600	14,180
1991	2,635	4,760	1,615	2,210	2,091	13,311
1992	2,635	4,760	1,615	3,910	3,655	16,575
1993	2,735	4,760	1,615	3,846	5,334	18,290
1994	4,000	7,650		11,050		22,700
1995	5,200	7,650		11,050		23,900
1996	5,200	7,650		11,050		23,900
1997	5,200	15,300		23,100		43,600
1998	8,632	15,300		46,200		70,132
1999	8,632	15,300		58,632		82,564
2000	8,632	15,300		61,632		85,564
2001	8,632	15,300		61,632		85,564
2002	8,632	15,300		61,632		85,564
2003	13,559**	33,087**		85,585**		132,231
2004	10,397	23,300		77,932		111,629
2005	10,391	23,300		78,014		111,705
2006	10,456	23,300		78,517		112,273
2007	10,348	23,805		79,799		113,952

** The offshore licence holders requested that their quotas starting in 2003 run from April 1 - March 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 quotas include quota transfers as well as bridging between years.

Table 2. Nominal catches (t) of Northern shrimp (*Pandalus borealis*)* by Shrimp Fishing Area (SFA), 1977 - 2007

YEAR	DIV2G	HOPE	CART	HAWKE	DIV3K	TOTAL
	SFA4	SFA5		SFA6		
1977	-	1,272	1,414	<1	<1	2,687
1978	-	2,109	1,521	-	-	3,630
1979	3	2,693	1,034	5	-	3,735
1980	<1	3,938	170	-	-	4,108
1981	2	3,382	67	135	-	3,586
1982	5	1,829	154	<1	-	1,989
1983	30	997	3	-	-	1,030
1984	-	712	290	-	-	1,002
1985	-	1,687	2	-	-	1,689
1986	2	3,498	1,328	-	-	4,828
1987	7	4,538	1,418	1,678	167	7,808
1988	1,083	6,584	1,254	3,747	4,102	16,770
1989	3,842	4,329	1,656	1,855	4,807	16,489
1990	2,945	3,769	1,591	1,929	3,669	13,903
1991	2,561	4,501	1,617	1,976	3,524	14,179
1992	2,706	4,680	1,635	3,015	3,594	15,630
1993	2,723	4,273	1,446	3,672	4,363	16,477
1994	3,982		7,499		10,978	22,459
1995	5,104		7,616		10,914	23,634
1996	5,160		7,383		10,923	23,466
1997	5,217		15,103		21,018	41,338
1998	8,051		14,827		46,337	69,215
1999	7,884		14,720		51,260	73,864
2000	8,048		14,451		63,175	85,674
2001	7,991		15,036		52,554	75,581
2002	8,516		15,121		59,912	83,549
2003*	13,057[4]		30,437		71,022	114,516
2004	9,644		22,690		77,820	110,154
2005	10,247		22,900		75,198	108,344
2006	10,084		22,616		75,674	108,374
2007	10,258		23,768		80,733	114,759

* In 2003, the offshore licence holders were allowed to change their quota period from January 1 – December 31 to April 1 – March 31.

Please note that the catches include quota transfers as well as bridging between years.

TABLE 3. NORTHERN SHRIMP LARGE VESSEL (>500 t) SHRIMP FISHERY DATA FOR HAWKE CHANNEL + 3K (SFA 6), 1977 - 2007. (Single + twin trawl, year, month, vessel, gear, area observer data, no windows)

YEAR	[1] TAC (t)	[2] FLEET CATCH (t)	UNSTANDARDIZED CPUE (KG/HR)	CPUE RELATIVE TO 2007	[3] EFFORT (HR)	STANDARDIZED CPUE RELATIVE TO 2007	MODELLED CPUE	EFFORT (HRS)
1977	0	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	818	0.43	8,147	0.62	856	7,783
1990	5,600	5,598	596	0.31	9,389	0.43	596	9,388
1991	4,301	5,500	446	0.23	12,324	0.34	474	11,607
1992	7,565	6,609	576	0.30	11,479	0.37	512	12,902
1993	9,180	8,035	700	0.37	11,473	0.49	683	11,766
1994	11,050	10,978	1,199	0.63	9,155	0.66	910	12,069
1995	11,050	10,914	1,611	0.85	6,773	0.92	1,274	8,566
1996	11,050	10,923	1,518	0.80	7,197	0.93	1,285	8,498
1997	15,335	14,954	1,454	0.77	10,281	1.14	1,585	9,434
1998	16,360	16,264	1,417	0.75	11,474	0.98	1,354	12,016
1999	17,603	17,587	1,390	0.73	12,654	0.96	1,327	13,249
2000	19,387	20,615	1,478	0.78	13,948	1.08	1,492	13,817
2001	20,103	19,894	1,528	0.80	13,019	1.08	1,490	13,354
2002	20,103	20,233	1,442	0.76	14,031	0.94	1,304	15,517
2003	33,276	29,371	1,679	0.88	17,497	0.94	1,296	22,661
2004	25,333	24,504	1,748	0.92	14,015	0.93	1,292	18,962
2005	25,527	25,466	1,800	0.95	14,148	0.97	1,342	18,981
2006	25,527	24,857	1,940	1.02	12,814	1.08	1,495	16,627
2007	27,200	27,576	1,901	1.00	14,508	1.00	1,385	19,908

[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] **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.**

Table 4. Multiplicative year, month, vessel gear and area CPUE model for large vessels, (> 500 t) fishing shrimp in Hawke Channel + 3K (SFA 6), 1989 – 2007, weighted by effort (Single + double trawl, year, month, area; Observer data, no windows, history> 3 years.)

The GLM Procedure

Class Level Information

Class	Levels	Values
year	19	1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
month	12	1 2 3 4 5 7 8 9 10 11 12 13 Standardized to June
CFV	20	
gear	2	2 10 Standardized to a single trawl (code 2 = single while 10 = double)
Area	6	67 68 69 90 92 99 Standardized to Hawke Channel

Number of Observations Read	2469
Number of Observations Used	2286

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	54	22013.90738	407.66495	74.99	<.0001
Error	2231	12127.51476	5.43591		
Corrected Total	2285	34141.42214			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.644786	31.25929	2.331504	7.458595

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	18	8569.528679	476.084927	87.58	<.0001
month	11	6519.934953	592.721359	109.04	<.0001
CFV	19	5843.445437	307.549760	56.58	<.0001
gear	1	698.509250	698.509250	128.50	<.0001
Area	5	382.489062	76.497812	14.07	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	18	3712.517889	206.250994	37.94	<.0001
month	11	5191.653640	471.968513	86.82	<.0001
CFV	19	4730.514521	248.974448	45.80	<.0001
gear	1	733.881332	733.881332	135.01	<.0001
Area	5	382.489062	76.497812	14.07	<.0001

Table 4 (Cont'd.)

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		7.150785337	B	0.04435677	161.21	<.0001
year	1989	-0.481277946	B	0.12422150	-3.87	0.0001
year	1990	-0.842795935	B	0.12757197	-6.61	<.0001
year	1991	-1.072693914	B	0.08086310	-13.27	<.0001
year	1992	-0.994764740	B	0.09747394	-10.21	<.0001
year	1993	-0.707198252	B	0.05917951	-11.95	<.0001
year	1994	-0.420541547	B	0.04105164	-10.24	<.0001
year	1995	-0.083571073	B	0.05199687	-1.61	0.1081
year	1996	-0.074727990	B	0.04684450	-1.60	0.1108
year	1997	0.134809254	B	0.04463221	3.02	0.0026
year	1998	-0.023101497	B	0.04165922	-0.55	0.5793
year	1999	-0.042554975	B	0.03925115	-1.08	0.2784
year	2000	0.074327070	B	0.03863331	1.92	0.0545
year	2001	0.072796874	B	0.03901975	1.87	0.0622
year	2002	-0.060422578	B	0.03686420	-1.64	0.1013
year	2003	-0.066472327	B	0.03713163	-1.79	0.0736
year	2004	-0.069415829	B	0.03618544	-1.92	0.0552
year	2005	-0.031901830	B	0.03307389	-0.96	0.3349
year	2006	0.076280416	B	0.03481957	2.19	0.0286
year	2007	0.000000000	B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
1989	6.752291	6.499532	7.005049
1990	6.390773	6.133202	6.648344
1991	6.160875	5.991271	6.330479
1992	6.238804	6.037834	6.439774
1993	6.526370	6.395553	6.657188
1994	6.813027	6.707088	6.918966
1995	7.149998	7.026939	7.273056
1996	7.158841	7.044608	7.273074
1997	7.368378	7.260798	7.475958
1998	7.210467	7.104222	7.316712
1999	7.191014	7.089010	7.293017
2000	7.307896	7.206831	7.408960
2001	7.306366	7.204156	7.408575
2002	7.173146	7.073416	7.272876
2003	7.167096	7.064912	7.269281
2004	7.164153	7.065300	7.263006
2005	7.201667	7.105932	7.297402
2006	7.309849	7.209521	7.410177
2007	7.233569	7.133039	7.334098

gear	lncpue LSMEAN	95% Confidence Limits	
2	7.125502	7.028866	7.222138
10	6.856032	6.766589	6.945476

TABLE 5. NORTHERN SHRIMP SMALL VESSEL (<500 t; loa<100') SHRIMP FISHERY DATA FOR HAWKE CHANNEL + 3K (SFA 6), 1997 - 2007. (Proposed model formulation; single trawl, year, size-class and area logbook data).

YEAR	[1] TAC (t)	[2] FLEET CATCH (t)	UNSTANDARDIZED CPUE (KG/HR)	CPUE RELATIVE TO 2007	[3] EFFORT (HR)	STANDARDIZED CPUE RELATIVE TO 2007	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1997	7,765	6,064						
1998	29,840	30,073	341	0.59	88,112	0.61	315	95,351
1999	41,029	33,673	329	0.57	102,263	0.61	317	106,340
2000	41,529	42,560	387	0.67	110,112	0.69	357	119,322
2001	41,529	32,660	369	0.64	88,598	0.72	369	88,443
2002	41,529	39,679	328	0.57	120,932	0.63	323	122,716
2003	52,299	41,651	364	0.63	114,393	0.65	337	123,659
2004	52,599	53,316	519	0.90	102,687	0.88	452	117,981
2005	52,599	49,732	548	0.95	90,763	0.94	484	102,734
2006	51,293	50,817	562	0.97	90,444	0.97	498	102,135
2007	53,525	53,232	579	1.00	91,867	1.00	515	103,348

[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 6. Multiplicative year, month, vessel size and area CPUE model for small vessels (<=500 t; LOA<=100') fishing shrimp in Hawke Channel + 3K, 1998-2007, weighted by effort (Logbook data, history > 3 years). The vessels were broken into the following three size classes; LOA<=50'; 50'<LOA<= 60' and 60'<LOA.

The GLM Procedure
Class Level Information

Class	Levels	Values
year	10	1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
month	6	5 6 8 9 10 13 Standardized against July
size_class	3	1 2 3
area	7	54 67 68 80 90 92 100 Standardized against the 3K shelf edge

Number of Observations Read 875
Number of Observations Used 874

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	22	54006.91497	2454.85977	119.99	<.0001
Error	851	17411.06130	20.45953		
Corrected Total	873	71417.97628			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.756209	74.39187	4.523221	6.080263

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	9	39832.40022	4425.82225	216.32	<.0001
month	5	1240.99827	248.19965	12.13	<.0001
size_class	2	3095.26221	1547.63111	75.64	<.0001
area	6	9838.25427	1639.70905	80.14	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	9	22276.78758	2475.19862	120.98	<.0001
month	5	2611.34009	522.26802	25.53	<.0001
size_class	2	2533.90229	1266.95114	61.92	<.0001
area	6	9838.25427	1639.70905	80.14	<.0001

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		6.535655699 B	0.02129083	306.97	<.0001
yearf	1998	-0.490496996 B	0.02653554	-18.48	<.0001
yearf	1999	-0.486504123 B	0.02477191	-19.64	<.0001
yearf	2000	-0.367468443 B	0.02384245	-15.41	<.0001
yearf	2001	-0.332763520 B	0.02561391	-12.99	<.0001
yearf	2002	-0.465610126 B	0.02328456	-20.00	<.0001
yearf	2003	-0.424758491 B	0.02320975	-18.30	<.0001
yearf	2004	-0.130844312 B	0.02341540	-5.59	<.0001
yearf	2005	-0.062053247 B	0.02410933	-2.57	0.0102
yearf	2006	-0.034623718 B	0.02413627	-1.43	0.1518
yearf	2007	0.000000000 B	.	.	.

Table 7. Northern shrimp stock size estimates in Hawke+3K (SFA 6) [1]
from fall research trawl surveys - offshore, 1996-2008.

Year	Biomass (tons)			Abundance (numbers x 10^{-6})			Survey
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1996	416,400	502,800	586,800	98,840	115,960	133,300	238
1997	362,100	424,900	467,700	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	502,700	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	513,300	599,500	671,600	131,600	149,391	165,600	236
2004	594,600	656,900	742,600	129,900	143,996	164,100	214
2005	578,800	668,600	757,800	128,800	144,997	163,600	242
2006	757,800	892,700	1,031,000	179,600	205,103	235,200	234
2007	643,000	753,100	865,300	151,100	172,532	199,100	206

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

Table 8 Total biomass (tons) of northern shrimp (*Pandalus borealis*) collected during the 1996 - 2007 DFO research bottom trawl multi-species research surveys into Hawke Channel + 3K (SFA 6). (All tows were standardized to 15 minutes; empty cells were not sampled.). The conversion from square nautical miles to square kilometres was 1 sq Nmi = 3.429904 sq km (www.onlineconversion.com/area.htm)

Depth Range (m)	Area sq. Nmi	Area sq. km	Stratum	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
101 - 200	1594	5467.261	205	831	460	3,098	2,074	5,748	4,261	5,289	3,330	4,457	6,776	1,985	8,061
101 - 200	1870	6413.913	206	1,448	7,415	9,506	5,432	6,021	11,178	9,185	8,413	8,534	5,899	12,027	21,229
101 - 200	2264	7765.294	207	570	1,184	3,370	1,957	8,097	6,233	4,189	2,115	5,782	3,236	3,723	13,297
101 - 200	1347	4620.075	618	72	1,149	190	871	1,444	2,496	2,435	1,677	5,413	2,299	4,947	11,013
101 - 200	1753	6012.615	619	36	120	573	352	1,471	2,522	3,655	318	2,971	3,125	2,345	3,538
201 - 300	680	2332.332	209	14,521	6,923	1,871	17,348	8,097	8,168	7,403	17,186	3,073	12,576	9,476	10,663
201 - 300	1035	3549.947	210	32,697	12,866	12,685	25,518	12,189	18,646	17,428	12,316	23,698	14,491	20,942	9,563
201 - 300	1583	5429.532	213	44,120	40,940	53,428	50,337	33,072	113,195	58,539	35,567	24,722	57,539	164,580	61,486
201 - 300	2196	7532.06	228	115,102	33,499	46,335	26,285	32,482	40,993	22,536	20,134	63,709	70,567	105,937	81,173
201 - 300	2545	8729.096	620	13,021	15,731	18,779	43,857	33,917	17,778	26,405	13,528	19,098	24,188	34,699	50,962
201 - 300	2537	8701.656	621	9,945	5,570	8,094	19,202	16,039	4,336	15,414	15,798	19,148	6,545	26,942	33,850
201 - 300	1105	3790.04	624	19,806	15,662	15,147	19,157	21,753	17,647	14,466	13,814	22,347	27,995	37,084	29,513
201 - 300	1555	5333.495	634	21,189	12,235	23,726	21,516	38,894	40,585	20,448	10,942	11,172	29,596	70,224	53,112
201 - 300	1274	4369.693	635	4,589	7,654	6,643	7,942	11,154	3,959	3,523	2,694	129	7,694	.	19,870
201 - 300	1455	4990.505	636	14,415	9,409	15,702	18,783	25,243	10,966	17,703	12,005	31,315	22,446	14,716	22,229
201 - 300	1132	3882.647	637	4,152	6,250	8,717	12,986	.	11,546	6,235	14,405	19,897	29,899	15,455	35,025
301 - 400	588	2016.781	208	11,831	10,274	12,039	7,810	10,765	12,575	10,424	9,205	10,525	30,035	10,823	7,449
301 - 400	251	860.9049	211	10,742	12,810	7,808	5,569	9,626	4,919	5,558	8,533	5,520	7,551	12,642	13,325
301 - 400	450	1543.455	222	6,182	6,080	6,942	6,398	12,852	6,650	5,369	7,013	4,475	3,761	4,270	1,187
301 - 400	536	1838.426	229	17,335	20,438	12,728	12,126	15,596	21,050	16,593	28,863	18,820	12,021	28,918	2,907
301 - 400	593	2033.931	617	11,348	5,566	8,741	6,629	12,829	9,947	18,166	23,733	9,059	11,173	3,582	8,747
301 - 400	494	1694.371	623	3,285	6,819	11,534	12,805	5,623	9,167	9,935	13,614	15,943	9,312	9,998	11,932
301 - 400	888	3045.751	625	14,021	15,709	13,692	29,648	21,277	24,103	19,186	6,182	24,215	22,753	29,580	25,409
301 - 400	1113	3817.479	626	2,768	10,890	5,183	15,457	15,287	31,151	15,139	27,610	16,806	13,771	20,202	21,120
301 - 400	1085	3721.442	628	2,678	3,493	6,193	10,593	19,209	14,898	20,031	12,333	34,904	12,253	25,065	32,312
301 - 400	495	1697.801	629	4,022	2,153	4,840	2,613	4,715	7,235	6,407	3,952	6,316	6,157	8,992	3,709
301 - 400	332	1138.727	630	1,816	4,411	4,112	1,921	4,767	9,497	4,197	2,677	2,918	1,623	2,375	3,063
301 - 400	2067	7089.603	633	47,482	47,922	49,550	42,458	68,608	114,939	49,286	65,854	62,927	90,791	126,880	39,881
301 - 400	2059	7062.164	638	25,028	19,163	30,877	25,397	11,045	34,011	45,057	47,301	47,188	23,599	21,000	62,968
301 - 400	1463	5017.944	639	38,678	32,821	31,066	27,350	48,276	22,159	24,194	24,648	53,844	26,952	9,647	5,354
401 - 500	158	541.9242	223	976	0	230	121	.	7	29	686	176	1	65	230
401 - 500	598	2051.08	227	5,047	3,734	3,842	156	6,497	3,095	534	5,618	5,360	9,395	13,828	9,689
401 - 500	414	1419.979	235	1,920	2,771	7,410	3,369	1,676	3,851	2,181	3,416	4,303	975	1,460	1,707
401 - 500	133	456.1767	240	44	4	3	552	0	17	30	130	1	10	26	0
401 - 500	691	2370.061	622	9,025	9,935	8,112	8,261	4,197	4,149	11,357	9,649	5,852	6,494	23,287	11,713
401 - 500	1255	4304.525	627	7,817	11,726	8,439	11,258	10,613	26,604	43,830	45,238	16,752	23,224	9,723	6,811
401 - 500	1321	4530.898	631	11,884	14,423	16,158	6,664	14,832	21,470	57,044	43,521	15,019	9,140	19,521	9,650
401 - 500	69	236.6631	640	233	16	3	1	7	14	25	17	1	3	0	1
401 - 500	216	740.8584	645	27	1	154	23	92	5	5	63	10	359	1	0
401 - 500	134	459.6066	650	1,094	9	0	15	.	25	8	20	22	1	0	0
501 - 750	557	1910.454	212	558	6,286	615	519	163	2,706	1,768	4,282	2,397	1,679	514	1,224
501 - 750	228	782.0172	224	0	0	0	3	0	1	65	0	0	3	0	0
501 - 750	185	634.5315	230	0	56	6	21	25	42	13	10	0	0	1	0
501 - 750	230	788.877	641	43	1	0	0	.	2	9	0	0	0	0	1
501 - 750	325	1114.718	646	0	0	1	0	11	5	26	3	1	0	0	1
501 - 750	359	1231.334	651	23	0	58	35	.	0	6	11	3	12	0	0
751 -1000	186	637.9614	231	1	0	5	0	0	3	0	3	17	0	83	0
751 -1000	193	661.9707	236	2	0	1	0	0	0	0	5	0	0	0	0
751 -1000	418	1433.698	642	54	5	0	0	2	0	0	0	0	2	0	0
751 -1000	360	1234.764	647	1	0	29	0	0	1	0	1	0	4	0	0
751 -1000	516	1769.828	652	0	0	60	0	0	0	0	0	0	0	0	0
1001 -1250	195	668.8305	225	0	8	0	0	0	0	0	0	0	0	0	0
1001 -1250	228	782.0172	232	0	1	0	0	0	0	0	0	0	0	0	0
1001 -1250	733	2514.117	643	0	0	0	0	0	0	0	0	0	2	0	0
1001 -1250	228	782.0172	648	0	9	5	0	0	0	0	0	0	1	0	0
1001 -1250	531	1821.277	653	0	0	0	0	0	0	0	0	0	0	0	0
1251 -1500	201	689.4099	226	0	0	0	0	0	1	0	0	3	0	0	0
1251 -1500	237	812.8863	233	0	0	1	0	0	0	0	0	8	0	0	0
1251 -1500	474	1625.773	644	0	0	0	0	0	0	0	0	0	1	0	0
1251 -1500	212	727.1388	649	0	0	0	0	0	0	0	0	0	0	0	0
1251 -1500	479	1642.922	654	0	0	0	0	1	0	0	0	0	0	0	0
lower 95% C.I.				421,937	381,981	424,992	449,478	478,884	584,612	538,150	509,529	561,721	553,828	759,118	531,171
biomass estimate (t)				532,484	424,598	478,305	511,391	554,207	698,807	601,327	578,434	628,853	647,928	907,567	744,971
upper 95% C.I.				643,030	467,214	531,617	573,303	629,529	813,000	664,503	647,339	695,984	742,028	1,056,016	802,880
100 - 200 m	% of total biomass/			0.56	2.43	3.50	2.09	4.11	3.82	4.12	2.74	4.32	3.29	2.76	7.67
201 - 500 m	depth range			99.32	96.07	96.34	97.80	95.85	95.79	95.57	96.51	95.29	96.44	97.18	92.17
>501 m				0.13	1.50	0.16	0.11	0.04	0.39	0.31	0.75	0.39	0.26	0.07	0.16

Table 9 Hawke Channel + 3K (SFA 6) percent contribution of each stratum by year, in terms of northern shrimp biomass (t), as determined using areal expansion calculations of DFO multi-species research survey data. (All tows were standardized to 15 minutes; missing cells were not sampled.).

Depth Range (m)	Area sq. Nmi	Area sq. km	Stratum	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
101 - 200	1594	5467.3	205	0.16	0.11	0.65	0.41	1.04	0.61	0.88	0.58	0.71	1.05	0.22	1.08
101 - 200	1870	6413.9	206	0.27	1.75	1.99	1.06	1.09	1.60	1.53	1.45	1.36	0.91	1.33	2.85
101 - 200	2264	7765.3	207	0.11	0.28	0.70	0.38	1.46	0.89	0.70	0.37	0.92	0.50	0.41	1.78
101 - 200	1347	4620.1	618	0.01	0.27	0.04	0.17	0.26	0.36	0.40	0.29	0.86	0.35	0.55	1.48
101 - 200	1753	6012.6	619	0.01	0.03	0.12	0.07	0.27	0.36	0.61	0.06	0.47	0.48	0.26	0.47
201 - 300	680	2332.3	209	2.73	1.63	0.39	3.39	1.46	1.17	1.23	2.97	0.49	1.94	1.04	1.43
201 - 300	1035	3549.9	210	6.14	3.03	2.65	4.99	2.20	2.67	2.90	2.13	3.77	2.24	2.31	1.28
201 - 300	1583	5429.5	213	8.29	9.64	11.17	9.84	5.97	16.20	9.73	6.15	3.93	8.88	18.13	8.25
201 - 300	2196	7532.1	228	21.62	7.89	9.69	5.14	5.86	5.87	3.75	3.48	10.13	10.89	11.67	10.90
201 - 300	2545	8729.1	620	2.45	3.70	3.93	8.58	6.12	2.54	4.39	2.34	3.04	3.73	3.82	6.84
201 - 300	2537	8701.7	621	1.87	1.31	1.69	3.75	2.89	0.62	2.56	2.73	3.04	1.01	2.97	4.54
201 - 300	1105	3790	624	3.72	3.69	3.17	3.75	3.93	2.53	2.41	2.39	3.55	4.32	4.09	3.96
201 - 300	1555	5333.5	634	3.98	2.88	4.96	4.21	7.02	5.81	3.40	1.89	1.78	4.57	7.74	7.13
201 - 300	1274	4369.7	635	0.86	1.80	1.39	1.55	2.01	0.57	0.59	0.47	0.02	1.19	0.00	2.67
201 - 300	1455	4990.5	636	2.71	2.22	3.28	3.67	4.55	1.57	2.94	2.08	4.98	3.46	1.62	2.98
201 - 300	1132	3882.6	637	0.78	1.47	1.82	2.54	0.00	1.65	1.04	2.49	3.16	4.61	1.70	4.70
301 - 400	588	2016.8	208	2.22	2.42	2.52	1.53	1.94	1.80	1.73	1.59	1.67	4.64	1.19	1.00
301 - 400	251	860.9	211	2.02	3.02	1.63	1.09	1.74	0.70	0.92	1.48	0.88	1.17	1.39	1.79
301 - 400	450	1543.5	222	1.16	1.43	1.45	1.25	2.32	0.95	0.89	1.21	0.71	0.58	0.47	0.16
301 - 400	536	1838.4	229	3.26	4.81	2.66	2.37	2.81	3.01	2.76	4.99	2.99	1.86	3.19	0.39
301 - 400	593	2033.9	617	2.13	1.31	1.83	1.30	2.31	1.42	3.02	4.10	1.44	1.72	0.39	1.17
301 - 400	494	1694.4	623	0.62	1.61	2.41	2.50	1.01	1.31	1.65	2.35	2.54	1.44	1.10	1.60
301 - 400	888	3045.8	625	2.63	3.70	2.86	5.80	3.84	3.45	3.19	1.07	3.85	3.51	3.26	3.41
301 - 400	1113	3817.5	626	0.52	2.56	1.08	3.02	2.76	4.46	2.52	4.77	2.67	2.13	2.23	2.84
301 - 400	1085	3721.4	628	0.50	0.82	1.29	2.07	3.47	2.13	3.33	2.13	5.55	1.89	2.76	4.34
301 - 400	495	1697.8	629	0.76	0.51	1.01	0.51	0.85	1.04	1.07	0.68	1.00	0.95	0.99	0.50
301 - 400	332	1138.7	630	0.34	1.04	0.86	0.38	0.86	1.36	0.70	0.46	0.46	0.25	0.26	0.41
301 - 400	2067	7089.6	633	8.92	11.29	10.36	8.30	12.38	16.45	8.20	11.38	10.01	14.01	13.98	5.35
301 - 400	2059	7062.2	638	4.70	4.51	6.46	4.97	1.99	4.87	7.49	8.18	7.50	3.64	2.31	8.45
301 - 400	1463	5017.9	639	7.26	7.73	6.50	5.35	8.71	3.17	4.02	4.26	8.56	4.16	1.06	0.72
401 - 500	158	541.92	223	0.18	0.00	0.05	0.02	0.00	0.00	0.00	0.12	0.03	0.00	0.01	0.03
401 - 500	598	2051.1	227	0.95	0.88	0.80	0.03	1.17	0.44	0.09	0.97	0.85	1.45	1.52	1.30
401 - 500	414	1420	235	0.36	0.65	1.55	0.66	0.30	0.55	0.36	0.59	0.68	0.15	0.16	0.23
401 - 500	133	456.18	240	0.01	0.00	0.00	0.11	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00
401 - 500	691	2370.1	622	1.69	2.34	1.70	1.62	0.76	0.59	1.89	1.67	0.93	1.00	2.57	1.57
401 - 500	1255	4304.5	627	1.47	2.76	1.76	2.20	1.91	3.81	7.29	7.82	2.66	3.58	1.07	0.91
401 - 500	1321	4530.9	631	2.23	3.40	3.38	1.30	2.68	3.07	9.49	7.52	2.39	1.41	2.15	1.30
401 - 500	69	236.66	640	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
401 - 500	216	740.86	645	0.01	0.00	0.03	0.00	0.02	0.00	0.00	0.01	0.00	0.06	0.00	0.00
401 - 500	134	459.61	650	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
501 - 750	557	1910.5	212	0.10	1.48	0.13	0.10	0.03	0.39	0.29	0.74	0.38	0.26	0.06	0.16
501 - 750	228	782.02	224	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
501 - 750	185	634.53	230	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
501 - 750	230	788.88	641	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
501 - 750	325	1114.7	646	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
501 - 750	359	1231.3	651	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
751 -1000	186	637.96	231	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
751 -1000	193	661.97	236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
751 -1000	418	1433.7	642	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
751 -1000	360	1234.8	647	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
751 -1000	516	1769.8	652	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1001 -1250	195	668.83	225	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1001 -1250	228	782.02	232	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1001 -1250	733	2514.1	643	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1001 -1250	228	782.02	648	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1001 -1250	531	1821.3	653	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1251 -1500	201	689.41	226	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1251 -1500	237	812.89	233	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1251 -1500	474	1625.8	644	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1251 -1500	212	727.14	649	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1251 -1500	479	1642.9	654	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grand total				100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 10 Biomass (t) of northern shrimp (*Pandalus borealis*) per km^2 in Hawke+3k (SFA 6). The analysis was from areal expansion of multi-species reseach survey data collected during such that the lower 1/3 is blue, intermediate is yellow and top 1/3 is the 1996 - 2007 by DFO. Densities within each stratum were divided into three equal parts and color coded orange. The Campelen 1800 research survey trawl was used, tows were at 3 Nmi/hr. and were 15 mniutes in length.

Depth Range (m)	Area sq. km	Stratum	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
101 - 200	5467.2606	205	0.15	0.08	0.57	0.38	1.05	0.78	0.97	0.61	0.82	1.24	0.36	1.47
101 - 200	6413.913	206	0.23	1.16	1.48	0.85	0.94	1.74	1.43	1.31	1.33	0.92	1.88	3.31
101 - 200	7765.2936	207	0.07	0.15	0.43	0.25	1.04	0.80	0.54	0.27	0.74	0.42	0.48	1.71
101 - 200	4620.0753	618	0.02	0.25	0.04	0.19	0.31	0.54	0.53	0.36	1.17	0.50	1.07	2.38
101 - 200	6012.6147	619	0.01	0.02	0.10	0.06	0.24	0.42	0.61	0.05	0.49	0.52	0.39	0.59
201 - 300	2332.332	209	6.23	2.97	0.80	7.44	3.47	3.50	3.17	7.37	1.32	5.39	4.06	4.57
201 - 300	3549.9465	210	9.21	3.62	3.57	7.19	3.43	5.25	4.91	3.47	6.68	4.08	5.90	2.69
201 - 300	5429.5317	213	8.13	7.54	9.84	9.27	6.09	20.85	10.78	6.55	4.55	10.60	30.31	11.32
201 - 300	7532.0604	228	15.28	4.45	6.15	3.49	4.31	5.44	2.99	2.67	8.46	9.37	14.06	10.78
201 - 300	8729.0955	620	1.49	1.80	2.15	5.02	3.89	2.04	3.02	1.55	2.19	2.77	3.98	5.84
201 - 300	8701.6563	621	1.14	0.64	0.93	2.21	1.84	0.50	1.77	1.82	2.20	0.75	3.10	3.89
201 - 300	3790.0395	624	5.23	4.13	4.00	5.05	5.74	4.66	3.82	3.64	5.90	7.39	9.78	7.79
201 - 300	5333.4945	634	3.97	2.29	4.45	4.03	7.29	7.61	3.83	2.05	2.09	5.55	13.17	9.96
201 - 300	4369.6926	635	1.05	1.75	1.52	1.82	2.55	0.91	0.81	0.62	0.03	1.76	0.00	4.55
201 - 300	4990.5045	636	2.89	1.89	3.15	3.76	5.06	2.20	3.55	2.41	6.27	4.50	2.95	4.45
201 - 300	3882.6468	637	1.07	1.61	2.25	3.34	0.00	2.97	1.61	3.71	5.12	7.70	3.98	9.02
301 - 400	2016.7812	208	5.87	5.09	5.97	3.87	5.34	6.24	5.17	4.56	5.22	14.89	5.37	3.69
301 - 400	860.9049	211	12.48	14.88	9.07	6.47	11.18	5.71	6.46	9.91	6.41	8.77	14.68	15.48
301 - 400	1543.455	222	4.01	3.94	4.50	4.15	8.33	4.31	3.48	4.54	2.90	2.44	2.77	0.77
301 - 400	1838.4264	229	9.43	11.12	6.92	6.60	8.48	11.45	9.03	15.70	10.24	6.54	15.73	1.58
301 - 400	2033.9307	617	5.58	2.74	4.30	3.26	6.31	4.89	8.93	11.67	4.45	5.49	1.76	4.30
301 - 400	1694.3706	623	1.94	4.02	6.81	7.56	3.32	5.41	5.86	8.03	9.41	5.50	5.90	7.04
301 - 400	3045.7512	625	4.60	5.16	4.50	9.73	6.99	7.91	6.30	2.03	7.95	7.47	9.71	8.34
301 - 400	3817.4787	626	0.73	2.85	1.36	4.05	4.00	8.16	3.97	7.23	4.40	3.61	5.29	5.53
301 - 400	3721.4415	628	0.72	0.94	1.66	2.85	5.16	4.00	5.38	3.31	9.38	3.29	6.74	8.68
301 - 400	1697.8005	629	2.37	1.27	2.85	1.54	2.78	4.26	3.77	2.33	3.72	3.63	5.30	2.18
301 - 400	1138.7268	630	1.60	3.87	3.61	1.69	4.19	8.34	3.69	2.35	2.56	1.43	2.09	2.69
301 - 400	7089.6033	633	6.70	6.76	6.99	5.99	9.68	16.21	6.95	9.29	8.88	12.81	17.90	5.63
301 - 400	7062.1641	638	3.54	2.71	4.37	3.60	1.56	4.82	6.38	6.70	6.68	3.34	2.97	8.92
301 - 400	5017.9437	639	7.71	6.54	6.19	5.45	9.62	4.42	4.82	4.91	10.73	5.37	1.92	1.07
401 - 500	541.9242	223	1.80	0.00	0.42	0.22	0.00	0.01	0.05	1.27	0.33	0.00	0.12	0.42
401 - 500	2051.0802	227	2.46	1.82	1.87	0.08	3.17	1.51	0.26	2.74	2.61	4.58	6.74	4.72
401 - 500	1419.9786	235	1.35	1.95	5.22	2.37	1.18	2.71	1.54	2.41	3.03	0.69	1.03	1.20
401 - 500	456.1767	240	0.10	0.01	0.01	1.21	0.00	0.04	0.07	0.29	0.00	0.02	0.06	0.00
401 - 500	2370.0609	622	3.81	4.19	3.42	3.49	1.77	1.75	4.79	4.07	2.47	2.74	9.83	4.94
401 - 500	4304.5245	627	1.82	2.72	1.96	2.62	2.47	6.18	10.18	10.51	3.89	5.40	2.26	1.58
401 - 500	4530.8979	631	2.62	3.18	3.57	1.47	3.27	4.74	12.59	9.61	3.31	2.02	4.31	2.13
401 - 500	236.6631	640	0.98	0.07	0.01	0.00	0.03	0.06	0.11	0.07	0.01	0.01	0.00	0.00
401 - 500	740.8584	645	0.04	0.00	0.21	0.03	0.12	0.01	0.01	0.09	0.01	0.48	0.00	0.00
401 - 500	459.6066	650	2.38	0.02	0.00	0.03	0.00	0.05	0.02	0.04	0.05	0.00	0.00	0.00
501 - 750	1910.4543	212	0.29	3.29	0.32	0.27	0.09	1.42	0.93	2.24	1.25	0.88	0.27	0.64
501 - 750	782.0172	224	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00
501 - 750	634.5315	230	0.00	0.09	0.01	0.03	0.04	0.07	0.02	0.02	0.00	0.00	0.00	0.00
501 - 750	788.877	641	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
501 - 750	1114.7175	646	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00	0.00	0.00	0.00
501 - 750	1231.3341	651	0.02	0.00	0.05	0.03	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00
751 -1000	637.9614	231	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.03	0.00	0.13	0.00
751 -1000	661.9707	236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
751 -1000	1433.6982	642	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
751 -1000	1234.764	647	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
751 -1000	1769.8284	652	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1001 -1250	668.8305	225	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1001 -1250	782.0172	232	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1001 -1250	2514.1167	643	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1001 -1250	782.0172	648	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1001 -1250	1821.2769	653	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1251 -1500	689.4099	226	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1251 -1500	812.8863	233	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
1251 -1500	1625.7726	644	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1251 -1500	727.1388	649	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1251 -1500	1642.9221	654	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 11. Hawke Channel + 3K (SFA 6) northern shrimp (*Pandalus borealis*) biomass (t) by depth range.

Depth Range (m)	Area sq. Nmi	Area sq. km	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
101 - 200	8,828	30,279	2,958	10,327	16,736	10,686	22,781	26,691	24,753	15,853	27,157	21,335	25,027	57,139
201 - 300	17,097	58,641	293,557	166,738	211,128	262,931	232,840	287,818	210,100	168,389	238,308	303,536	500,055	407,446
301 - 400	12,414	42,579	197,217	198,548	205,306	206,775	260,474	322,301	249,541	281,519	313,461	271,751	313,974	239,362
401 - 500	4,989	17,112	38,068	42,619	44,351	30,420	37,914	59,237	115,045	108,359	47,497	49,601	67,912	39,801
501 - 750	1,884	6,462	624	6,343	681	578	199	2,756	1,886	4,306	2,401	1,694	515	1,226
751 -1000	1,673	5,738	57	6	95	0	2	4	0	9	17	7	83	0
1001 -1250	1,915	6,568	0	18	5	0	0	0	0	0	0	3	0	0
1251 -1500	1,603	5,498	0	0	1	0	1	1	0	0	11	1	0	0
Grand total			532,482	424,599	478,303	511,390	554,210	698,807	601,326	578,435	628,851	647,927	907,566	744,973

Table 12. Hawke Channel + 3K (SFA 6) northern shrimp (*Pandalus borealis*) density (t/km^2) by depth range.

Depth Range (m)	Area sq. Nmi	Area sq. km	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
101 - 200	8,828	30,279	0.098	0.341	0.553	0.353	0.752	0.881	0.817	0.524	0.897	0.705	0.827	1.887
201 - 300	17,097	58,641	5.006	2.843	3.600	4.484	3.971	4.908	3.583	2.872	4.064	5.176	8.527	6.948
301 - 400	12,414	42,579	4.632	4.663	4.822	4.856	6.117	7.570	5.861	6.612	7.362	6.382	7.374	5.622
401 - 500	4,989	17,112	2.225	2.491	2.592	1.778	2.216	3.462	6.723	6.332	2.776	2.899	3.969	2.326
501 - 750	1,884	6,462	0.097	0.982	0.105	0.089	0.031	0.426	0.292	0.666	0.372	0.262	0.080	0.190
751 -1000	1,673	5,738	0.010	0.001	0.017	0.000	0.000	0.001	0.000	0.002	0.003	0.001	0.014	0.000
1001 -1250	1,915	6,568	0.000	0.003	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1251 -1500	1,603	5,498	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000

Table 13. SFA 6 total female biomass (SSB) and biomass.

Year	Biomass (tons)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	157,200	203,800	247,700	17,970	23,369	28,360
1997	143,900	181,700	210,500	17,590	21,950	25,230
1998	181,300	213,000	239,200	24,970	30,215	35,710
1999	224,300	259,400	298,700	30,400	35,001	40,410
2000	247,600	298,400	340,400	33,460	40,537	46,690
2001	291,700	352,700	430,200	42,630	51,544	62,970
2002	295,800	350,500	388,300	45,190	53,293	58,900
2003	261,500	320,900	369,600	40,270	49,274	56,940
2004	327,400	379,800	439,700	46,780	54,273	63,060
2005	321,400	390,900	450,700	43,000	53,133	61,000
2006	393,400	462,500	545,200	52,370	61,827	73,150
2007	350,900	426,700	496,100	46,840	56,957	66,190

Table 14. SFA 6 fishable biomass ($tX10^3$) created by selecting males (>17 mm) on a set by set basis, converting the counts at length to weights, adding to the female weights and running ogmap.

Year	lower 95% CL	Fishable biomass (t)	upper 95% CL	lower 95% CL	Fishable abundance ($tX10^6$)	upper 95% CL
1995						
1996	287,500	361,500	430,400	48,480	60,361	71,230
1997	289,200	339,300	375,800	52,300	60,492	66,510
1998	350,400	391,000	430,800	64,500	72,716	81,280
1999	378,100	434,600	492,000	65,520	75,128	85,180
2000	415,700	480,300	534,300	72,980	83,606	92,960
2001	464,600	535,000	644,900	85,130	96,733	115,100
2002	441,300	504,200	546,500	81,100	91,920	100,000
2003	424,000	504,200	567,000	80,090	94,402	105,800
2004	473,400	525,700	600,100	80,940	90,336	102,900
2005	488,100	569,700	638,100	84,020	96,858	108,400
2006	638,900	746,300	856,700	109,600	127,791	147,000
2007	523,300	615,600	686,900	85,900	101,063	112,700

Table 15. SFA 6 recruitment indices (all males 11.5–16 mm carapace length) as determined using Ogmap calculations.

Year	lower 95% CL	recruitment index ($X10^6$)	upper 95% CL
1996	32,790	38,248	45,620
1997	19,450	21,921	24,580
1998	15,050	18,110	21,630
1999	28,660	34,011	40,730
2000	28,860	33,326	39,070
2001	39,160	45,554	52,790
2002	29,560	34,102	39,430
2003	31,760	37,093	43,520
2004	31,300	36,949	43,630
2005	19,270	22,523	26,400
2006	49,980	57,870	67,850
2007	43,210	49,755	57,130

Table 16. SFA 6 exploitation rate indices (total catch/ lower 95% confidence interval of previous year's biomass estimate; total catch/ previous year's total biomass and total catch/ previous year's fishable biomass). Each index is expressed as a percent. Please note that the values presented here are for the calendar years (Jan. 1 – Dec. 31) from 1996 – 2002. There was a change in management year to Apr. 1 – Mar 31 starting in 2003. The values presented below reflect that change in management year. However, the values presented during the March 2008 ZAP were converted to calendar years therefore the values presented below do not agree with those presented during ZAP.

	lower CL of total biomass (t)	total biomass (t)	fishable biomass (t)
1996	416,400	502,800	361,500
1997	362,100	424,900	339,300
1998	404,200	459,500	391,000
1999	458,000	521,100	434,600
2000	502,700	576,700	480,300
2001	566,400	654,100	535,000
2002	536,700	609,400	504,200
2003	513,300	599,500	504,200
2004	594,600	656,900	525,700
2005	578,800	668,600	569,700
2006	757,800	892,700	746,300

Year	Catch (t)	Catch/ lower C.L.	Catch/ total biomass	Catch/ fishable biomass
1997	21,246	5.10	4.23	5.88
1998	46,337	12.80	10.91	13.66
1999	51,202	12.67	11.14	13.10
2000	63,175	13.79	12.12	14.54
2001	52,554	10.45	9.11	10.94
2002	60,198	10.63	9.20	11.25
2003	71,227	13.27	11.69	14.13
2004	77,820	15.16	12.98	15.43
2005	75,198	12.65	11.45	14.30
2006	75,674	13.07	11.32	13.28
2007	80,773	10.66	9.05	10.82

Table 17. 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
1996	9.66 (.018)	14.70 (.045)	17.46 (.047)	20.86 (.050)	
1997	9.71 (.033)	14.26 (.015)	17.54 (.021)	19.66 (.019)	
1998	10.04 (.014)	13.91 (.078)	16.55 (.028)	19.40 (.021)	
1999	10.24 (.012)	14.95 (.009)	18.02 (.026)	20.14 (.013)	
2000	9.82 (.015)	14.29 (.027)	17.59 (.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	10.35 (.017)	14.31 (.018)	17.17 (.042)	19.21 (.020)	
2004	10.54 (.020)	14.36 (.023)	16.57 (.036)	19.11 (.017)	
2005	10.34 (.013)	14.74 (.131)	17.70 (.042)	20.05 (.081)	
2006	10.48 (.014)	14.42 (.011)	17.65 (0.43)	19.67 (.017)	
2007	10.62 (.029)	13.79 (.021)	16.67 (.020)	19.80 (.013)	

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

	Age					
Year	1	2	3	4	5	Total
1996	.036 (.000)	.299 (.019)	.523 (.026)	.142 (.008)		1.000
1997	.025 (.006)	.234 (.002)	.419 (.005)	.322 (.005)		1.000
1998	.114 (.001)	.101 (.007)	.256 (.013)	.529 (.007)		1.000
1999	.104 (.001)	.384 (.002)	.207 (.003)	.305 (.004)		1.000
2000	.076 (.001)	.316 (.005)	.358 (.010)	.250 (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	.090 (.001)	.286 (.003)	.249 (.006)	.375 (.006)		1.000
2004	.029 (.001)	.231 (.005)	.358 (.004)	.383 (.005)		1.001
2005	.153 (.002)	.187 (.017)	.423 (.032)	.236 (.020)		0.999
2006	.100 (.001)	.367 (.020)	.182 (.005)	.351 (.005)		1.000
2007	.060 (.001)	.270 (.003)	.368 (.003)	.302 (.002)		1.000

Distributional Sigmas (Standard Error and constraints)

	Age				
Year	1	2	3	4	5
1996	.908 (.014)	1.024 (.019)	1.45 (.067)	1.02 (.021)	
1997	1.132 (.007) Sigmas Eq.				
1998	.936 (.011)	1.02 (.053)	.983 (.041)	1.15 (.011)	
1999	1.044 (.004) Sigmas Eq.				
2000	.837 (.011)	1.331 (.022)	0.988 (.023)	1.058 (.016)	
2001	.824 (.026)	1.383 (.073)	1.263 (.145)	1.181 (.022)	
2002	1.178 (.008) Sigmas Eq.				
2003	1.190 (.007) Sigmas Eq.				
2004	.791(CV=.075)	1.077(CV=.075)	1.242(CV=.075)	1.433(CV=.075)	
2005	.937 (.009)	1.376 (.079)	1.113 (.059)	1.066 (.027)	
2006	1.217 (.006) Sigmas Eq.				
2007	1.258 (.006) Sigmas Eq.				

Table 17 (Cont'd.)

Population at Age Estimates (000,000's)

	Male Ages						Female	Total
Year	0	1	2	3	4	5		
1996	31	3,376	27,580	48,156	13,055	11	23,692	115,901
1997	10	1,827	16,885	30,143	23,255	55	22,867	94,962
1998	8	8,767	7,761	19,575	40,619	49	30,992	107,723
1999	1	9,235	33,912	18,286	26,934	2	36,363	124,733
2000	0	7,246	30,179	34,230	23,970	11	42,116	137,753
2001	12	2,406	31,529	32,101	42,762	32	51,539	160,381
2002	9	6,876	17,591	42,106	27,782	0	53,293	147,665
2003	14	7,535	24,691	23,539	36,848	12	48,694	141,332
2004	41	2,641	20,497	31,780	34,035	31	53,880	142,907
2005	36	13,901	16,942	38,284	21,445	3	52,404	143,022
2006	159	14,291	52,562	26,140	50,607	165	61,051	204,976
2007	72	6,883	31,124	42,491	34,986	21	56,960	172,538

Table 18. Survival, annual mortality and instantaneous mortality rate indices for Northern Shrimp (*Pandalus borealis)* within Hawke Channel and 3K (SFA 6). Indices were calculated by combining 4 years of data in order to account for vagaries within the survey data and due to aging by modal analysis. The survival, S, in the blue box is the sum of the age 4+ shrimp shaded green divided by the sum of the age 3+ shrimp shaded yellow. Median survival, annual mortality, and instantaneous mortality rates were 0.761, 0.238 and 0.272 respectively.

Year	Age 3+ male and total female abundance (millions; yr=t)	Age 4+ male and total female abundance (millions; yr=t)	Survival rate ($S=e^{-1}$)	Annual mortality rate ($A=1-e^{Z}$)	Instantaneous mortality rate ($Z=-\ln(S)$)
1996	84,914	36,758			
1997	76,320	46,177	0.740099	0.259901094	0.300971445
1998	91,235	71,660	0.845256	0.154744225	0.168116005
1999	81,585	63,299	0.762809	0.237190958	0.270747551
2000	100,327	66,097	0.757911	0.242089139	0.277189498
2001	126,434	94,333	0.76009	0.239909811	0.274318183
2002	123,181	81,075	0.686463	0.313537499	0.376203679
2003	109,093	85,554	0.773857	0.226142768	0.256367878
2004	119,726	87,946	0.763362	0.236637587	0.270022376
2005	112,136	73,852			
2006	137,963	111,823			
2007	134,458	91,967			

Table 19. Survival, annual mortality and instantaneous mortality rate indices of Northern shrimp (*Pandalus borealis)* within Hawke Channel and 3K (SFA 6). Indices were calculated by combining 4 years of data in order to account for vagaries within the observer data. The survival, S, in the blue box is the sum of the multiparous shrimp shaded green divided by the sum of the primiparous shrimp shaded yellow. Median survival, annual mortality, and instantaneous mortality rates were 0.447, 0.553 and 0.806 respectively. The values in the cells shaded red are unreasonable and were not included in the calculation of averages.

Year	Abundance of primiparous females (millions) (year = t)	Abundance of multiparous females (millions) (year = t+1)	Survival Rate ($S = e^{-Z}$)	Annual mortality rate ($A = 1-e^{-Z}$)	Instantaneous mortality rate ($Z = -\ln(S)$)
1990	11.29	3.35			
1991	8.74	7.54	0.446617	0.553383	0.806054
1992	0.72	2.98	0.313316	0.686684	1.160543
1993	4.82	0.73	0.237009	0.762991	1.439658
1994	1.04	0.17	0.548077	0.451923	0.60134
1995	1.31	0.92	4.953052	-3.95305	-1.6
1996	0.11	0.05	2.217562	-1.21756	-0.79641
1997	1.8	2.85	0.965345	0.034655	0.035269
1998	12.04	17.28	0.590978	0.409022	0.525977
1999	32.22	13.66	0.474857	0.525143	0.744741
2000	46.82	10.78	0.371687	0.628313	0.989704
2001	40.37	13.17	0.320451	0.679549	1.138026
2002	33.38	24.81	0.308648	0.691352	1.175554
2003	32.87	8.03	0.209771	0.790229	1.561737
2004	18.15	3.16			
2005	56.42	2.51			
2006	67.28	15.84			
2007	88.17	16.65			

Table 20. Observed and predicted mean lengths from the von Bertalanffy growth curve. Observed lengths used yielded L_{∞}, K, and t_0 values of 30.7986, 0.2187 and -1.0659 respectively.

Year	Age	Observed Mean Length	Predicted Mean Length
2001	0	6.77	6.40
2002	1	10.61	11.20
2003	2	14.94	15.05
2004	3	18.09	18.14
2005	4	20.52	20.63
2006	5	24.26	22.63
2007	6	23.07	24.23

Table 21. Instantaneous mortality rate indices from the length based method for Northern Shrimp in SFA 6. Median survival, annual mortality and instantaneous mortality for all shrimp (males and females over the entire length range) are 0.651, 0.349 and 0.430 respectively.

Year	Z of all shrimp	S of all shrimp	A of all shrimp	Z of female shrimp	S of female shrimp	A of female shrimp
1995	0.4245	0.6541	0.3459	0.3026	0.7389	0.2611
1996	0.4177	0.6586	0.3414	0.2777	0.7575	0.2425
1997	0.4179	0.6584	0.3416	0.2878	0.7499	0.2501
1998	0.4214	0.6561	0.3439	0.3133	0.7310	0.2690
1999	0.4293	0.6510	0.3490	0.3204	0.7258	0.2742
2000	0.4415	0.6431	0.3569	0.3352	0.7152	0.2848
2001	0.4482	0.6388	0.3612	0.3465	0.7072	0.2928
2002	0.4512	0.6369	0.3631	0.3593	0.6982	0.3018
2003	0.4458	0.6403	0.3597	0.3528	0.7027	0.2973
2004	0.4398	0.6442	0.3558	0.3534	0.7023	0.2977
2005	0.4302	0.6504	0.3496	0.3435	0.7093	0.2907
2006	0.4259	0.6532	0.3468	0.3212	0.7253	0.2747
2007	0.4299	0.6506	0.3494	0.3322	0.7173	0.2827

Table 22. A selection of instantaneous annual mortalities indices by shrimp carapace length.

Carapace length (mm)	Z (male and female combined)	Z (Female)
8	0.2379	0.1133
11	0.3015	0.1408
14	0.4006	0.1860
17	0.4826	0.2724
20	0.5836	0.4833
23+	0.7094	0.7072

TABLE 23. NORTHERN SHRIMP LARGE VESSEL (>500 t) FISHERY DATA FOR HOPEDALE & CARTWRIGHT CHANNELS (SFA 5), 1977 - 2007.

YEAR	TAC[1] (t)	FLEET CATCH[2] (t)	UNSTANDARDIZED CPUE (KG/HR)	CPUE RELATIVE TO 2007	EFFORT[3] (HR)	STANDARDIZED CPUE RELATIVE TO 2007	MODELLED CPUE	EFFORT (HRS)
1977		2,686						
1978	5,300	3,630						
1979	4,000	3,727						
1980	4,800	4,108	444	0.19	9,249	0.50	896	4,587
1981	4,800	3,449	473	0.20	7,298	0.53	949	3,633
1982	4,800	1,983	405	0.18	4,894	0.48	860	2,305
1983	4,800	1,000						
1984	4,200	1,002	367	0.16	2,732	0.41	735	1,364
1985	3,570	1,689	339	0.15	4,980	0.35	627	2,694
1986	4,400	4,826						
1987	4,800	5,956						
1988	4,800	7,838						
1989	6,000	5,985	888	0.38	6,737	0.67	1,205	4,968
1990	6,000	5,360	579	0.25	9,253	0.57	1,031	5,201
1991	6,375	6,118	537	0.23	11,385	0.45	810	7,557
1992	6,375	6,315	560	0.24	11,277	0.40	714	8,838
1993	6,375	5,719	611	0.26	9,363	0.44	788	7,256
1994	7,650	7,499	736	0.32	10,186	0.49	887	8,459
1995	7,650	7,616	1,261	0.55	6,041	0.62	1,123	6,785
1996	7,650	7,383	1,523	0.66	4,848	0.80	1,437	5,138
1997	15,300	15,103	1,158	0.50	13,046	0.90	1,629	9,273
1998	14,929	14,827	1,629	0.71	9,103	0.91	1,637	9,057
1999	15,136	14,720	1,524	0.66	9,656	0.97	1,754	8,394
2000	14,050	14,451	1,707	0.74	8,467	1.04	1,876	7,702
2001	14,694	15,036	1,849	0.80	8,132	1.10	1,993	7,543
2002	15,089	15,979	2,085	0.90	7,666	1.09	1,975	8,092
2003	28,072[4]	29,882	2,167	0.94	13,789	1.05	1,903	15,701
2004	16,780	21,043	2,018	0.87	10,430	0.95	1,707	12,330
2005	20,525	21,756	2,032	0.88	10,707	0.98	1,771	12,287
2006	17,624	22,501	2,162	0.94	10,406	1.02	1,832	12,279
2007	18,688	23,577	2,309	1.00	10,209	1.00	1,805	13,061

[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 9,787 T.**

Table 24. Multiplicative year, month, area and vessel CPUE model for large vessels (>500 t) fishing shrimp in Hopedale and Cartwright Channels (SFA 5), 1980 – 2007, weighted by effort. (Original model formulation, single trawl no windows, observer data, history>3 yrs.)

The GLM Procedure
Class Level Information

Class	Levels	Values
year	24	1980 1981 1982 1984 1985 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
month	12	1 2 3 4 5 6 7 8 9 10 11 12
CFV	18	
area	4	51 52 53 54

Number of Observations Read 1556
Number of Observations Used 1552

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	54	37430.07538	693.14954	99.03	<.0001
Error	1497	10477.69180	6.99913		
Corrected Total	1551	47907.76718			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.781295	36.15188	2.645586	7.317977

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	23	27097.77620	1178.16418	168.33	<.0001
month	11	6137.43362	557.94851	79.72	<.0001
CFV	17	3675.16540	216.18620	30.89	<.0001
area	3	519.70017	173.23339	24.75	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	23	5377.637426	233.810323	33.41	<.0001
month	11	4037.379413	367.034492	52.44	<.0001
CFV	17	3501.147256	205.949839	29.43	<.0001
area	3	519.700166	173.233389	24.75	<.0001

Table 24. (Cont'd.)

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		7.093869302	B	0.08266318	85.82	<.0001
year	1980	-0.700954558	B	0.09712113	-7.22	<.0001
year	1981	-0.642622091	B	0.10952463	-5.87	<.0001
year	1982	-0.741175605	B	0.12585926	-5.89	<.0001
year	1984	-0.899153397	B	0.15330220	-5.87	<.0001
year	1985	-1.057398013	B	0.12950290	-8.17	<.0001
year	1989	-0.404512977	B	0.10459808	-3.87	0.0001
year	1990	-0.560550475	B	0.11031618	-5.08	<.0001
year	1991	-0.801877694	B	0.08572272	-9.35	<.0001
year	1992	-0.926827734	B	0.08921831	-10.39	<.0001
year	1993	-0.828628346	B	0.07127296	-11.63	<.0001
year	1994	-0.711066891	B	0.06001334	-11.85	<.0001
year	1995	-0.475091839	B	0.06868292	-6.92	<.0001
year	1996	-0.228071002	B	0.06884001	-3.31	0.0009
year	1997	-0.102864596	B	0.06029249	-1.71	0.0882
year	1998	-0.097711336	B	0.06130988	-1.59	0.1112
year	1999	-0.028927385	B	0.06156577	-0.47	0.6385
year	2000	0.038595570	B	0.06027328	0.64	0.5220
year	2001	0.099237318	B	0.06021669	1.65	0.0996
year	2002	0.089736760	B	0.06095889	1.47	0.1412
year	2003	0.052854455	B	0.06089663	0.87	0.3856
year	2004	-0.056082857	B	0.05570049	-1.01	0.3142
year	2005	-0.019363456	B	0.06015476	-0.32	0.7476
year	2006	0.015028185	B	0.05797518	0.26	0.7955
year	2007	0.000000000	B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
1980	6.797453	6.636124	6.958781
1981	6.855785	6.662405	7.049165
1982	6.757232	6.530149	6.984315
1984	6.599254	6.314529	6.883979
1985	6.441009	6.204945	6.677074
1989	7.093894	6.906334	7.281454
1990	6.937857	6.741092	7.134622
1991	6.696529	6.555049	6.838010
1992	6.571579	6.423933	6.719226
1993	6.669779	6.564978	6.774580
1994	6.787340	6.710169	6.864511
1995	7.023315	6.913735	7.132896
1996	7.270336	7.162757	7.377915
1997	7.395543	7.314533	7.476552
1998	7.400696	7.311940	7.489451
1999	7.469480	7.382613	7.556346
2000	7.537003	7.450787	7.623218
2001	7.597644	7.509789	7.685500
2002	7.588144	7.496614	7.679674
2003	7.551262	7.458520	7.644003
2004	7.442324	7.362373	7.522276
2005	7.479044	7.385943	7.572145
2006	7.513435	7.424314	7.602556
2007	7.498407	7.396097	7.600717

Table 25. Northern shrimp stock size estimates in Cartwright Channel (SFA 5) from offshore fall research trawl surveys, 1996 - 2007.

Year	Biomass (tons)			Abundance (numbers x 10^6)			No.
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1996	25,860	77,500	213,100	5,299	21,372	64,160	23
1997	34,840	48,900	75,040	7,192	10,374	16,410	26
1998	32,140	43,300	58,510	6,572	8,584	11,750	27
1999	41,210	56,900	77,700	8,205	11,021	14,780	23
2000	44,800	73,900	121,300	10,970	17,153	26,720	24
2001	70,060	89,500	123,500	17,380	21,847	28,800	20
2002	45,410	58,300	76,760	12,480	16,135	20,270	20
2003	65,240	95,300	133,900	15,840	21,327	28,350	18
2004	64,240	85,600	108,400	13,300	17,739	22,940	23
2005	93,750	141,300	192,400	21,540	29,248	36,450	24
2006	61,560	79,400	109,300	15,720	19,546	24,810	21
2007	70,800	85,900	103,700	19,960	23,772	27,840	22

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

Table 26. Northern shrimp stock size estimates in Hopedale Channel (SFA 5)[2] from fall research trawl surveys - offshore, 1996 - 2006.

Year	Biomass (tons)			Abundance (numbers x 10^6)			No.
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
1996	25,850	64,200	127,400	6,142	14,503	32,050	68
1997	41,990	80,000	115,800	9,156	17,962	27,990	65
1998	23,080	44,000	68,500	4,612	9,079	14,100	71
1999	24,470	52,700	87,940	4,939	10,816	18,230	67
2000							
2001	96,370	154,100	219,600	24,140	38,430	56,010	49
2002							
2003							
2004	52,840	93,400	138,100	11,460	20,536	31,460	74
2005							
2006	72,630	101,600	124,300	14,810	20,256	24,980	72
2007							

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

Table 27. Northern shrimp stock size estimates in Hopedale+Cartwright (SFA 5) [3] from fall research trawl surveys - offshore, 1996 - 2008.

Year	Biomass (tons)			Abundance (numbers x 10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	62,610	151,300	310,700	13,070	38,941	90,760
1997	85,780	129,200	174,800	17,950	28,636	40,430
1998	60,700	86,100	117,700	12,360	17,330	23,970
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	26,840	39,128	52,170
2005						
2006	143,700	177,800	213,100	32,710	39,080	45,880
2007						

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

Table 28. Total biomass (t) of northern shrimp (*Pandalus borealis*) collected during the 1996 - 2007 DFO research bottom trawl multi-species research surveys into Hopedale and Cartwright Channels (SFA 5). (All tows were standardized to 15 minutes; empty cells were not sampled.). The conversion from square nautical miles to square kilometres was 1 sq Nmi = 3.429904 sq km (www.onlineconversion.com/area.htm) Please note that no total biomass estimate is provided because not all of the strata were filled each year therefore between year comparisons are not appropriate.

Depth Range (m)	Area sq. Nmi	Area sq. km	Stratum	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
<=200	1,028	3,526	930	388	.	102	876	.	1,802	.	.	10,875	.	6,048	.
<=200	971	3,330	954	450	.	12,387	2,023	.	11,571	.	.	25,719	.	17,151	.
<=200	1,051	3,605	956	20	.	7,681	37	.	216	.	.	13,131	.	8,532	.
101 - 200	633	2,171	201	693	123	1,184	1,618	2,854	2,023	6,390	2,683	1,860	8,336	3,783	6,117
101 - 200	778	2,668	238	428	112	69	167	221	146	58	.	7	5,555	223	748
201 - 300	621	2,130	202	3,713	1,738	2,365	4,261	511	11,616	4,319	4,772	13,308	18,971	3,186	11,532
201 - 300	1,341	4,600	214	.	11,721	4,950	.	.	.	12,107	.	.	.	19,520	9,687
201 - 300	1,302	4,466	215	94,544	6,811	18,677	18,994	44,251	19,634	8,396	42,481	32,456	42,358	21,362	22,699
201 - 300	276	947	931	184	940	566	732	.	.	.	.	3,891	.	6,012	.
201 - 300	354	1,214	943	142	278	78	368	.	.	.	.	681	.	1,206	.
201 - 300	261	895	950	4,073	1,129	.	299	.	1,041	.	.	19,593	.	5,643	.
201 - 300	291	998	953	20,955	5,145	1,291	14,555	.	18,733	.	.	19,164	.	8,524	.
201 - 300	389	1,334	955	18,048	9,767	2,197	1,676	.	30,276	.	.	9,042	.	12,622	.
301 - 400	487	1,670	203	7,700	.	.	.	5,473	14,922	.	.	.	39,168	.	.
301 - 400	360	1,235	216	.	2,428	3,662	7,563	5,816	.	.	.	4,226	.	.	.
301 - 400	55	189	932	2	51	5	7	.	.	.	.	1,293	.	815	.
301 - 400	860	2,950	944	917	13,731	2,587	11,608	.	.	.	.	5,037	.	18,723	.
301 - 400	206	707	949	5,877	16,013	.	.	.	14,803	.	.	0	.	.	.
301 - 400	177	607	952	782	2,291	1,770	1,616	.	9,639	.	.	193	.	3,350	.
301 - 400	178	611	959	363	.	.	.	.	307	.	.	512	.	388	.
401 - 500	241	827	217	.	281	1,087	1	185	.	.	.	.	19	.	.
401 - 500	50	171	933	1	2	3	0	.	.	.	.	0	.	22	.
401 - 500	55	189	942	0	12	0	0	.	1	.	.	17	.	1	.
401 - 500	461	1,581	945	120	208	547	291	.	1,231	.	.	1,107	.	1,778	.
401 - 500	246	844	948	1,001	2,288	2,336	.	.	13,188	.	.	.	.	677	.
401 - 500	234	803	951	962	2,172	215	142	.	119	.	.	106	.	1,163	.
501 - 750	362	1,242	218	.	7	10	0	.	.	.	.	0	0	0	0
501 - 750	78	268	934	0	0	0	0	.	.	.	.	1	.	0	.
501 - 750	89	305	941	0	0	0	0	.	2	.	.	0	.	1	.
501 - 750	721	2,473	946	1,269	705	1,164	509	.	1,829	.	.	2,339	.	170	.
501 - 750	227	779	947	356	715	318	86	.	5,592	.	.	155	.	151	.
501 - 750	211	724	961	0	.	.	.	.	.	.	.	.	.	0	.
751 -1000	283	971	219	.	.	6	51	.	.	26	0	0	0	.	.
751 -1000	96	329	935	.	0	0	0	.	.	.	.	0	.	0	.
751 -1000	97	333	940	0	0	0	0	.	.	.	.	0	.	13	.
1001 -1250	303	1,039	220	0	.	.	.	.	0	0	.	0	.	.	0
1001 -1250	78	268	936	.	0	0	.	.	0	.	.	0	.	0	.
1001 -1250	130	446	939	0	0	.	0	.	.	.	.	0	.	.	.
1001 -1250	265	909	963	0	0	.	.	.	.	.	.	0	.	.	.
1251 -1500	330	1,132	221	0	2	0	.	0	.	0	.	.	.	0	0
1251 -1500	94	322	937	.	0	0	.	.	0	.	.	0	.	0	.
1251 -1500	191	655	938	0	2	0	0	.	0	.	.	0	.	0	.
1251 -1500	342	1,173	964	.	0	0	0	.	.	.	.	.	.	0	.
100-200 m				1	0	33	7	5	10	21	5	31	12	25	14
201-500 m				98	98	65	92	95	85	79	95	67	88	74	86
>501 m				1	2	2	1	0	5	0	0	2	0	0	0

Table 29. Hopedale and Cartwright Channels (SFA 5) percent contribution of each stratum by year, in terms of northern shrimp biomass (t) as determined by areal expansion calculations of DFO multi-species survey data. (All tows were standardized to 15 minutes, missing cells were not sampled).

Depth Range (m)	Area sq. Nmi	Area sq. km	Stratum	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
<=200	1,028	3,526	930	0.24	.	0.16	1.30	.	1.14	.	.	6.60	.	4.29	.
<=200	971	3,330	954	0.28	.	18.98	3.00	.	7.29	.	.	15.61	.	12.16	.
<=200	1,051	3,605	956	0.01	.	11.77	0.05	.	0.14	.	.	7.97	.	6.05	.
101 - 200	633	2,171	201	0.43	0.16	1.81	2.40	4.81	1.27	20.42	5.37	1.13	7.29	2.68	12.05
101 - 200	778	2,668	238	0.26	0.14	0.11	0.25	0.37	0.09	0.18	.	0.00	4.86	0.16	1.47
201 - 300	621	2,130	202	2.28	2.21	3.62	6.32	0.86	7.32	13.80	9.56	8.08	16.58	2.26	22.71
201 - 300	1,341	4,600	214	.	14.90	7.59	.	.	.	38.69	.	.	.	13.84	19.08
201 - 300	1,302	4,466	215	58.01	8.66	28.62	28.15	74.61	12.37	26.83	85.07	19.70	37.02	15.14	44.70
201 - 300	276	947	931	0.11	1.19	0.87	1.09	.	.	.	.	2.36	.	4.26	.
201 - 300	354	1,214	943	0.09	0.35	0.12	0.54	.	.	.	.	0.41	.	0.85	.
201 - 300	261	895	950	2.50	1.44	.	0.44	.	0.66	.	.	11.90	.	4.00	.
201 - 300	291	998	953	12.86	6.54	1.98	21.57	.	11.80	.	.	11.63	.	6.04	.
201 - 300	389	1,334	955	11.07	12.41	3.37	2.48	.	19.08	.	.	5.49	.	8.95	.
301 - 400	487	1,670	203	4.72	.	.	.	9.23	9.40	.	.	.	34.24	.	.
301 - 400	360	1,235	216	.	3.09	5.61	11.21	9.81	.	.	.	2.57	.	.	.
301 - 400	55	189	932	0.00	0.07	0.01	0.01	.	.	.	.	0.79	.	0.58	.
301 - 400	860	2,950	944	0.56	17.45	3.96	17.20	.	.	.	.	3.06	.	13.27	.
301 - 400	206	707	949	3.61	20.35	.	.	.	9.33	.	.	0.00	.	.	.
301 - 400	177	607	952	0.48	2.91	2.71	2.39	.	6.07	.	.	0.12	.	2.38	.
301 - 400	178	611	959	0.22	.	.	.	.	0.19	.	.	0.31	.	0.28	.
401 - 500	241	827	217	.	0.36	1.67	0.00	0.31	.	.	.	.	0.02	.	.
401 - 500	50	171	933	0.00	0.00	0.00	0.00	.	.	.	.	0.00	.	0.02	.
401 - 500	55	189	942	0.00	0.02	0.00	0.00	.	0.00	.	.	0.01	.	0.00	.
401 - 500	461	1,581	945	0.07	0.26	0.84	0.43	.	0.78	.	.	0.67	.	1.26	.
401 - 500	246	844	948	0.61	2.91	3.58	.	.	8.31	.	.	.	.	0.48	.
401 - 500	234	803	951	0.59	2.76	0.33	0.21	.	0.07	.	.	0.06	.	0.82	.
501 - 750	362	1,242	218	.	0.01	0.02	0.00	.	.	.	.	0.00	0.00	0.00	0.00
501 - 750	78	268	934	0.00	0.00	0.00	0.00	.	.	.	.	0.00	.	0.00	.
501 - 750	89	305	941	0.00	0.00	0.00	0.00	.	0.00	.	.	0.00	.	0.00	.
501 - 750	721	2,473	946	0.78	0.90	1.78	0.75	.	1.15	.	.	1.42	.	0.12	.
501 - 750	227	779	947	0.22	0.91	0.49	0.13	.	3.52	.	.	0.09	.	0.11	.
501 - 750	211	724	961	0.00	.	.	.	.	.	.	.	.	.	0.00	.
751 -1000	283	971	219	.	.	0.01	0.08	.	.	0.08	0.00	0.00	0.00	.	.
751 -1000	96	329	935	.	0.00	0.00	0.00	.	.	.	.	0.00	.	0.00	.
751 -1000	97	333	940	0.00	0.00	0.00	0.00	.	.	.	.	0.00	.	0.01	.
1001 -1250	303	1,039	220	0.00	.	.	.	.	0.00	0.00	.	0.00	.	.	0.00
1001 -1250	78	268	936	.	0.00	0.00	.	.	0.00	.	.	0.00	.	0.00	.
1001 -1250	130	446	939	0.00	0.00	.	0.00	.	.	.	.	0.00	.	0.00	.
1001 -1250	265	909	963	0.00	0.00	.	.	.	.	.	.	0.00	.	.	.
1251 -1500	330	1,132	221	0.00	0.00	0.00	.	0.00	.	0.00	.	.	.	0.00	0.00
1251 -1500	94	322	937	.	0.00	0.00	.	.	0.00	.	.	0.00	.	0.00	.
1251 -1500	191	655	938	0.00	0.00	0.00	0.00	.	0.00	.	.	0.00	.	0.00	.
1251 -1500	342	1,173	964	.	0.00	0.00	0.00	.	.	.	.	.	.	0.00	.

Table 30. Biomass (t) of northern shrimp (*Pandalus borealis*) per km^2 in SFA 5. The analysis was from areal expansion of multi-species reseach survey data collected during the 1996 - 2007 by DFO. Densities within each stratum were divided into three equal parts and color coded such that the lower 1/3 is blue, intermediate is yellow and top 1/3 is orange. The Campelen 1800 research survey trawl was used, tows were at 3 Nmi/hr. and were 15 minutes in length.

Depth Range (m)	Area sq. km	Stratum	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
<=200	3,526	930	0.11	.	0.03	0.25	.	0.51	.	.	3.08	.	1.72	.
<=200	3,330	954	0.14	.	3.72	0.61	.	3.47	.	.	7.72	.	5.15	.
<=200	3,605	956	0.01	.	2.13	0.01	.	0.06	.	.	3.64	.	2.37	.
101 - 200	2,171	201	0.32	0.06	0.55	0.75	1.31	0.93	2.94	1.24	0.86	3.84	1.74	2.82
101 - 200	2,668	238	0.16	0.04	0.03	0.06	0.08	0.05	0.02	.	0.00	2.08	0.08	0.28
201 - 300	2,130	202	1.74	0.82	1.11	2.00	0.24	5.45	2.03	2.24	6.25	8.91	1.50	5.41
201 - 300	4,600	214	.	2.55	1.08	.	.	.	2.63	.	.	.	4.24	2.11
201 - 300	4,466	215	21.17	1.53	4.18	4.25	9.91	4.40	1.88	9.51	7.27	9.49	4.78	5.08
201 - 300	947	931	0.19	0.99	0.60	0.77	.	.	.	.	4.11	.	6.35	.
201 - 300	1,214	943	0.12	0.23	0.06	0.30	.	.	.	.	0.56	.	0.99	.
201 - 300	895	950	4.55	1.26	.	0.33	.	1.16	.	.	21.89	.	6.30	.
201 - 300	998	953	20.99	5.16	1.29	14.58	.	18.77	.	.	19.20	.	8.54	.
201 - 300	1,334	955	13.53	7.32	1.65	1.26	.	22.69	.	.	6.78	.	9.46	.
301 - 400	1,670	203	4.61	.	.	.	3.28	8.93	.	.	.	23.45	.	.
301 - 400	1,235	216	.	1.97	2.97	6.12	4.71	.	.	.	3.42	.	.	.
301 - 400	189	932	0.01	0.27	0.03	0.04	.	.	.	.	6.86	.	4.32	.
301 - 400	2,950	944	0.31	4.66	0.88	3.94	.	.	.	.	1.71	.	6.35	.
301 - 400	707	949	8.32	22.66	.	.	.	20.95	.	.	0.00	.	.	.
301 - 400	607	952	1.29	3.77	2.92	2.66	.	15.88	.	.	0.32	.	5.52	.
301 - 400	611	959	0.59	.	.	.	.	0.50	.	.	0.84	.	0.64	.
401 - 500	827	217	.	0.34	1.31	0.00	0.22	.	.	.	.	0.02	.	.
401 - 500	171	933	0.00	0.01	0.01	0.00	.	.	.	.	0.00	.	0.13	.
401 - 500	189	942	0.00	0.06	0.00	0.00	.	0.00	.	.	0.09	.	0.01	.
401 - 500	1,581	945	0.08	0.13	0.35	0.18	.	0.78	.	.	0.70	.	1.12	.
401 - 500	844	948	1.19	2.71	2.77	.	.	15.63	.	.	.	.	0.80	.
401 - 500	803	951	1.20	2.71	0.27	0.18	.	0.15	.	.	0.13	.	1.45	.
501 - 750	1,242	218	.	0.01	0.01	0.00	.	.	.	.	0.00	0.00	0.00	0.00
501 - 750	268	934	0.00	0.00	0.00	0.00	.	.	.	.	0.00	.	0.00	.
501 - 750	305	941	0.00	0.00	0.00	0.00	.	0.01	.	.	0.00	.	0.00	.
501 - 750	2,473	946	0.51	0.29	0.47	0.21	.	0.74	.	.	0.95	.	0.07	.
501 - 750	779	947	0.46	0.92	0.41	0.11	.	7.18	.	.	0.20	.	0.19	.
501 - 750	724	961	0.00	.	.	.	.	.	.	.	.	.	0.00	.
751 -1000	971	219	.	.	0.01	0.05	.	.	0.03	0.00	0.00	0.00	.	.
751 -1000	329	935	.	0.00	0.00	0.00	.	.	.	.	0.00	.	0.00	.
751 -1000	333	940	0.00	0.00	0.00	0.00	.	.	.	.	0.00	.	0.04	.
1001 -1250	1,039	220	0.00	.	.	.	.	0.00	0.00	.	0.00	.	.	0.00
1001 -1250	268	936	.	0.00	0.00	.	.	0.00	.	.	0.00	.	0.00	.
1001 -1250	446	939	0.00	0.00	.	0.00	.	.	.	.	0.00	.	.	.
1001 -1250	909	963	0.00	0.00	.	.	.	.	.	.	0.00	.	.	.
1251 -1500	1,132	221	0.00	0.00	0.00	.	0.00	.	0.00	.	.	.	0.00	0.00
1251 -1500	322	937	.	0.00	0.00	.	.	0.00	.	.	0.00	.	0.00	.
1251 -1500	655	938	0.00	0.00	0.00	0.00	.	0.00	.	.	0.00	.	0.00	.
1251 -1500	1,173	964	.	0.00	0.00	0.00	.	.	.	.	.	.	0.00	.

Table 31. Hopedale + Cartwright Channels (SFA 5) northern shrimp (*Pandalus borealis)* biomass (t) by depth range.

Depth Range (m)	Area sq. Nmi	Area sq. km	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
<=200 m	4,461	15,301	1,978	236	21,424	4,720	3,075	15,758	6,448	2,683	51,592	13,891	35,737	6,865
201 - 300 m	4,835	16,584	141,659	37,529	30,123	40,885	44,762	81,300	24,822	47,253	98,134	61,329	78,075	43,918
301 - 400 m	2,323	7,968	15,640	34,515	8,024	20,794	11,290	39,670	0	0	11,261	39,168	23,277	0
401 - 500 m	1,287	4,414	2,083	4,963	4,187	433	185	14,539	0	0	1,230	19	3,642	0
501 - 750 m	1,688	5,790	1,625	1,427	1,492	595	0	7,422	0	0	2,495	0	321	0
751 - 1000 m	476	2,094	0	0	6	51	0	0	26	0	0	0	13	0
1001 - 1250 m	776	2,662	0	0	0	0	0	0	0	0	0	0	0	0
1251 - 1500 m	3,282	3,060	0	4	0	0	0	0	0	0	0	0	0	0

Table 32. Hopedale + Cartwright Channels (SFA 5) northern shrimp (*Pandalus borealis*) density (t/km^2) by depth range.

Depth Range (m)	Area sq. Nmi	Area sq. km	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
<=200 m	4,461	15,301	0.129	0.015	1.400	0.308	0.201	1.030	0.421	0.175	3.372	0.908	2.336	0.449
201 - 300 m	4,835	16,584	8.542	2.263	1.816	2.465	2.699	4.902	1.497	2.849	5.918	3.698	4.708	2.648
301 - 400 m	2,323	7,968	1.963	4.332	1.007	2.610	1.417	4.979	0.000	0.000	1.413	4.916	2.921	0.000
401 - 500 m	1,287	4,414	0.472	1.124	0.948	0.098	0.042	3.294	0.000	0.000	0.279	0.004	0.825	0.000
501 - 750 m	1,688	5,790	0.281	0.246	0.258	0.103	0.000	1.282	0.000	0.000	0.431	0.000	0.056	0.000
751 - 1000 m	476	2,094	0.000	0.000	0.003	0.024	0.000	0.000	0.012	0.000	0.000	0.000	0.006	0.000
1001 - 1250 m	776	2,662	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1251 - 1500 m	3,282	3,060	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 33. Cartwright Channel total female biomass (SSB) and abundance estimates

Year	Biomass (t)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	10,420	15,900	22,800	1,182	1,833	2,675
1997	12,450	18,400	25,020	1,524	2,228	2,981
1998	13,010	20,700	28,650	1,300	2,070	2,864
1999	17,530	30,800	41,960	2,233	3,847	5,330
2000	15,700	33,100	62,170	2,044	4,198	7,924
2001	29,360	41,200	61,760	3,888	5,382	8,017
2002	18,410	24,600	36,150	2,836	3,738	5,492
2003	28,000	53,000	84,520	4,202	7,578	11,890
2004	31,050	46,300	65,700	4,469	6,413	8,898
2005	35,200	76,200	121,800	4,764	10,181	16,300
2006	22,410	33,200	49,110	2,949	4,397	6,501
2007	25,430	35,200	46,370	3,601	4,959	6,454

Table 34. SFA 5 total female biomass (SSB) and abundance estimates

Year	Biomass (t X10^3)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	21,160	33,200	48,230	2,389	3,937	5,774
1997	28,100	39,700	50,470	3,403	4,859	6,170
1998	26,360	38,200	50,000	3,281	4,715	6,377
1999	32,940	51,100	69,790	4,135	6,359	8,640
2000						
2001	64,280	95,300	130,600	8,779	12,642	17,000
2002						
2003						
2004	60,700	85,500	108,800	8,603	11,898	15,010
2005						
2006	59,180	81,400	106,400	7,648	10,619	13,940
2007						

Table 35. Cartwright Channel recruitment index. (Abundances of males with 11.5 – 16 mm carapace lengths as estimated using Ogmap calculations).

Year	Lower 95% C.I.	Recruitment index ($X10^6$)	Upper 95% C.I.
1996	1,010	7,026	23,400
1997	604	932	1,534
1998	607	956	1,289
1999	895	1,536	2,033
2000	2,391	3,947	5,634
2001	4,027	5,844	7,927
2002	3,769	5,361	7,321
2003	2,559	3,955	5,406
2004	1,787	2,806	3,787
2005	1,920	2,709	3,320
2006	4,772	6,216	8,166
2007	7,561	9,928	11,880

Table 36. Recruitment index for the entire of SFA 5.

Year	Lower 95% C.I.	Recruitment index ($X10^6$)	Upper 95% C.I.
1996	1,733	9,737	30,010
1997	1,842	3,197	4,669
1998	1,188	1,720	2,268
1999	1,451	2,418	3,196
2000			
2001	9,937	14,340	19,570
2002			
2003			
2004	2,866	4,503	6,088
2005			
2006	6,022	7,588	9,601
2007			

Table 37. Cartwright Channel fishable biomass and abundance as estimated from autumn bottom trawl research survey data using Ogmap calculations. Fishable biomass and abundance consists of the biomass of all males with carapace lengths greater than 17 mm plus the biomass/ abundance of all females.

Year	Lower 95% C.I.	Fishable biomass (t)	Upper 95% C.I.	Lower 95% C.I.	Fishable abundance ($X10^6$)	Upper 95% C.I.
1996	19,260	38,300	78,680	3,164	7,814	19,190
1997	28,230	38,400	53,670	5,223	7,209	10,690
1998	26,930	36,600	50,220	4,677	6,292	8,741
1999	34,320	50,900	68,290	5,578	8,241	11,290
2000	31,070	53,700	93,090	5,688	9,353	15,760
2001	49,400	67,700	91,060	8,969	12,247	16,050
2002	29,840	40,500	56,410	5,928	8,014	11,030
2003	49,730	77,300	114,800	9,576	13,980	19,980
2004	52,860	70,800	92,990	9,539	12,580	16,130
2005	77,160	126,500	179,400	15,110	22,409	30,280
2006	46,750	61,400	84,090	8,443	11,067	15,340
2007	42,420	58,300	73,800	7,629	10,449	12,910

Table 38. Fishable biomass and abundance within the entire of SFA 5.

Year	Lower 95% C.I.	Fishable biomass (t)	Upper 95% C.I.	Lower 95% C.I.	Fishable abundance ($X10^6$)	Upper 95% C.I.
1996	42,320	85,700	150,400	7,603	17,289	32,480
1997	77,660	114,900	146,000	14,810	23,052	30,450
1998	52,800	75,800	101,500	9,241	13,751	19,100
1999	58,290	92,700	129,400	10,020	15,940	22,930
2000						
2001	126,500	180,700	239,300	24,710	34,956	46,470
2002						
2003						
2004	115,300	161,100	208,100	20,980	30,250	40,580
2005						
2006	119,200	151,700	187,600	21,690	27,461	33,680
2007						

Table 39. Exploitation rate indices for northern shrimp (*Pandalus borealis*) harvested from Hopedale and Cartwright Channels (SFA 5) as estimated using survey and total catch data over the period 1996 – 2007. Please note that the values presented here are for the calendar years (Jan. 1 – Dec. 31) from 1996 – 2002. There was a change in management year to Apr. 1 – Mar 31 starting in 2003. The values presented below reflect that change in management year. However, the values presented during the March 2008 ZAP were converted to calendar years therefore the values presented below do not agree with those presented during ZAP.

	lower 95% CL total biomass	Total biomass (t)	Fishable biomass (t)
1996	62,610	151,300	85,700
1997	85,780	129,200	114,900
1998	60,700	86,100	75,800
1999	72,970	108,100	92,700
2000			
2001	178,500	247,800	180,700
2002			
2003			
2004	131,700	183,000	161,100
2005			
2006	143,700	177,800	151,700

Year	Catch (t)	Catch/ lower 95% CL total biomass	Catch/ biomass	Catch/ fishable biomass
1997	15,103	24.12	9.98	17.62
1998	14,827	17.28	11.48	12.90
1999	14,720	24.25	17.10	19.42
2000	14,451	19.80	13.37	15.59
2001	15,036			
2002	15,121	8.47	6.10	8.37
2003	30,437			
2004	22,690			
2005	22,900	17.39	12.51	14.21
2006	22,616			
2007	23,768	16.54	13.37	15.67

Table 40. Modal analysis using Mix 3.01 (MacDonald and Pitcher, 1993) of *Pandalus borealis* in Cartwright Channel (SFA 5), from autumn multi-species bottom trawl surveys.

Cartwright Channel Northern Shrimp Demographics
Mean Carapace Length (Standard Error)

	Age				
Year	1	2	3	4	5
1996		15.34 (.068)	16.87 (.026)	18.97 (.122)	20.86 (.082)
1997		14.29 (.286)	17.34 (.194)	19.05 (.181)	20.63 (.601)
1998	9.72 (.069)	14.43 (.790)	16.41 (.126)	18.36 (1.534)	19.72 (.570)
1999	10.25 (.066)	14.36 (.060)	16.63 (.092)	18.64 (.074)	20.63 (.043)
2000	9.42 (.143)	13.95 (.043)	16.91 (.022)	19.37 (.113)	20.94 (.086)
2001	9.91 (.143)	14.00 (.307)	16.36 (.056)	18.77 (.068)	21.29 (.017)
2002		13.29 (.082)	15.97 (.046)	18.72 (.038)	
2003	13.00 (.145)	14.75 (.052)	17.34 (.135)	19.56 (.250)	
2004		14.32 (.181)	16.60 (.103)	18.75 (.208)	20.10 (.632)
2005	10.45 (.028)	14.45 (.083)	17.45 (.634)	19.31 (.432)	21.04 (1.229)
2006	10.08 (.078)	13.82 (.044)	16.79 (.168)	19.02 (.072)	21.31 (.218)
2007	10.88 (.186)	13.16 (.076)	16.06 (.036)	19.55 (.539)	20.33 (1.066)

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

	Age					
Year	1	2	3	4	5	Total
1996		.113 (.014)	.754 (.017)	.094 (.008)	.039 (.004)	1.000
1997		.029 (.006)	.529 (.125)	.333 (.192)	.109 (.085)	1.000
1998	.016 (.002)	.042 (.041)	.115 (.144)	.541 (.278)	.286 (.445)	1.000
1999	.032 (.002)	.119 (.006)	.191 (.011)	.328 (.012)	.331 (.013)	1.001
2000	.005 (.001)	.091 (.003)	.622 (.046)	.181 (.010)	.101 (.013)	1.000
2001	.010 (.002)	.151 (.031)	.389 (.050)	.432 (.032)	.018 (.005)	1.000
2002		.101 (.008)	.501 (.009)	.398 (.010)		1.000
2003	.069 (.004)	.075 (.012)	.606 (.083)	.250 (.074)		1.000
2004		.039 (.009)	.442 (.033)	.474 (.047)	.045 (.073)	1.000
2005	.093 (.002)	.066 (.004)	.380 (.369)	.397 (.580)	.064 (.224)	1.000
2006	.038 (.002)	.325 (.008)	.178 (.014)	.426 (.014)	.033 (.009)	1.000
2007	.026 (.006)	.220 (.006)	.496 (.011)	.201 (.190)	.056 (.197)	0.999

Table 40 (Cont'd.)

Distributional Sigmas (Standard Error and constraints)

	Age				
Year	1	2	3	4	5
1996			.895 (.020) Sigmas Eq.		
1997		1.016 (.169)	.851 (.093)	.780 (.225)	.869 (.176)
1998	.648 (.054)	.974 (.260)	.578 (.219)	1.394 (.383)	.957 (.265)
1999			.892 (.019) Sigmas Eq.		
2000			.944 (.015) Sigmas Eq.		
2001	.751 (.089)	1.36 (.174)	.874 (.067)	.986 (.063)	.586 (.080)
2002			1.21 (.020) Sigmas Eq.		
2003	.9978 (Fixed)	.509 (.052)	1.158 (.109)	1.055 (.076)	
2004			1.107 (.061) Sigmas Eq.		
2005	1.022 (fixed)	1.022 (fixed)	.956 (.188)	1.041 (0.910)	.831 (.298)
2006			1.197 (.025) Sigmas Eq.		
2007			1.190 (.032) Sigmas Eq.		

Population at Age Estimates (10^6)

	Male Ages						Female	Total
Year	0	1	2	3	4	5		
1996	0	23	2,290	15,213	1,888	788	1,991	22,193
1997	2	14	276	4,251	2,682	878	2,262	10,367
1998	0	99	254	693	3,252	1,720	2,573	8,591
1999	0	227	853	1,369	2,353	2,376	3,899	11,077
2000	0	60	1,173	7,997	2,326	1,311	4,287	17,155
2001	0	221	1,892	5,652	8,213	577	5,379	21,830
2002	0	270	1,225	6,060	4,813	0	3,741	16,108
2003	3	948	1,034	8,331	3,435	0	7,574	21,324
2004	1	449	4,907	5,254	502	9	6,314	17,461
2005	0	1,826	1,573	8,123	6,158	673	9,971	28,324
2006	30	592	5,092	2,788	6,665	598	4,572	20,337
2007	16	509	4,142	9,335	3,784	1,071	5,192	24,049

Table 41. NORTHERN SHRIMP LARGE VESSEL (>500 t) FISHERY DATA FOR DIV. 2G (SFA 4), 1979 - 2007.

YEAR	TAC [1] (t)	FLEET [2] CATCH (t)	UNSTANDARDIZED CPUE (KG/HR)	CPUE Relative to 2007	EFFORT [3] (HR)	CPUE Relative to 2007	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	0.17	10,926	0.27	563	6,821
1990	2,580	2,945	719	0.34	4,096	0.28	571	5,160
1991	2,635	2,561	1,714	0.81	1,494	1.22	2,518	1,017
1992	2,635	2,706	2,110	0.99	1,283	1.01	2,093	1,293
1993	2,735	2,723	2,210	1.04	1,232	0.94	1,942	1,402
1994	4,000	3,982	3,986	1.88	999	1.69	3,497	1,139
1995	5,200	5,104	1,404	0.66	3,636	0.62	1,275	4,002
1996	5,200	5,160	1,395	0.66	3,698	0.64	1,316	3,921
1997	5,200	5,216	3,230	1.52	1,615	1.41	2,924	1,784
1998	8,008	7,918	2,356	1.11	3,361	1.05	2,178	3,635
1999	8,008	7,836	2,439	1.15	3,213	1.12	2,308	3,395
2000	8,008	8,048	2,591	1.22	3,106	1.18	2,439	3,299
2001	8,008	7,991	3,897	1.84	2,050	1.70	3,517	2,272
2002	8,008 [4]	8,516	2,543	1.20	3,349	1.04	2,149	3,964
2003	13,122	13,020	3,190	1.50	4,082	1.31	2,712	4,800
2004	10,243	9,644	2,318	1.09	4,160	1.00	2,075	4,647
2005	10,249	10,247	2,313	1.09	4,431	0.89	1,839	5,571
2006	10,240	10,084	2,747	1.29	3,671	1.08	2,222	4,538
2007	10,129	10,258	2,123	1.00	4,831	1.00	2,067	4,962

[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.

Table 42. Multiplicative year, month, and vessel CPUE model for large vessels (>500 t) fishing shrimp in NAFO Division 2G (SFA 4), 1989 – 2007, weighted by effort (single trawl, no windows, observer data).

The GLM Procedure
Class Level Information

Class	Levels	Values
year	19	1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007
month	8	5 6 8 9 10 11 12 99 Standardized against July
CFV	20	

Number of Observations Read 576
Number of Observations Used 576

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	44	5469.002653	124.295515	18.92	<.0001
Error	531	3488.547988	6.569770		
Corrected Total	575	8957.550642			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.610547	33.46476	2.563156	7.659269

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	18	3969.970109	220.553895	33.57	<.0001
month	7	244.863840	34.980549	5.32	<.0001
CFV	19	1254.168705	66.008879	10.05	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	18	2465.181551	136.954531	20.85	<.0001
month	7	217.092712	31.013245	4.72	<.0001
CFV	19	1254.168705	66.008879	10.05	<.0001

Table 42 (cont'd.)

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		7.118851127	B	0.15409619	46.20	<.0001
year	1989	-1.300155453	B	0.22501990	-5.78	<.0001
year	1990	-1.287024263	B	0.17547900	-7.33	<.0001
year	1991	0.197320216	B	0.20448837	0.96	0.3350
year	1992	0.012509492	B	0.18501406	0.07	0.9461
year	1993	-0.062375492	B	0.20977015	-0.30	0.7663
year	1994	0.525627443	B	0.15356936	3.42	0.0007
year	1995	-0.482826687	B	0.13117767	-3.68	0.0003
year	1996	-0.451657565	B	0.12639489	-3.57	0.0004
year	1997	0.346818523	B	0.13985872	2.48	0.0135
year	1998	0.052254373	B	0.12149365	0.43	0.6673
year	1999	0.110332158	B	0.12165842	0.91	0.3649
year	2000	0.165594562	B	0.12234539	1.35	0.1765
year	2001	0.531508315	B	0.13096198	4.06	<.0001
year	2002	0.038634291	B	0.12260336	0.32	0.7528
year	2003	0.271663882	B	0.12111935	2.24	0.0253
year	2004	0.003907750	B	0.11795878	0.03	0.9736
year	2005	-0.116754668	B	0.11592911	-1.01	0.3143
year	2006	0.072346209	B	0.11518992	0.63	0.5302
year	2007	0.000000000	B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
1989	6.333761	5.945586	6.721936
1990	6.346892	6.068222	6.625562
1991	7.831237	7.495994	8.166479
1992	7.646426	7.356731	7.936121
1993	7.571541	7.213869	7.929213
1994	8.159544	7.941889	8.377199
1995	7.151090	7.009464	7.292716
1996	7.182259	7.060983	7.303535
1997	7.980735	7.817184	8.144286
1998	7.686171	7.576789	7.795552
1999	7.744249	7.644857	7.843640
2000	7.799511	7.690869	7.908153
2001	8.165425	8.018430	8.312419
2002	7.672551	7.555368	7.789733
2003	7.905580	7.788056	8.023105
2004	7.637824	7.532658	7.742991
2005	7.517162	7.415387	7.618937
2006	7.706263	7.594410	7.818116
2007	7.633916	7.423841	7.843992

Table 43. SFA 4 northern shrimp (*Pandalus borealis*) biomass and abundance estimates over the period 2005 – 2007. The estimates were calculated using Ogmap and used data from the joint NSRF – DFO research bottom trawl survey conducted in 2G during July of each year.

Year	Biomass (t)			Abundance (numbers X 10^6)			Survey
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	Sets
2005	33,240	69,100	115,000	6,298	13,569	22,780	79
2006	51,460	114,400	182,700	9,456	21,103	35,630	77
2007	88,700	128,200	198,600	16,100	22,588	35,240	77

Table 44 Total biomass (t) of northern shrimp (*Pandalus borealis*) collected during the 2005 - 2007 joint NSRF - DFO research bottom trawl northern shrimp research surveys into Div. 2G (SFA 4). (All tows were standardized to 15 minutes; empty cells were not sampled.). The conversion from square nautical miles to square kilometres was 1 sq Nmi = 3.429904 sq km (www.onlineconversion.com/area.htm) (Biomass estimates made use of stratified analysis calculations.)

Depth Range (m)	Area sq. Nmi	Area sq. km	Stratum	2005	2006	2007
<=200	1,643	5,635	909	1.09	44.38	96.49
<=200	2,397	8,221	910	40.36	94.58	31.14
<=200	2,009	6,891	925	16.48	238.51	814.08
<=200	1,007	3,454	930	5174.2	37.24	728.65
<=200	213	731	931	.	24.55	4889.7
201 - 300	1,225	4,202	901	12707	7053.7	40396
201 - 300	607	2,082	908	27297	26644	26939
201 - 300	717	2,459	911	17289	2787	6512.7
201 - 300	833	2,857	924	3205.7	14169	43140
201 - 300	462	1,585	926	2590.1	20343	1515.2
301 - 400	128	439	902	79.2	87.36	190.82
301 - 400	67	230	912	0.91	20.39	0.54
301 - 400	248	851	923	5777.5	24478	1137.3
301 - 400	452	1,550	927	242.87	31.42	86.76
401 - 500	88	302	903	0	0.15	0
401 - 500	54	185	913	0.04	0.03	0
401 - 500	195	669	922	3.79	191.1	0
401 - 500	365	1,252	928	67.77	13.17	3.32
501 - 750	152	521	904	0.94	.	0
501 - 750	130	446	914	0	0.06	0
501 - 750	161	552	921	0.45	3.65	0
501 - 750	742	2,545	929	0.14	0.71	20.68
Lower 95% CL				11,369	23,959	58,963
Biomass Estimate				74,495	96,262	126,502
Upper 95% CL				140,315	168,564	192,894
100-200 m				7.024	0.456	5.186
201-400 m				92.878	99.327	94.795
>401 m				0.098	0.217	0.019

Table 45 Biomass (t) of northern shrimp (*Pandalus borealis*) per km^2 in SFA 4). The analysis was from areal expansion of the joint NSRF - DFO reseach survey data collected during the 2005 - 2007. Densities within each stratum were divided into three equal parts and color coded such that the lower 1/3 is blue, intermediate is yellow and top 1/3 is orange. The Campelen 1800 research survey trawl was used, tows were 15 minutes in length at 3 Nmi/hr.

Depth Range (m)	Area sq. Nmi	Area sq. km	Stratum	2005	2006	2007
<=200	5,635	909	0.000	0.008	0.017	
<=200	8,221	910	0.005	0.012	0.004	
<=200	6,891	925	0.002	0.035	0.118	
<=200	3,454	930		0.011	0.211	
<=200	731	931		0.034	6.693	
201 - 300	4,202	901	3.024	1.679	9.614	
201 - 300	2,082	908	13.111	12.798	12.939	
201 - 300	2,459	911	7.030	1.133	2.648	
201 - 300	2,857	924	1.122	4.959	15.099	
201 - 300	1,585	926	1.635	12.838	0.956	
301 - 400	439	902	0.180	0.199	0.435	
301 - 400	230	912	0.004	0.089	0.002	
301 - 400	851	923	6.792	28.777	1.337	
301 - 400	1,550	927	0.157	0.020	0.056	
401 - 500	302	903	0.000	0.000	0.000	
401 - 500	185	913	0.000	0.000	0.000	
401 - 500	669	922	0.006	0.286	0.000	
401 - 500	1,252	928	0.054	0.011	0.003	
501 - 750	521	904	0.002	.	0.000	
501 - 750	446	914	0.000	0.000	0.000	
501 - 750	552	921	0.001	0.007	0.000	
501 - 750	2,545	929	0.000	0.000	0.008	

Table 46. Div 2G (SFA 4) northern shrimp (*Pandalus borealis*) biomass (t) by depth range.

Depth Range (m)	Area sq. Nmi	Area sq. km	2005	2006	2007
<=200	7,269	24,932	5,232	439	6,560
201 - 300	3,844	13,185	63,089	70,997	118,503
301 - 400	895	3,070	6,100	24,617	1,415
401 - 500	702	2,408	72	204	3
501 - 750	1,185	4,064	2	4	21

Table 47 Div 2G (SFA 4) northern shrimp (*Pandalus borealis*) density (t/km^2).

Depth Range (m)	Area sq. Nmi	Area sq. km	2005	2006	2007
<=200	7,269	24,932	0.2099	0.0176	0.2631
201 - 300	3,844	13,185	4.7851	5.3848	8.9880
301 - 400	895	3,070	1.9873	8.0192	0.4611
401 - 500	702	2,408	0.0297	0.0849	0.0014
501 - 750	1,185	4,064	0.0004	0.0011	0.0051

Table 48. Recruitment index (all males 11.5 – 16 mm carapace length) created using ogmap calculations from data collected on the joint NSRF – DFO summer research northern shrimp survey.

year	Recruitment index ($X10^6$)		
	Lower 95% C.I.	Estimate	Upper 95% C.I.
2005	475	1,042	1,799
2006	884	2,222	4,276
2007	1,387	2,104	3,238

Table 49. SFA 4 female spawning stock biomass and abundance.

Year	Biomass (t)			Abundance (10^9)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
2005	17,020	33,100	51,630	2,268	4,392	6,749
2006	29,790	55,600	79,720	3,767	6,832	9,849
2007	55,190	77,600	117,900	7,170	10,016	15,320

Table 50. SFA 4 fishable biomass (biomass of all males with >17.0 mm carapace lengths + biomass of all females) and abundance.

year	Fishable biomass (000 t)			year	Fishable abundance (10^6)		
	Lower 95% C.I.	Estimate	Upper 95% C.I.		Lower 95% C.I.	Estimate	Upper 95% C.I.
2005	31	66	110	2005	5,240	11,663	19,840
2006	50	106	165	2006	8,680	21,389	35,320
2007	75	111	176	2007	11,540	17,674	28,520

Table 51. Exploitation rate indices for northern shrimp (*Pandalus borealis*) harvested from NAFO Division 2G (SFA 4) as estimated using survey and total catch data over the period 2005 – 2007. Please note that the values presented here are for the calendar years (Jan. 1 – Dec. 31) from 1996 – 2002. There was a change in management year to Apr. 1 – Mar 31 starting in 2003. The values presented below reflect that change in management year. However, the values presented during the March 2008 ZAP were converted to calendar years therefore the values presented below do not agree with those presented during ZAP. Please note that Division 2G is surveyed during July and is therefore near the mid season for the fishery. In this case, exploitation is catch/ index within the present year.

	Lower C.L. of total biomass (t)	Total biomass (t)	Fishable biomass (t)
2005	33,240	69,100	66,200
2006	51,460	114,400	106,100
2007	88,700	128,200	111,300

Year	Catch (t)	Catch/ lower 95% CL total biomass	Catch/ biomass	Catch/ fishable biomass
2005	10,247	30.83	14.83	15.48
2006	10,084	19.60	8.81	9.50
2007	10,258	11.56	8.00	9.22

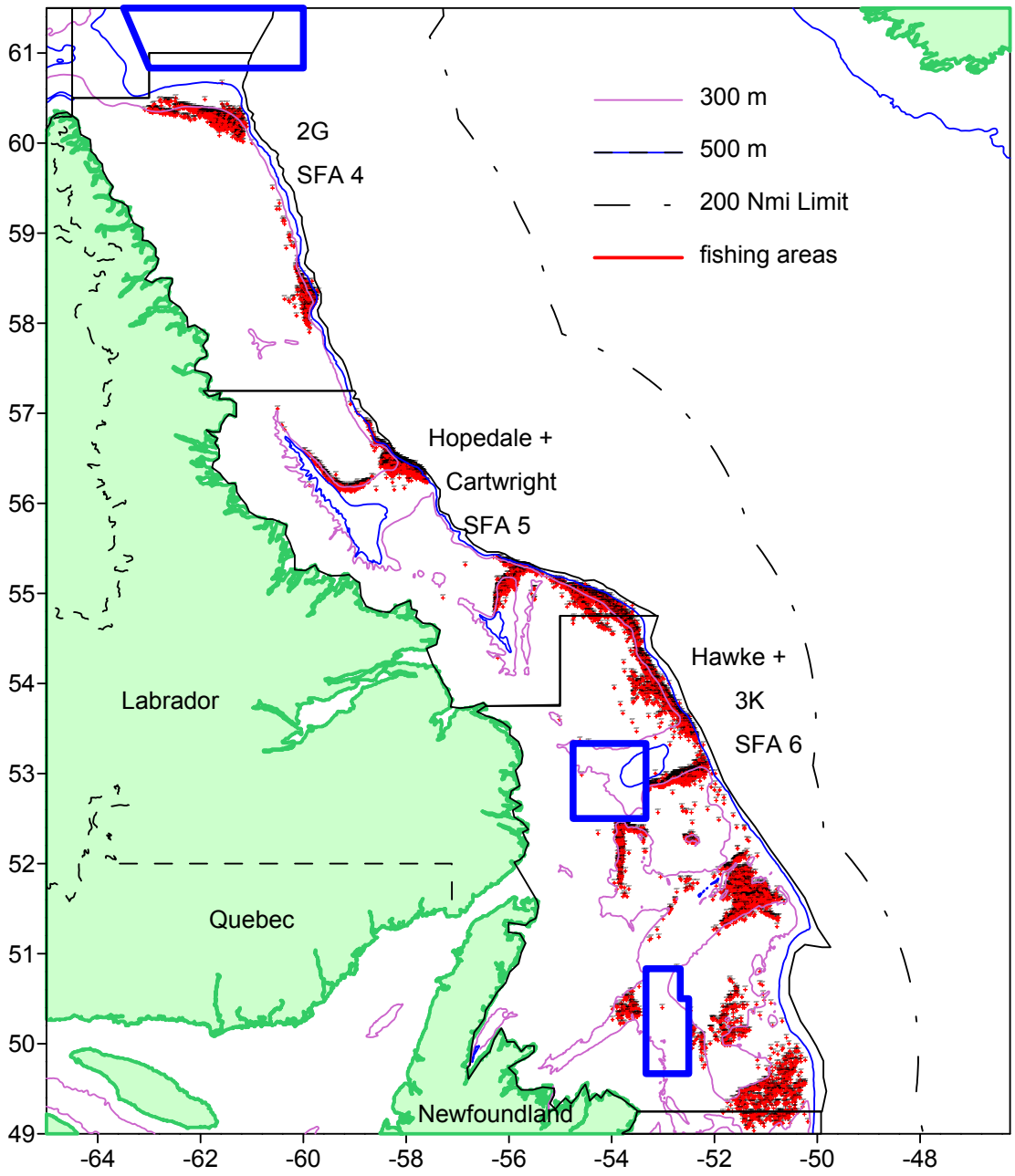


Figure 1. Map of northern shrimp fishing areas (SFA's) including the northern SFA 4, Hawke Channel and Funk Island Deep closed areas. The northern SFA 4 is a voluntary closed area established by the large vessel shrimp fishing fleet to protect corals. The Funk Island Deep closed area is mandatory for small vessels and voluntary for large vessels. The red crosses indicate large and small vessel fishing positions.

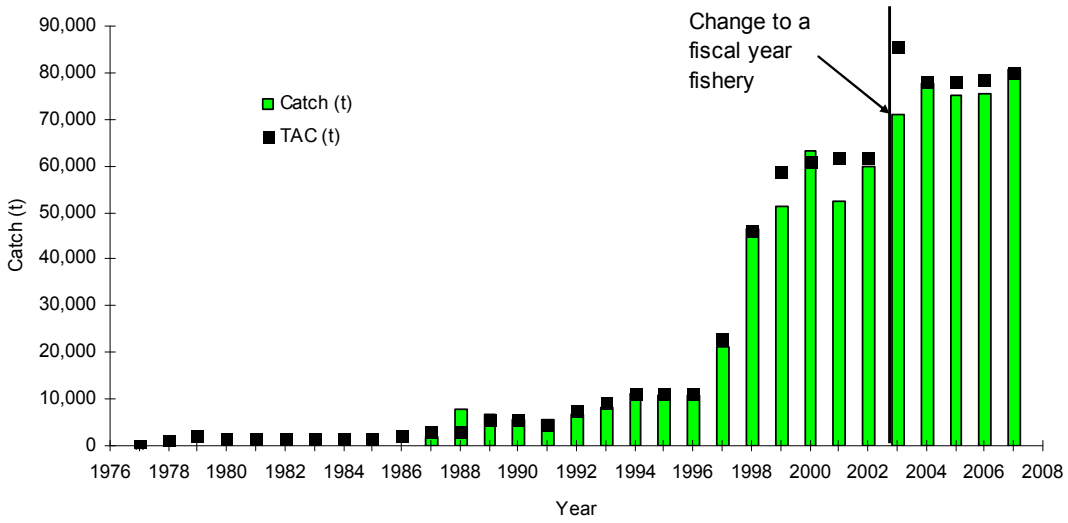


Figure. 2. Historic northern shrimp catches (SFA's 4-6) and TAC's for the period 1977-2008 (2007-08 catches were updated since the SAR was produced). In 2003, the management year changed from Jan. 1–Dec.31 to Apr. 1–Mar.31. Catches are not complete for the 2007-08 management year.

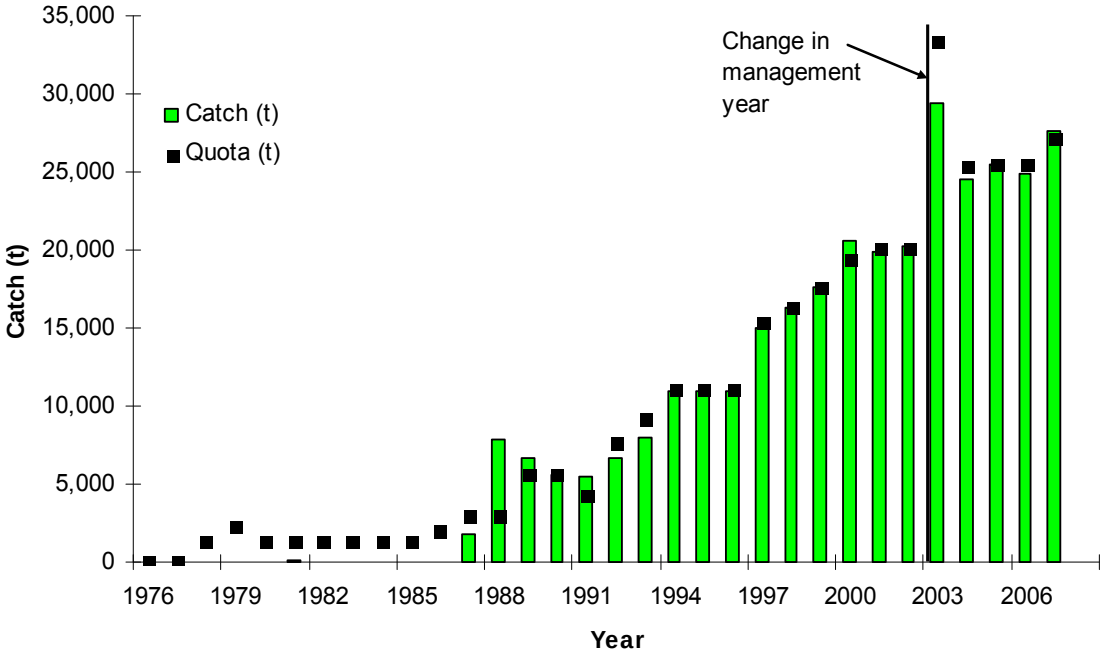


Figure 3. History of SFA 6 large vessel (>500 t) quotas and catches, 1977–2007. Note that beginning in 2003, TAC's have been allocated by fiscal year (Apr.1–Mar.31).

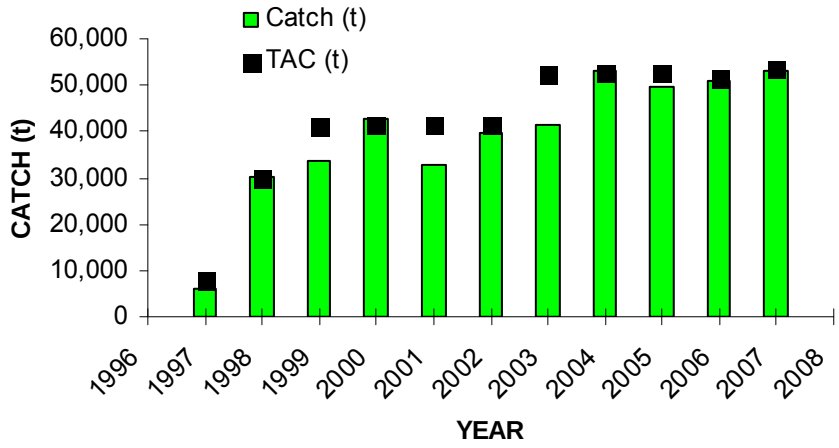


Figure 4. History of SFA 6 small vessel (<= 500 t; <=100' LOA) quotas and catches, 1977–2007.

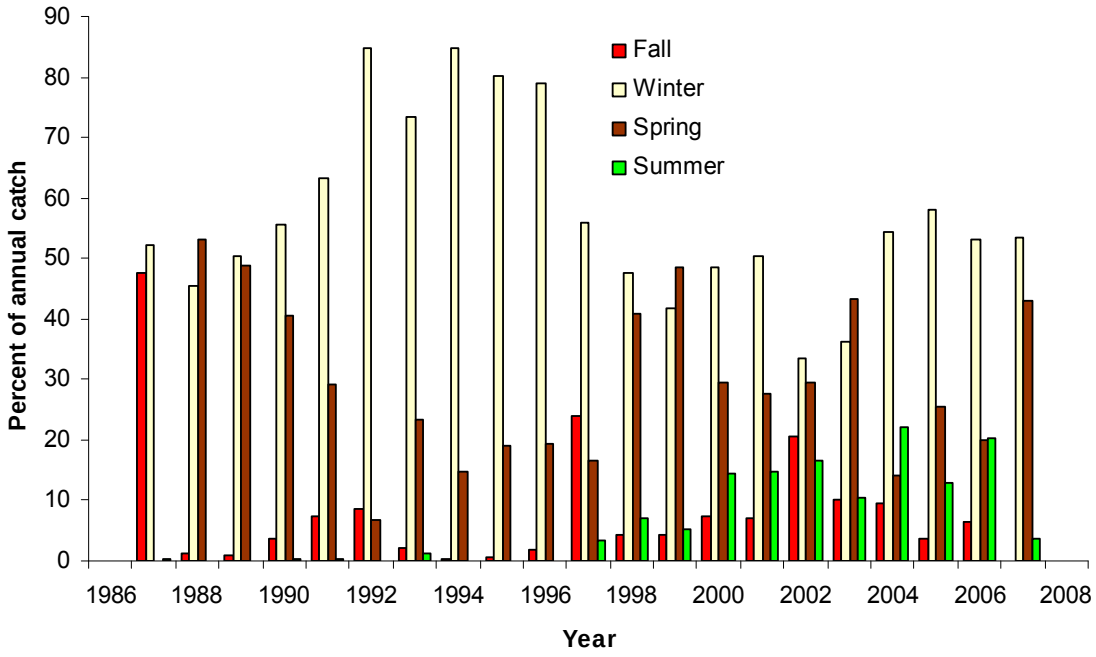


Figure 5. Seasonality of the large vessel (>500 t) shrimp fishery within Hawke Channel + 3K (SFA 6) as determined from percent annual catch by season.

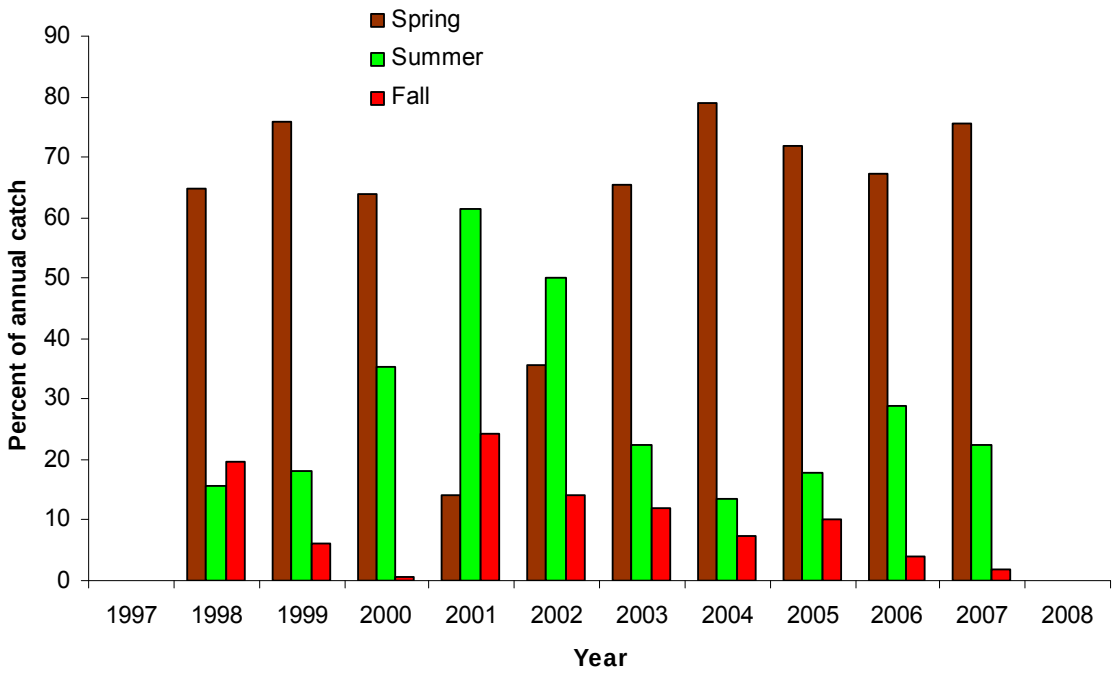


Figure 6. Seasonality of the small vessel (<=500 t; <= 100‘ LOA) shrimp fishery within Hawke Channel + 3K (SFA 6) as determined from percent annual catch by season.

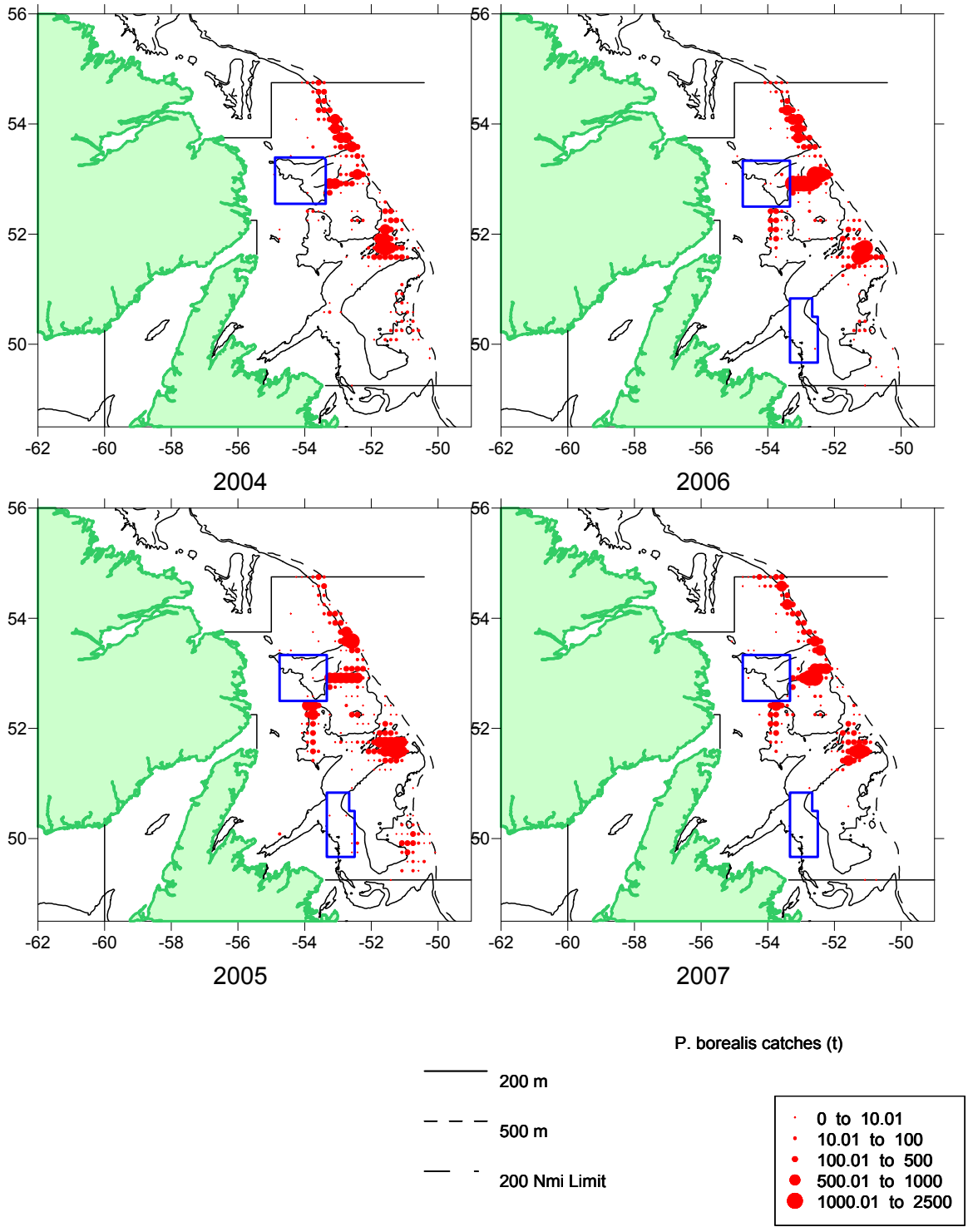


Figure 7. Distribution of large vessel (>500 t) shrimp catches in Hawke+3K (SFA 6). (Observer data aggregated into 10 min X 10 min cells). Please note that the blue boxes indicate the Hawke Channel and Funk Island Deep closed areas. The Hawke Channel closed area is a mandatory closure for trawlers while the Funk Island Deep closed area is mandatory for small vessels and voluntary for large vessels.

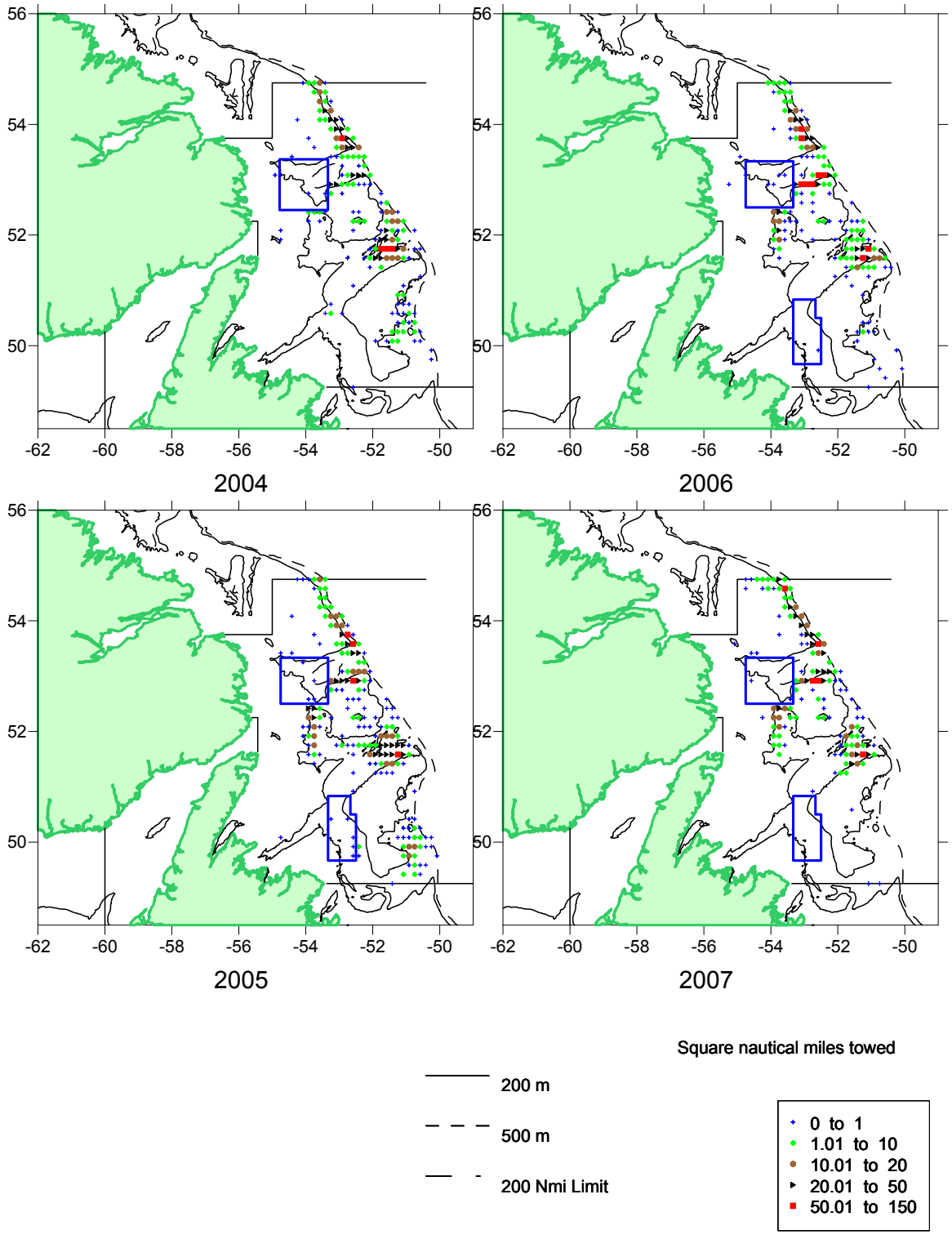


Figure 8. Distribution of large vessel (>500 t) towed areas in Hawke+3K (SFA 6). (Observer data aggregated into 10 min X 10 min cells). Please note that the blue boxes indicate the Hawke Channel and Funk Island Deep closed areas. The Hawke Channel closed area is a mandatory closure for trawlers while the Funk Island Deep closed area is mandatory for small vessels and voluntary for large vessels.

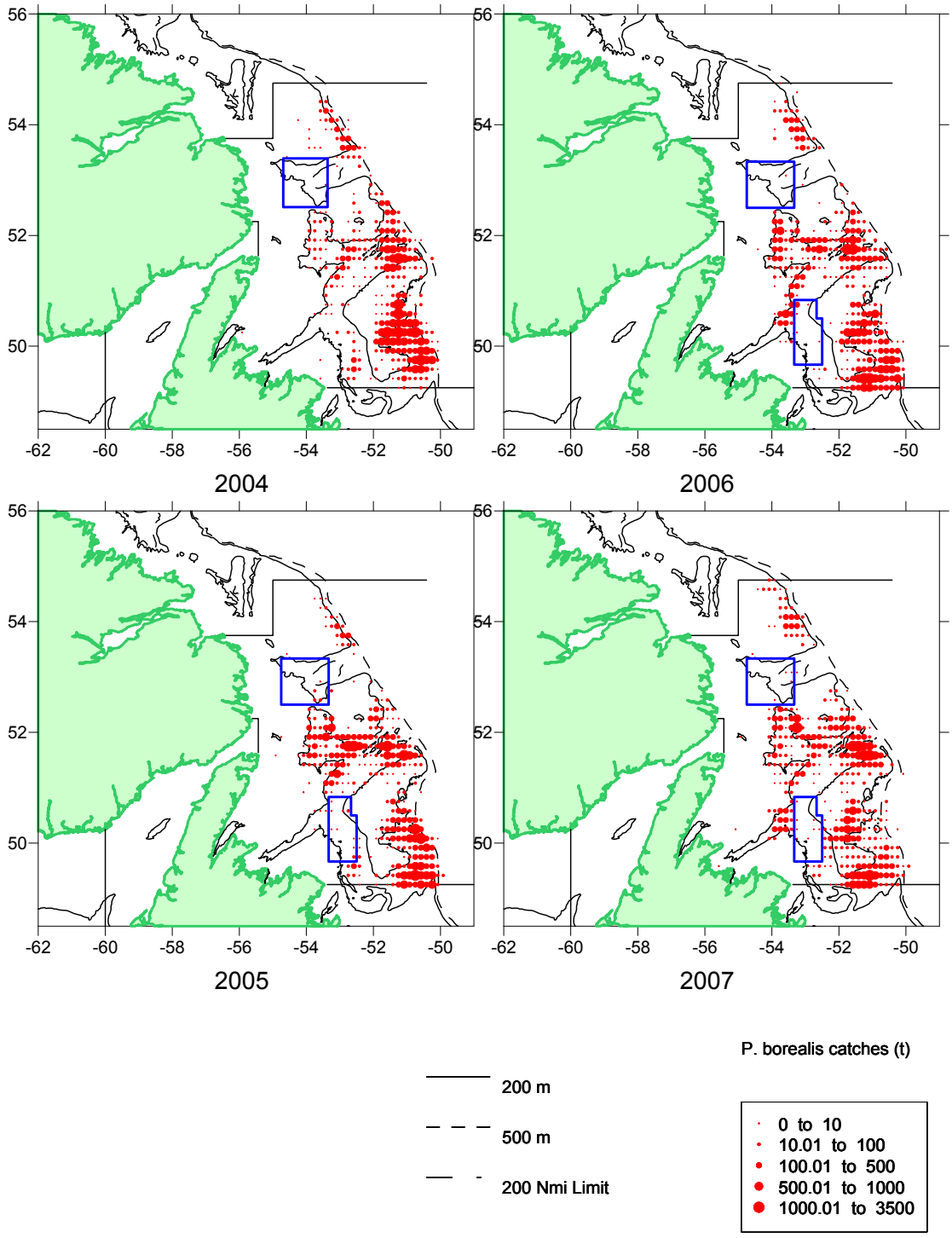


Figure 9. Distribution of small vessel (<=500 t; <= 100' LOA) towed areas in Hawke+3K (SFA 6). (Observer data aggregated into 10 min X 10 min cells). Please note that the blue boxes indicate the Hawke Channel and Funk Island Deep closed areas. The Hawke Channel closed area is a mandatory closure for trawlers while the Funk Island Deep closed area is mandatory for small vessels and voluntary for large vessels.

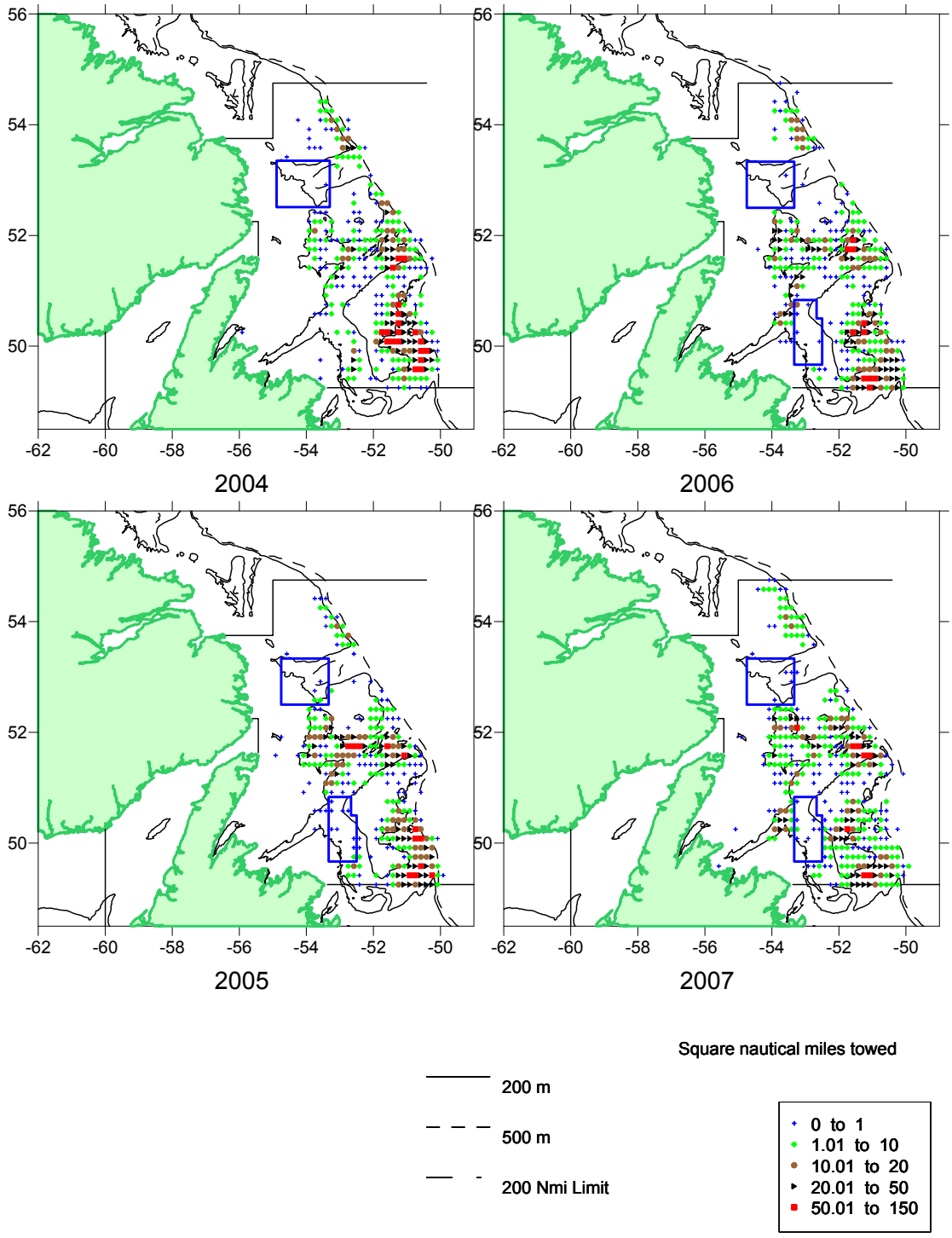


Figure 10. Distribution of small vessel (<=500 t; <=100' LOA) towed areas in Hawke+3K (SFA 6). (Observer data aggregated into 10 min X 10 min cells). Please note that the blue boxes indicate the Hawke Channel and Funk Island Deep closed areas. The Hawke Channel closed area is a mandatory closure for trawlers while the Funk Island Deep closed area is mandatory for small vessels and voluntary for large vessels.

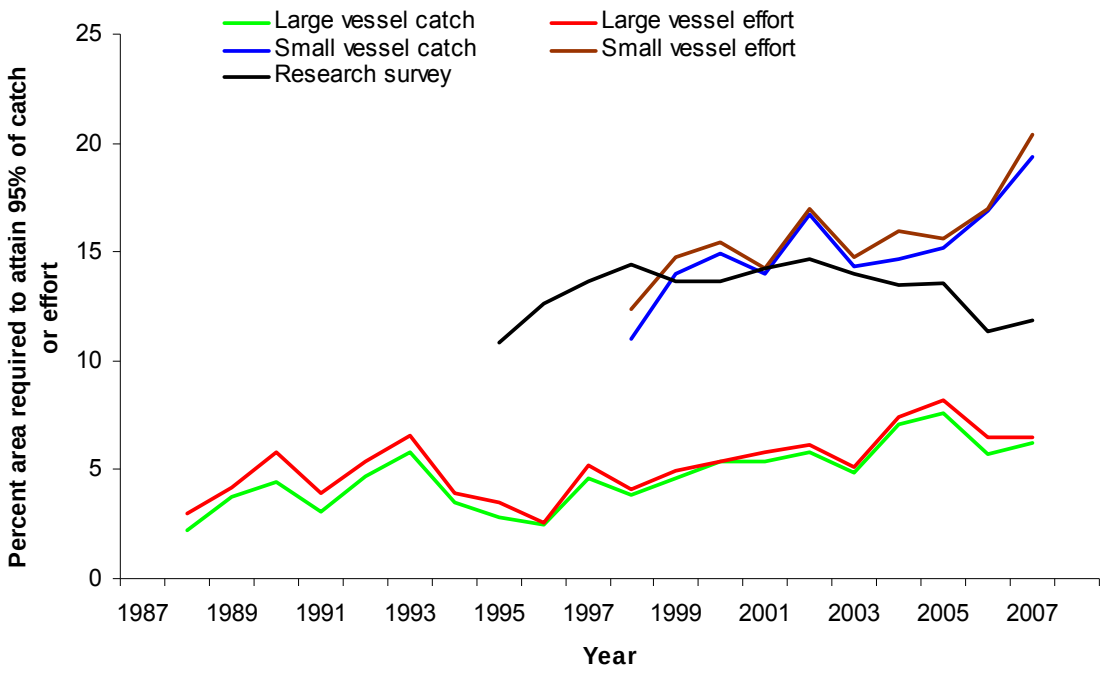


Figure 11. The percent total area within SFA 6 necessary to obtain 95% of the research survey and fishery catches as well as 95% of the bottom contact by the large and small vessel fleets.

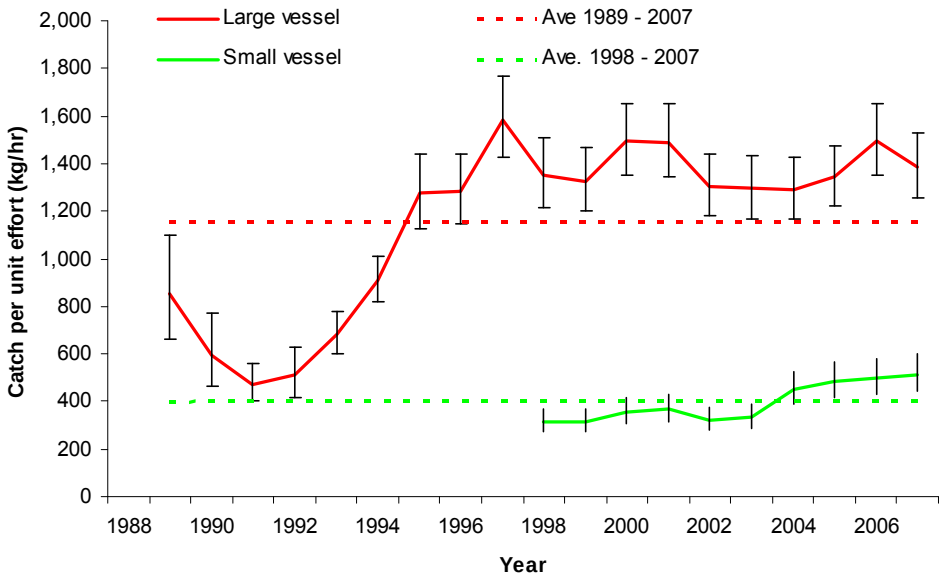


Figure 12. SFA 6 large and small vessel CPUE (error bars indicate 95% confidence intervals.

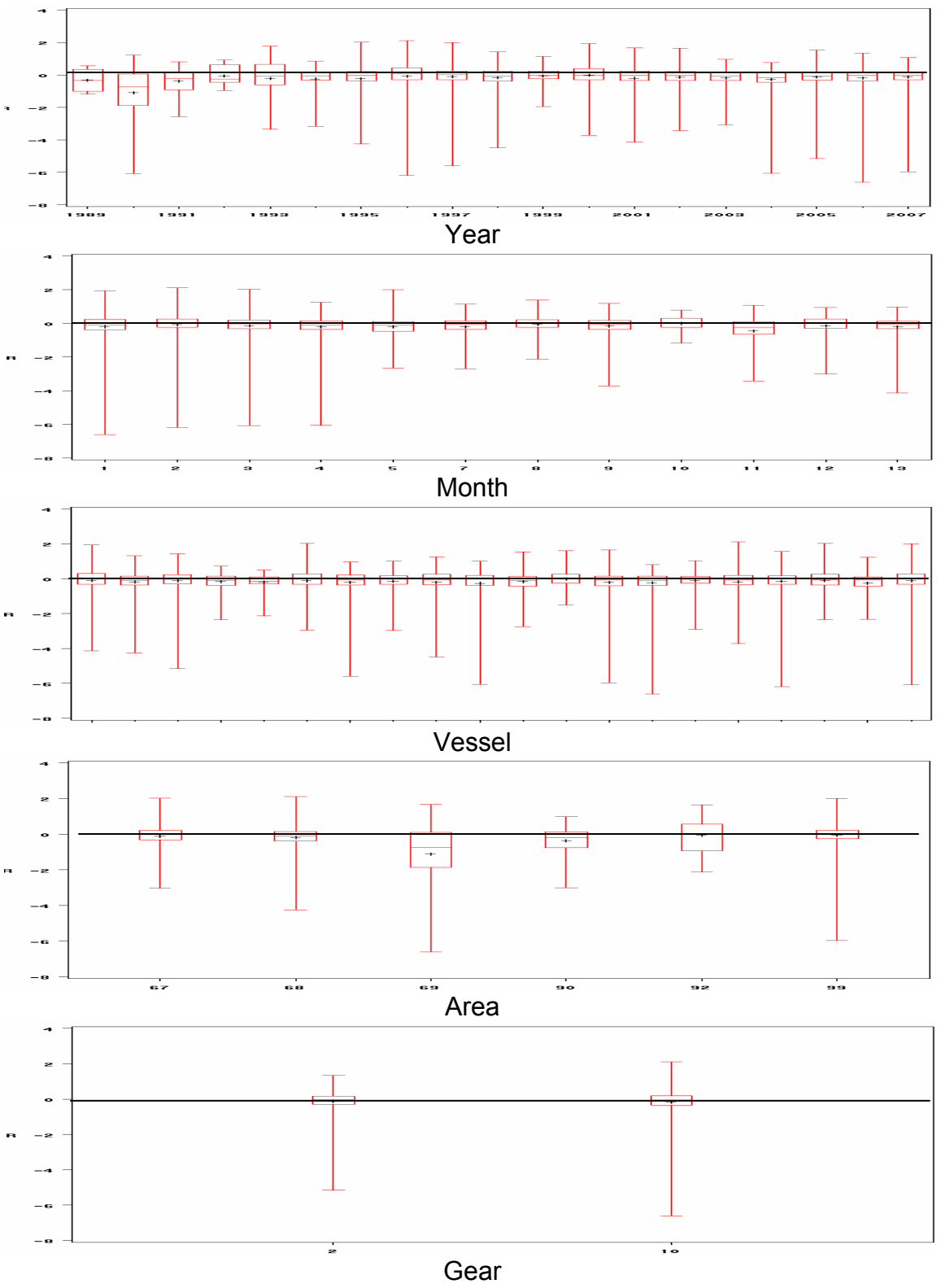


Figure 13. The distribution of residuals around estimated values for parameters used in the large vessel (>500 t) shrimp catch rate model for Hawke Channel + 3K (SFA 6), 1989–2007.

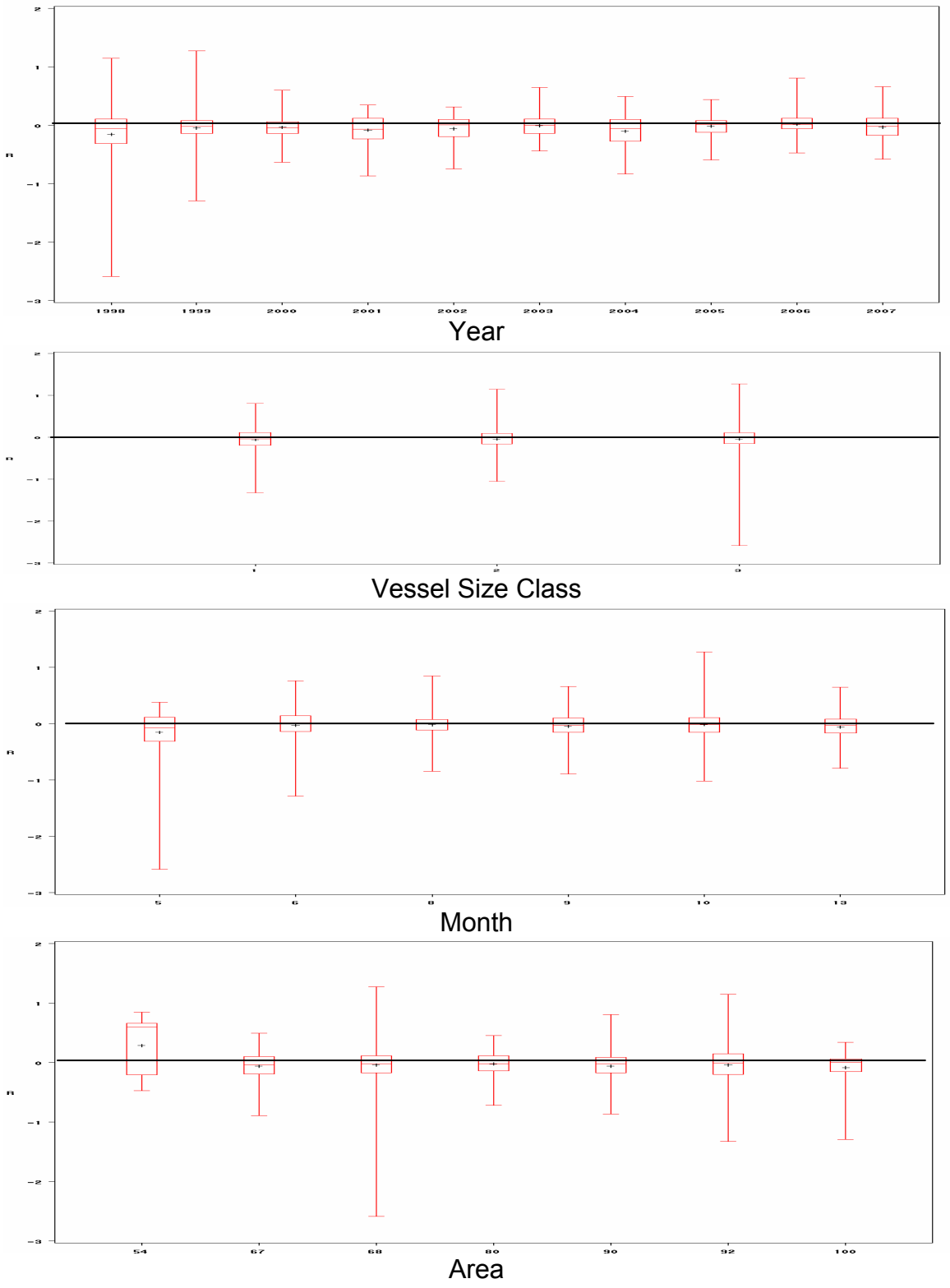


Figure 14. The distribution of residuals around estimated values for parameters used in the small vessel (<=500 t; LOA<= 100') shrimp catch rate model for Hawke Channel + 3K (SFA 6), 1998–2007.

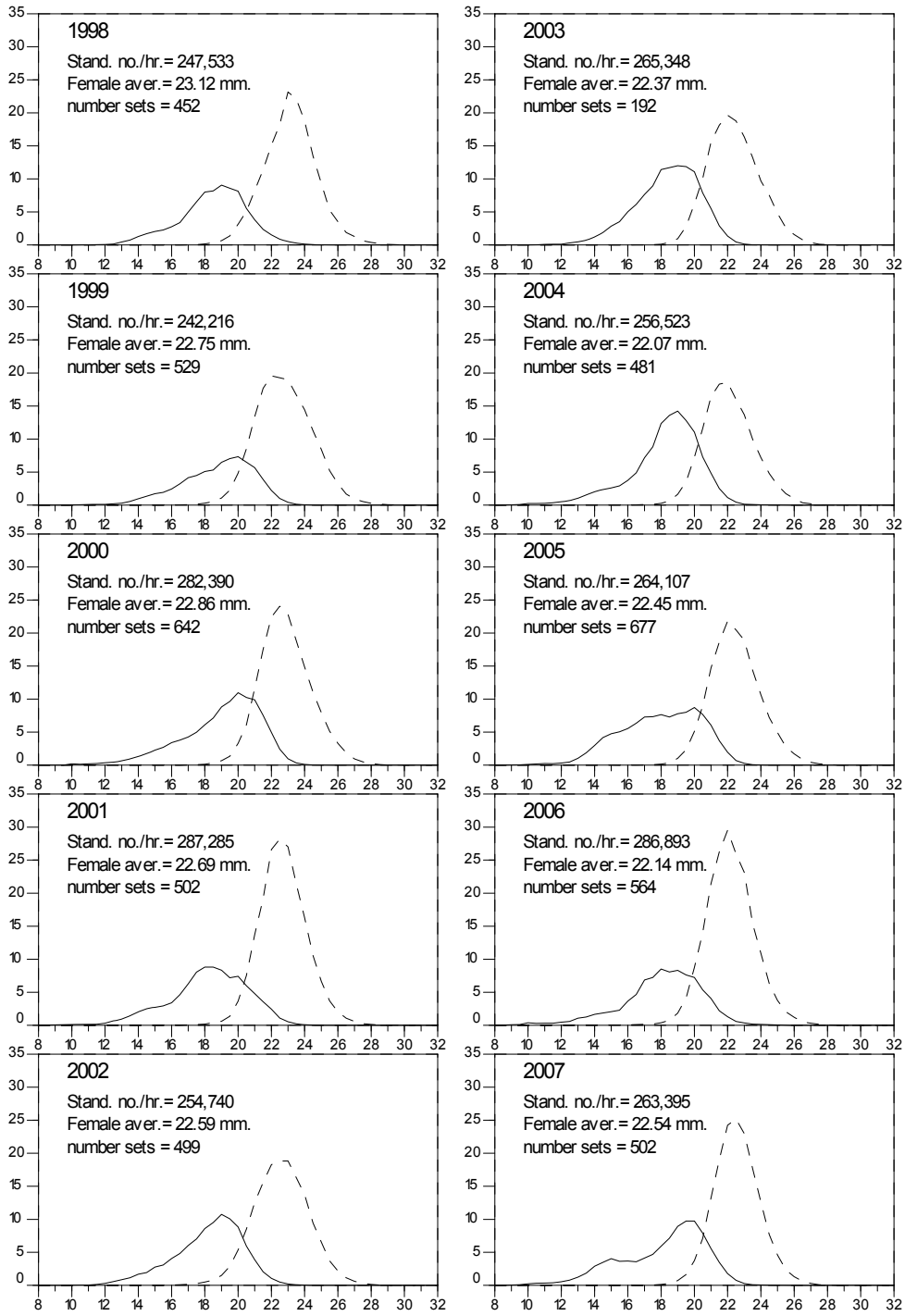


Figure 15. Observed northern shrimp length frequencies (000's per hr.) from the Canadian large vessel (>500 t) fleet fishing shrimp in Hawke Channel + 3K (SFA 6) over the period 1998–2007. Solid lines = males; dotted lines = females.

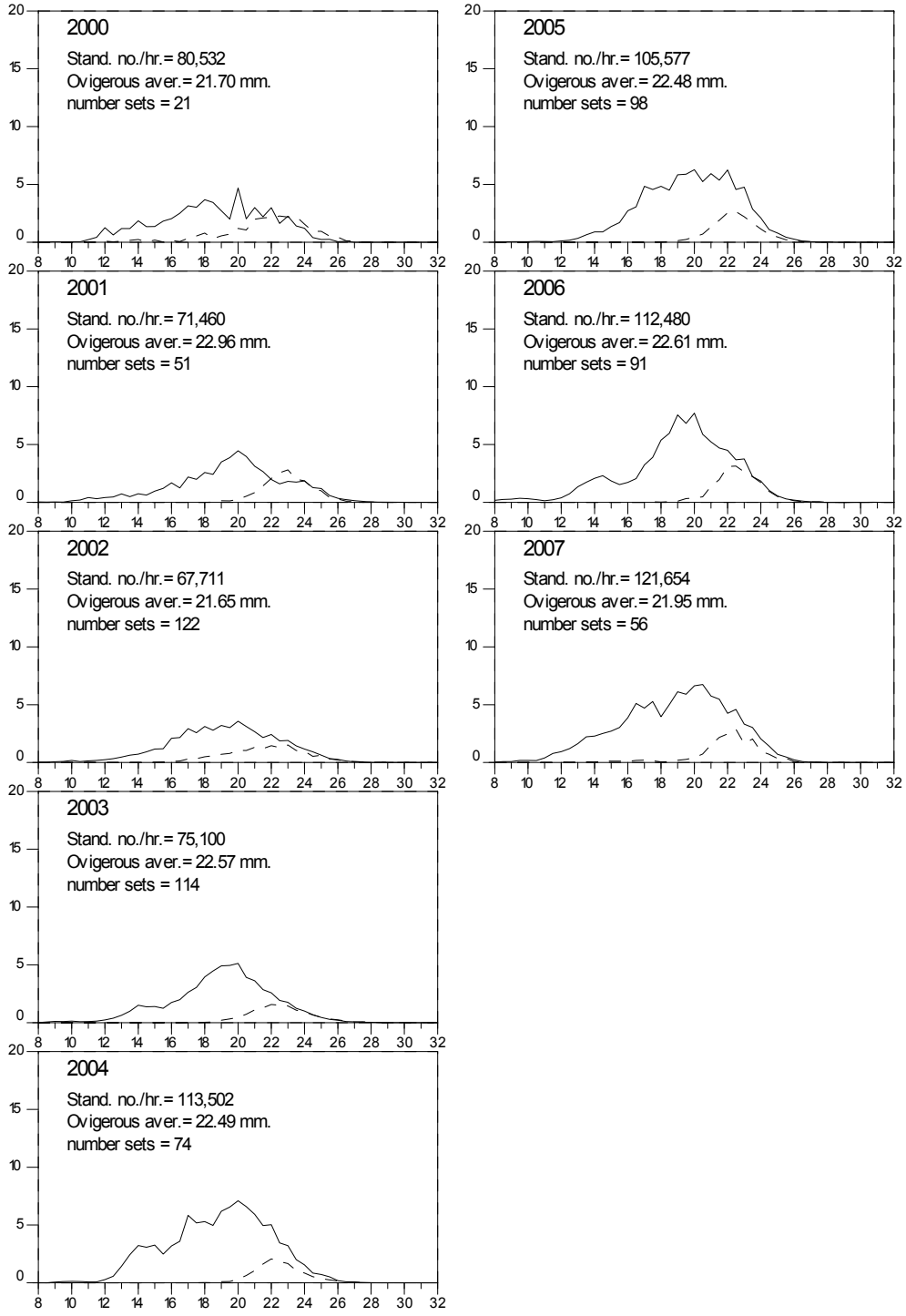


Figure 16. Observed northern shrimp length frequencies (000's per hr.) from the Canadian small vessel (<=500 t; LOA <= 100') fleet fishing shrimp in Hawke Channel + 3K (SFA 6) over the period 1998–2007. Solid lines = males; dotted lines = females.

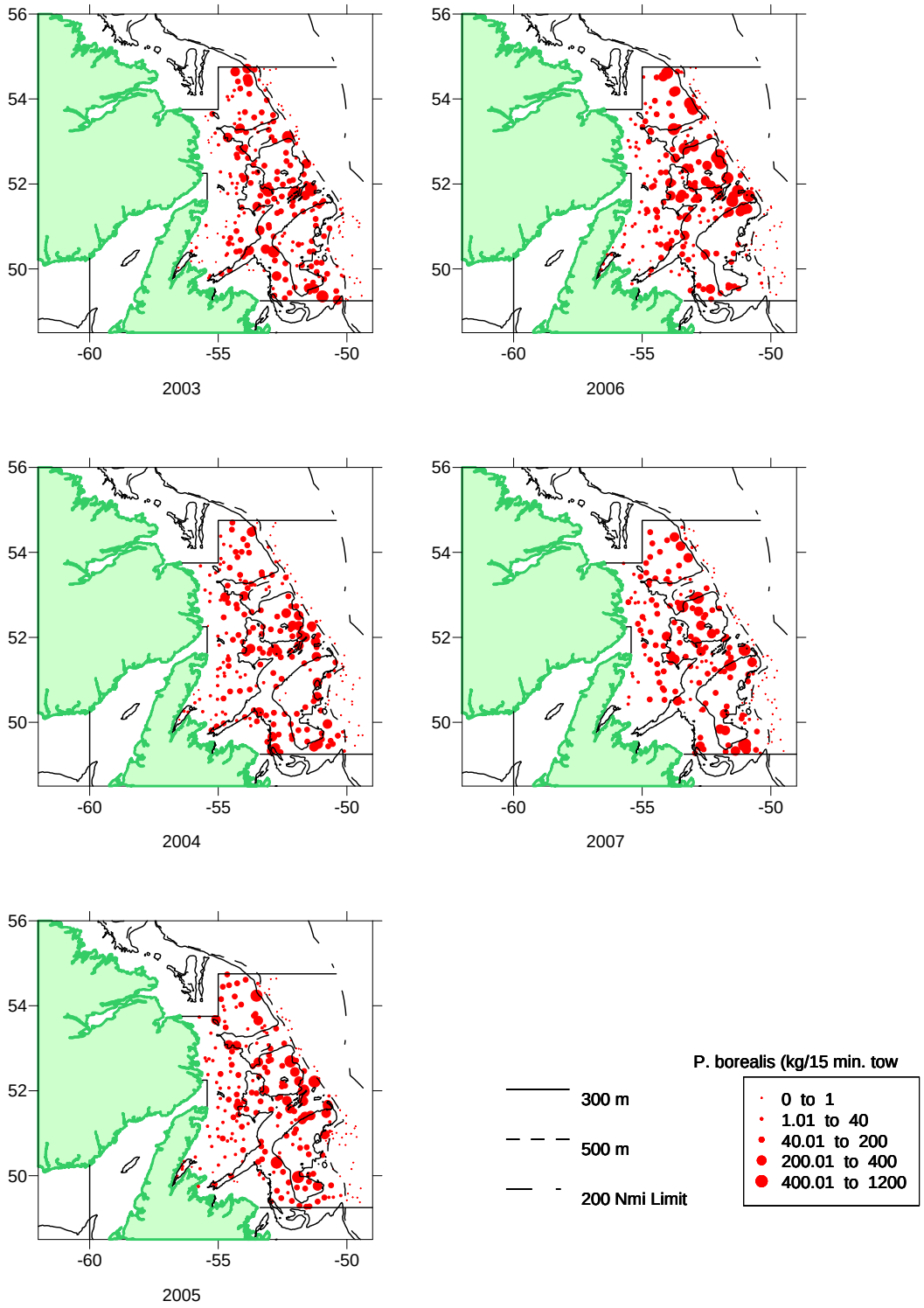


Figure 17. Distribution of Hawke Channel + 3K (SFA 6) northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from autumn research bottom trawl surveys conducted over the period 2003–07.

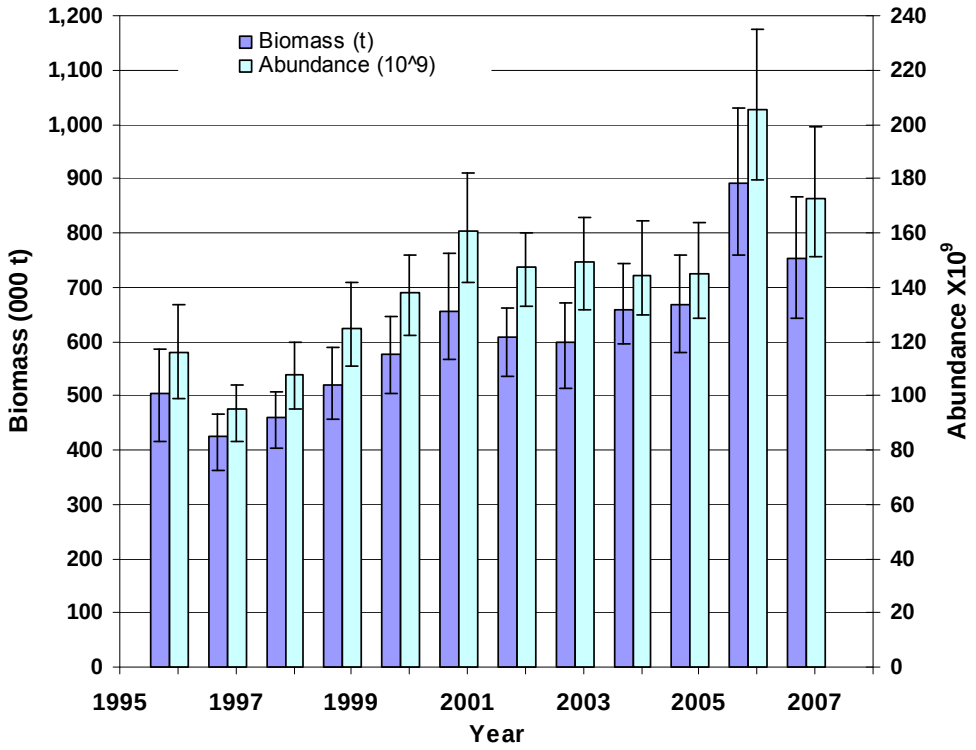


Figure 18. Autumn northern shrimp (*Pandalus borealis*) biomass and abundance indices within Hawke Channel + 3K (SFA 6), as determined using OGive MAPped calculations. Data were from the annual Canadian multi-species bottom trawl surveys using Campelen 1800 shrimp trawl.

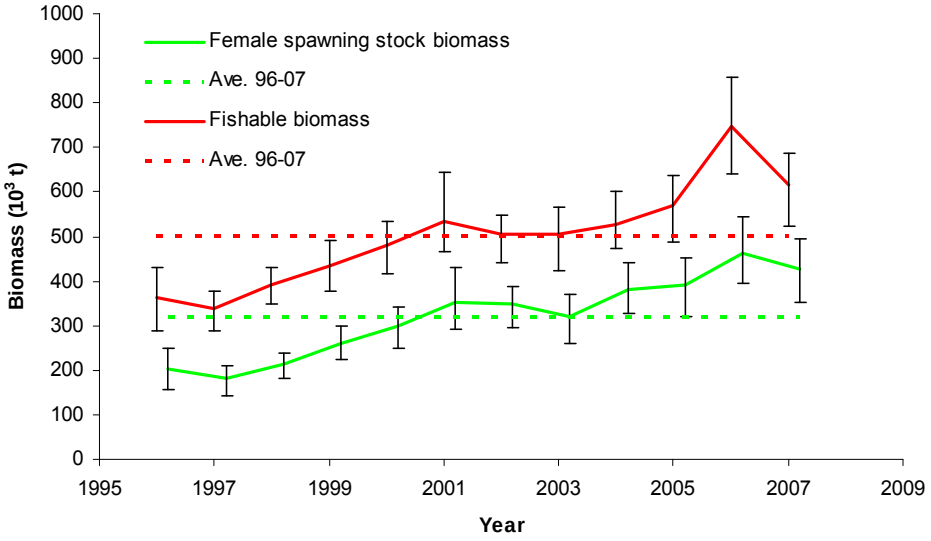


Figure 19. SFA 6 female spawning stock and fishable biomass indices (error bars indicate 95% confidence intervals).

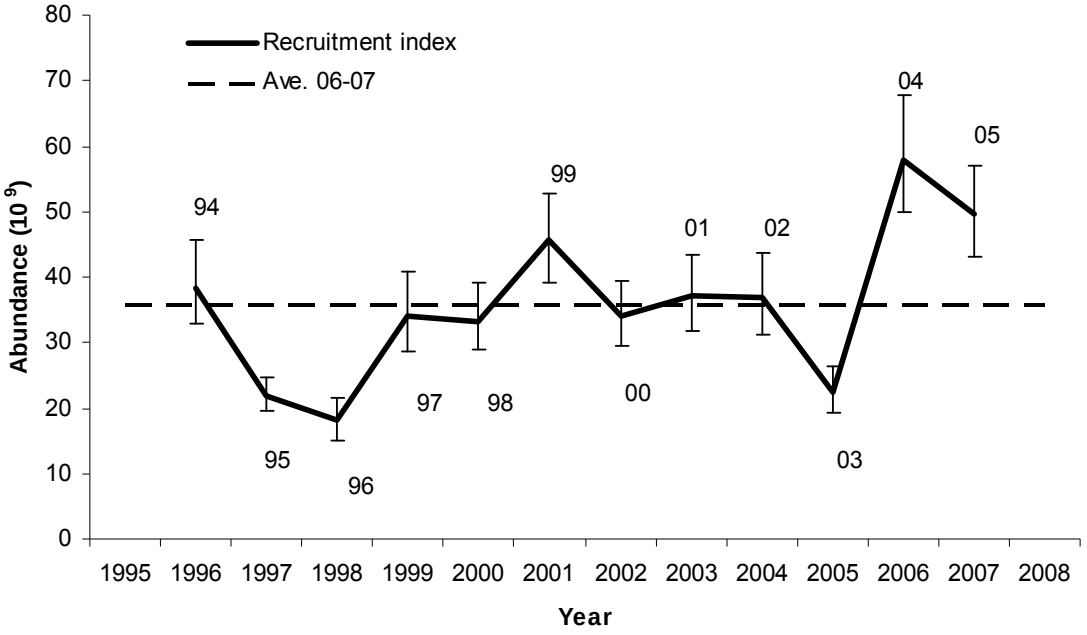


Figure 20. SFA 6 recruitment indices (error bars indicate 95% confidence intervals; numbers denote year-classes).

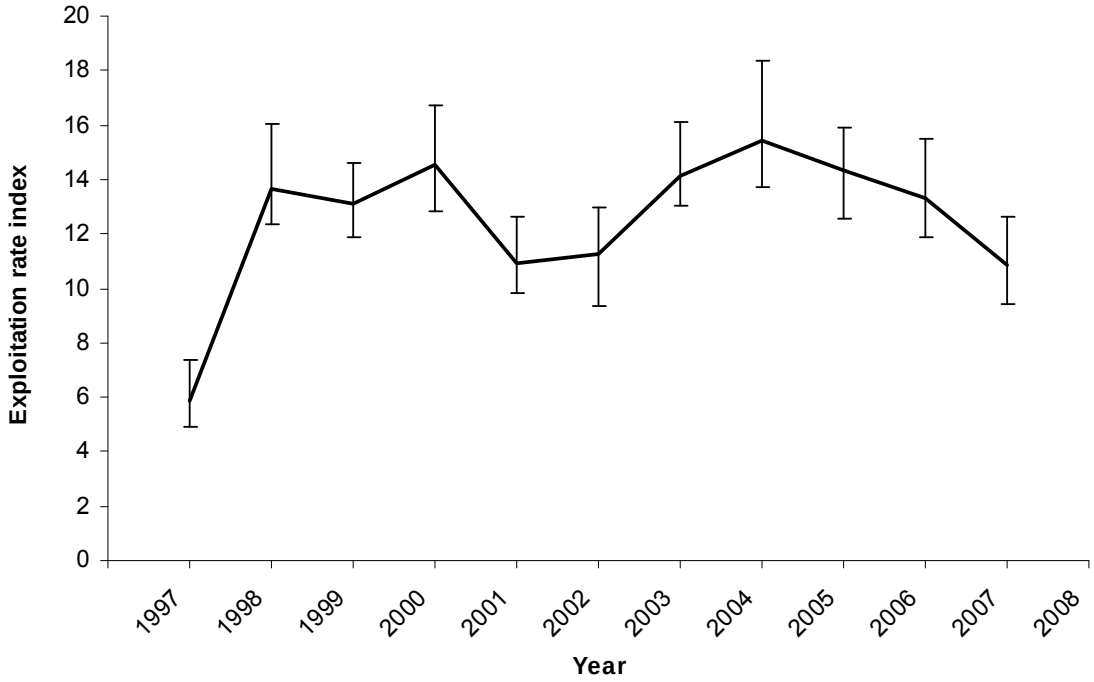


Figure 21. SFA 6 exploitation rate indices (total catch/ fishable biomass index from previous year expressed as a percent; error bars indicate 95% confidence intervals).

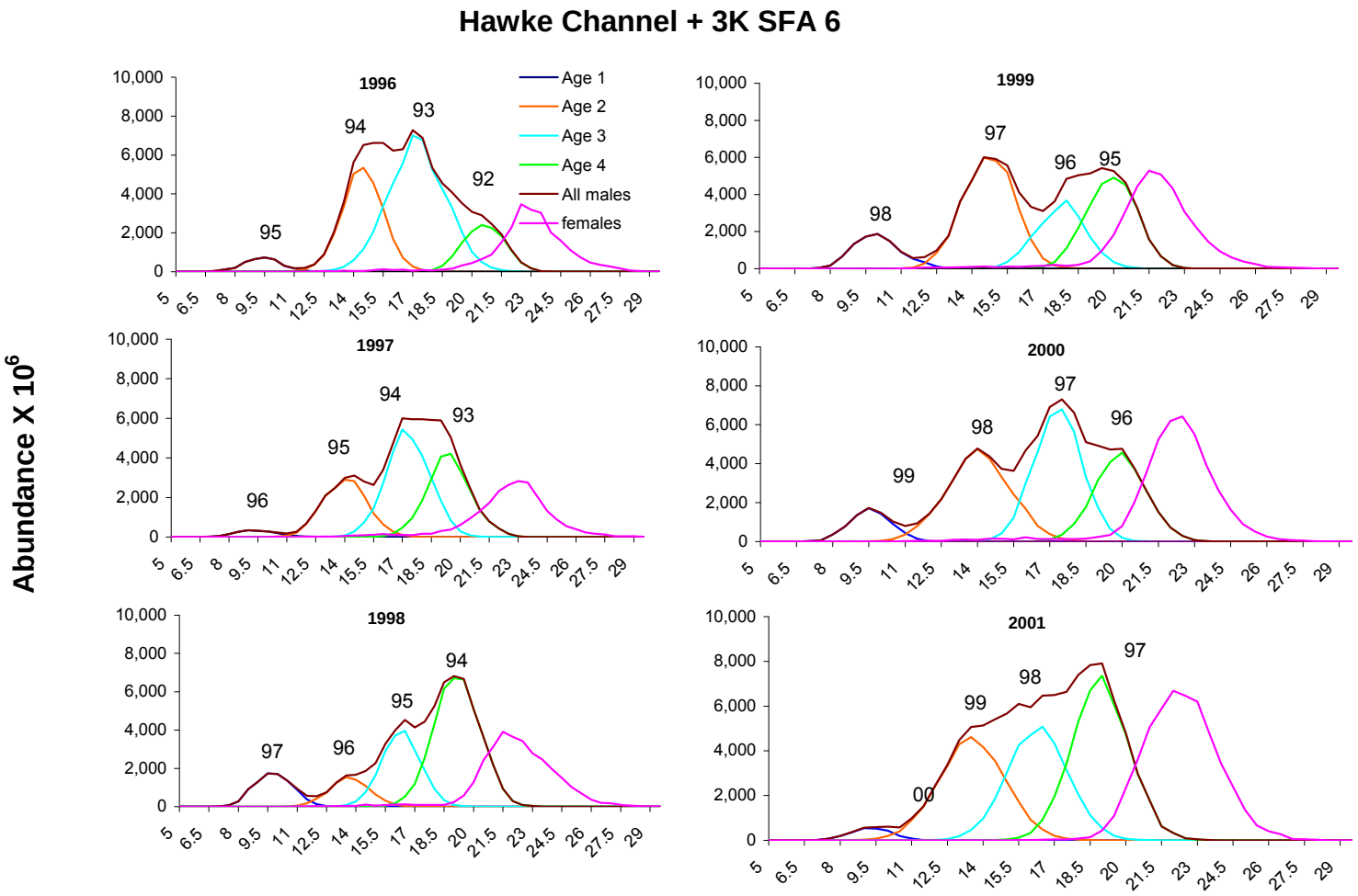


Figure 22. Abundance at length for Hawke Channel + 3K (SFA 6) northern shrimp (*Pandalus borealis*) estimated from OGive MAPped calculations of autumn multi-species bottom trawl survey data, 1996–2007.

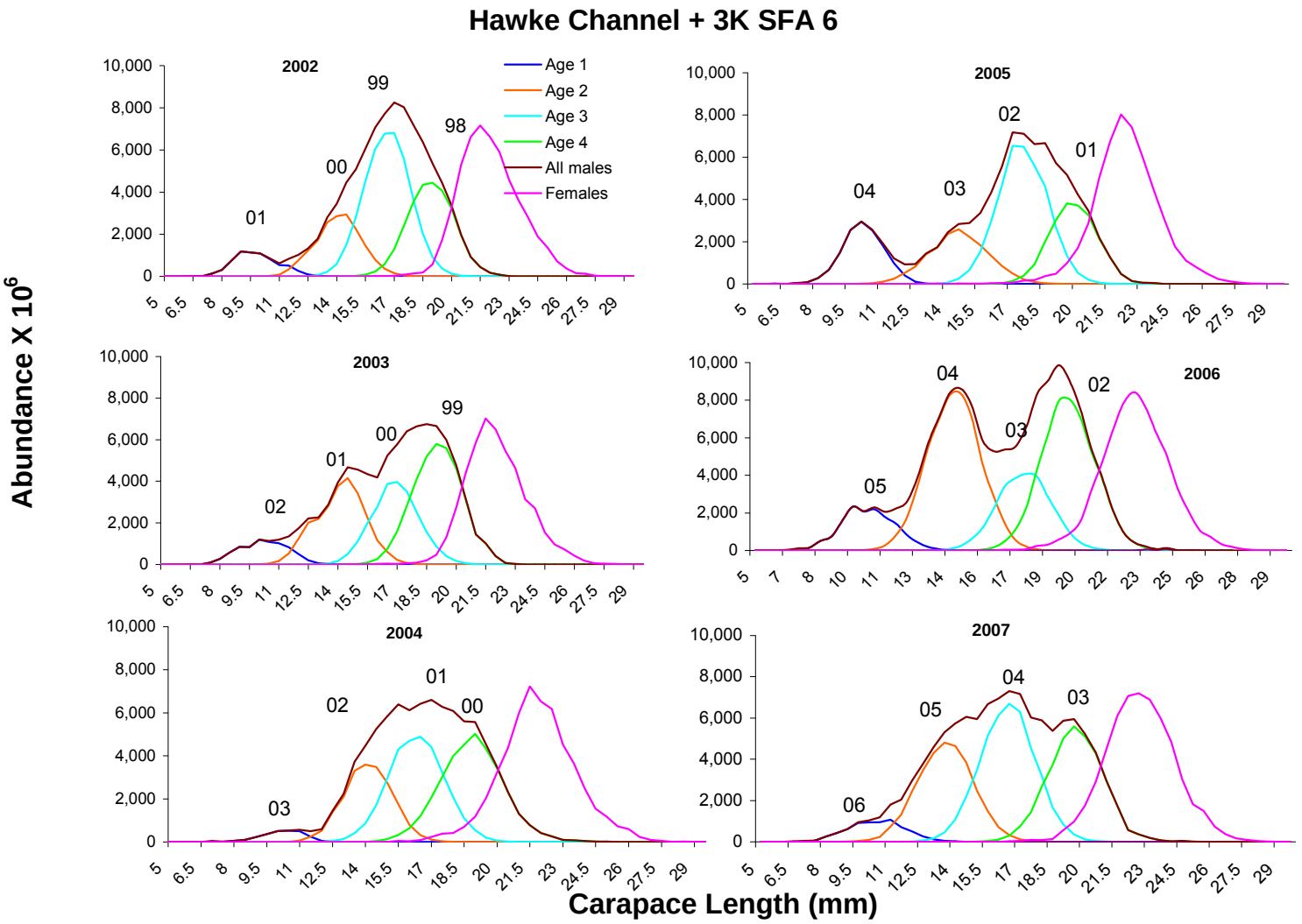


Figure 22. (Continued).

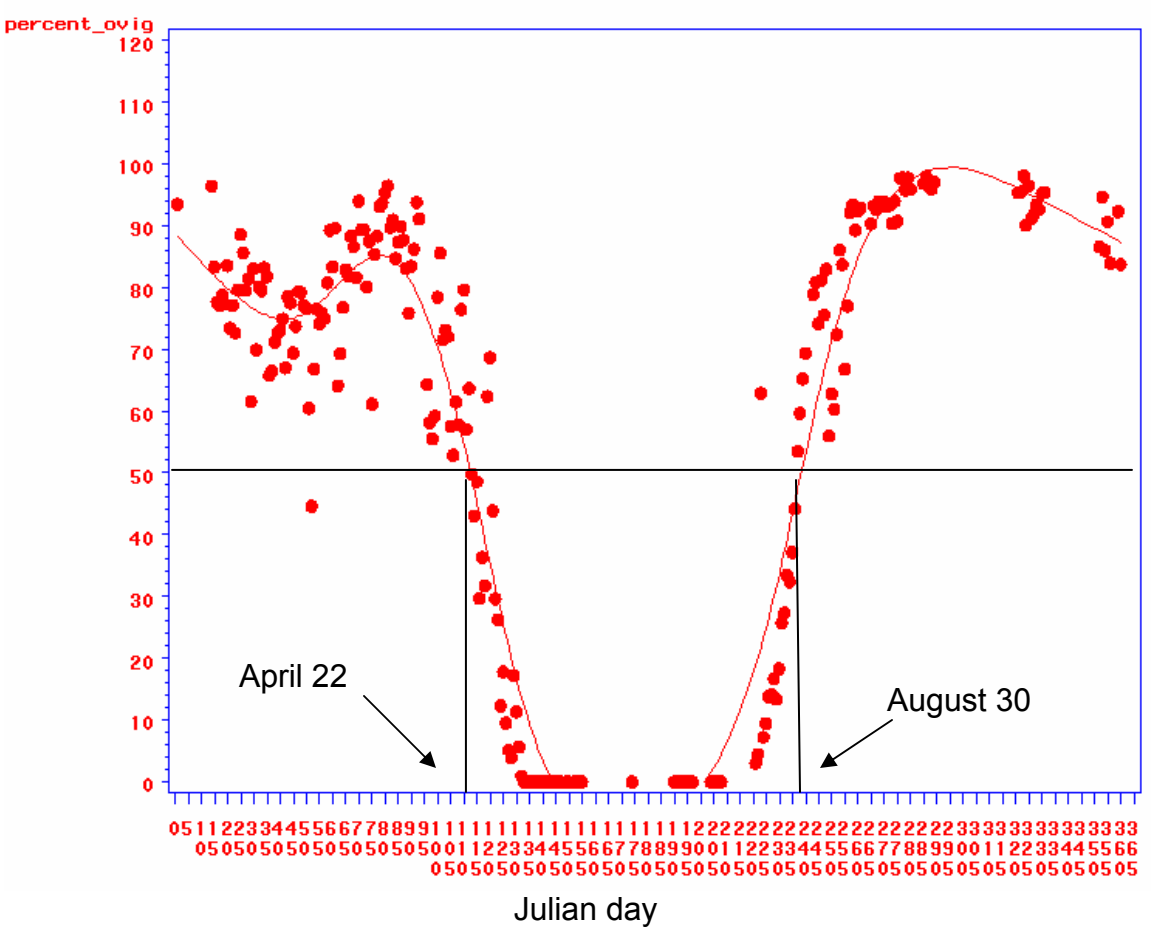
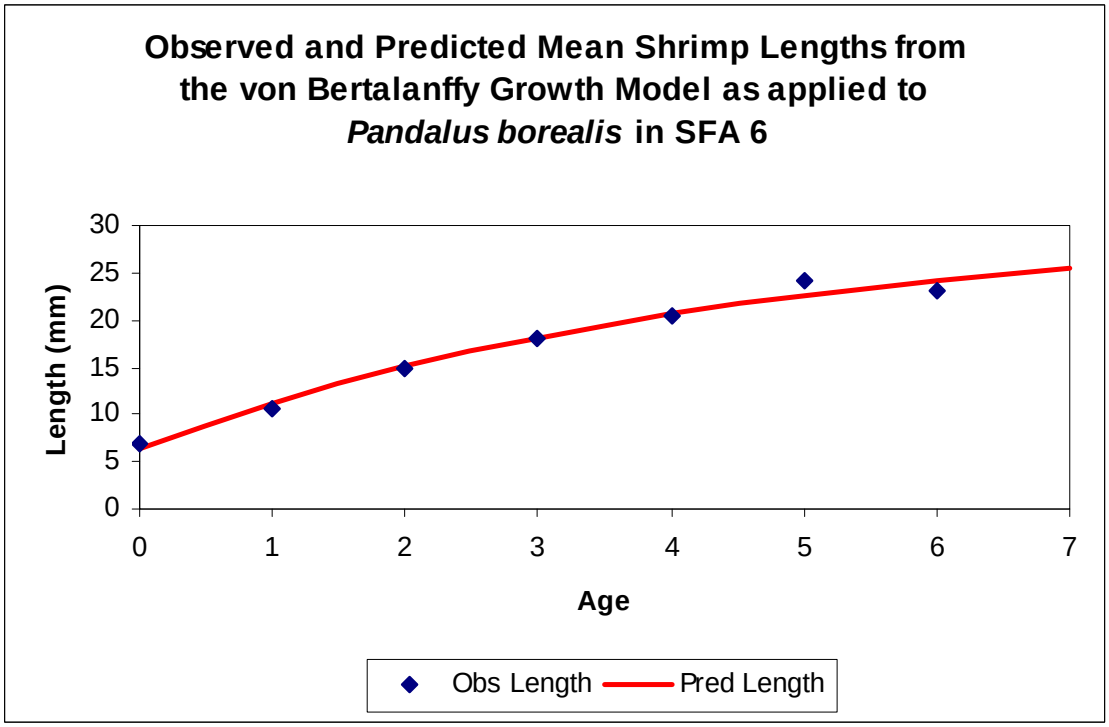


Figure 23. A plot of percent ovigerous females in the SFA 6 shrimp fishery. The 50% marks provided an indication of the resting period between hatch and spawning. The resting period was used as a timeframe for obtaining abundances of primiparous and multiparous females. The number of multiparous females in one year divided by the number of primiparous females in the previous year provided an index of survivorship.



Growth Parameters	
K	0.2187
L_{inf}	30.7986
t_0	-1.0659

Figure 24. A von Bertalanffy growth model was applied to mean length data for Northern Shrimp (*Pandalus borealis*) in SFA 6. The mean length of females was assumed to be that of age 6 shrimp and was taken from 2007 fall survey data. The mean length of age 0 shrimp was taken from 2001 fall survey data.

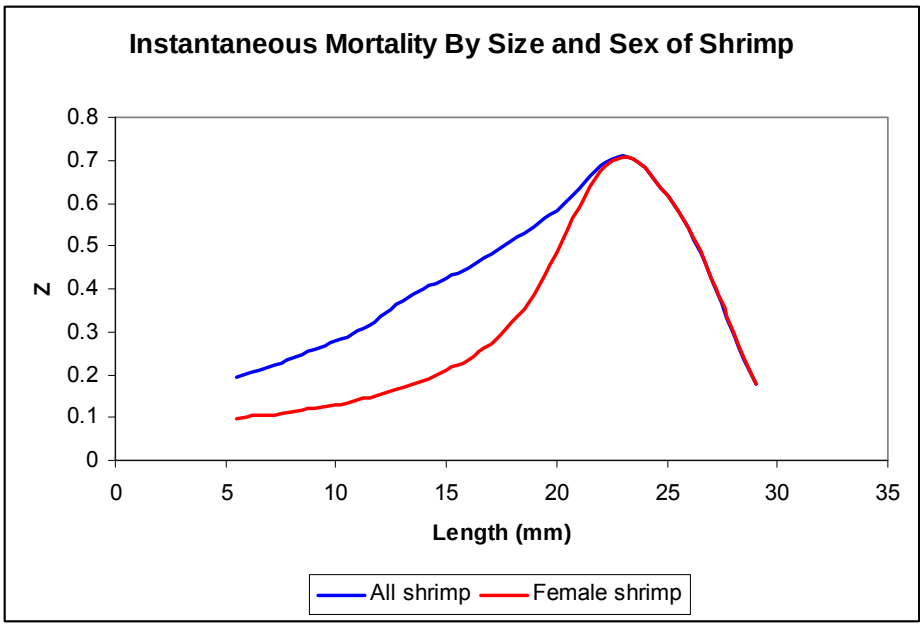


Figure 25. Instantaneous annual mortalities by size for all shrimp and females only, based upon von Bertalanffy growth parameters using the formula $Z = \frac{K(L_\infty - \bar{L})}{\bar{L} - L_c}$. These results were based on data collected from the autumn multi-species research survey data into Hawke Channel + 3K (SFA 6).

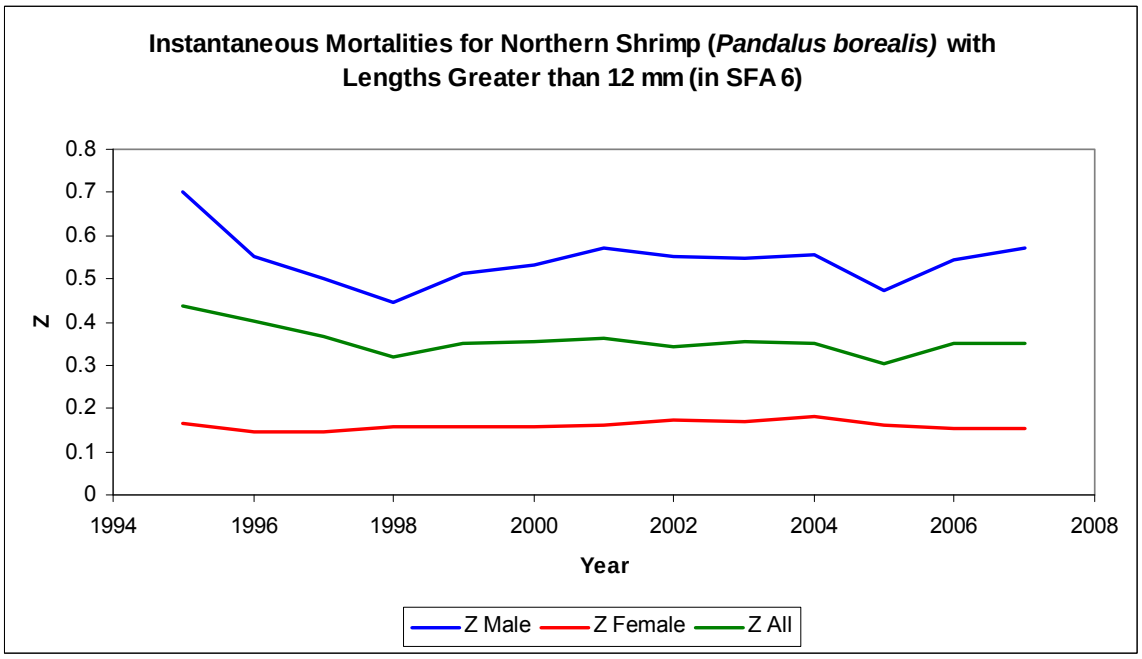


Figure 26. Instantaneous annual mortalities of SFA 6 northern shrimp (*Pandalus borealis*) based upon von Bertalanffy growth parameters.

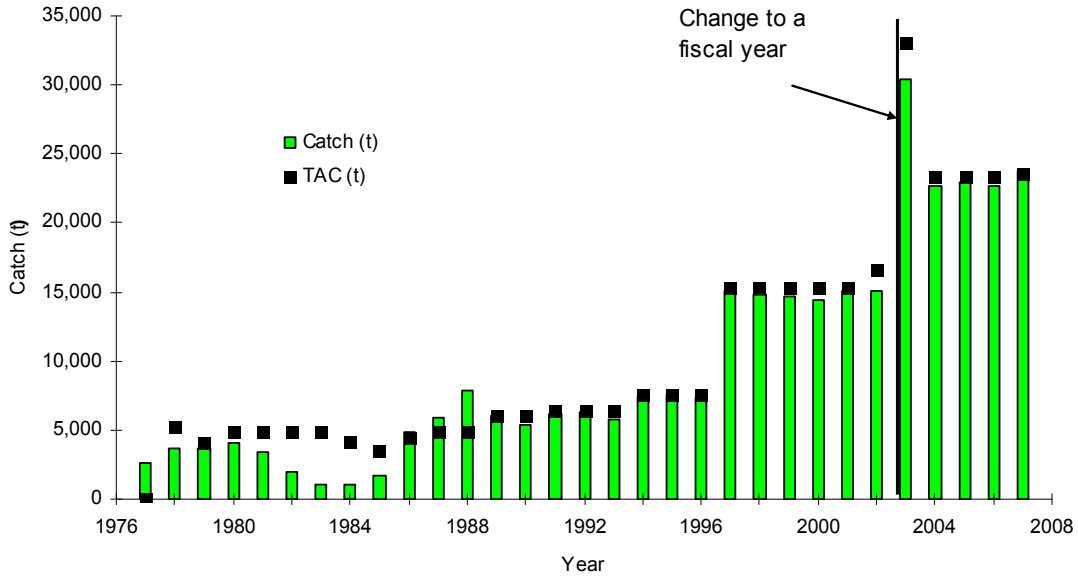


Figure 27. History of SFA 5 quotas and catches, 1977–2007. Note that beginning in 2003, TAC's have been allocated by fiscal year (Apr.1–Mar.31).

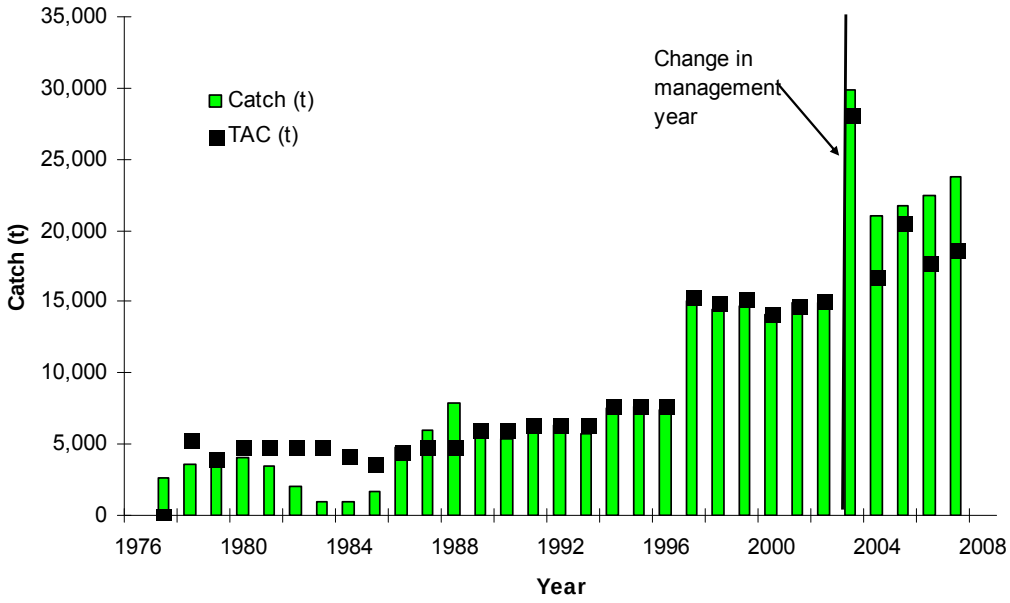


Figure 28. History of SFA 5 large vessel (>500 t) quotas and catches, 1977–2007. Note that beginning in 2003, TAC's have been allocated by fiscal year (Apr.1–Mar.31). This graph takes into account bridging between years as well as quota transfers.

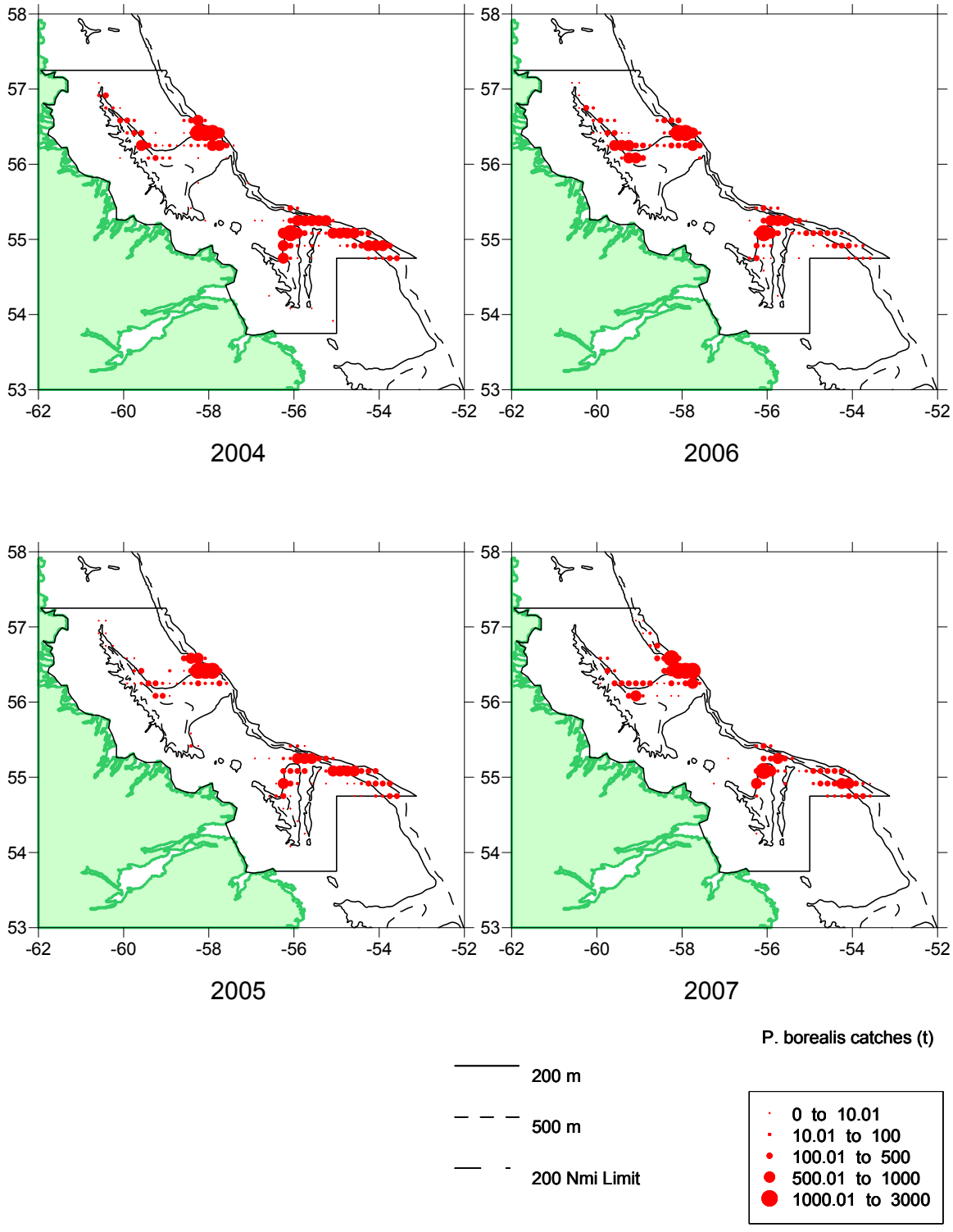


Figure 29. Distribution of large vessel (>500 t) shrimp catches in Hopedale + Cartwright Channels (SFA 5). (Observer data aggregated into 10 min X 10 min cells).

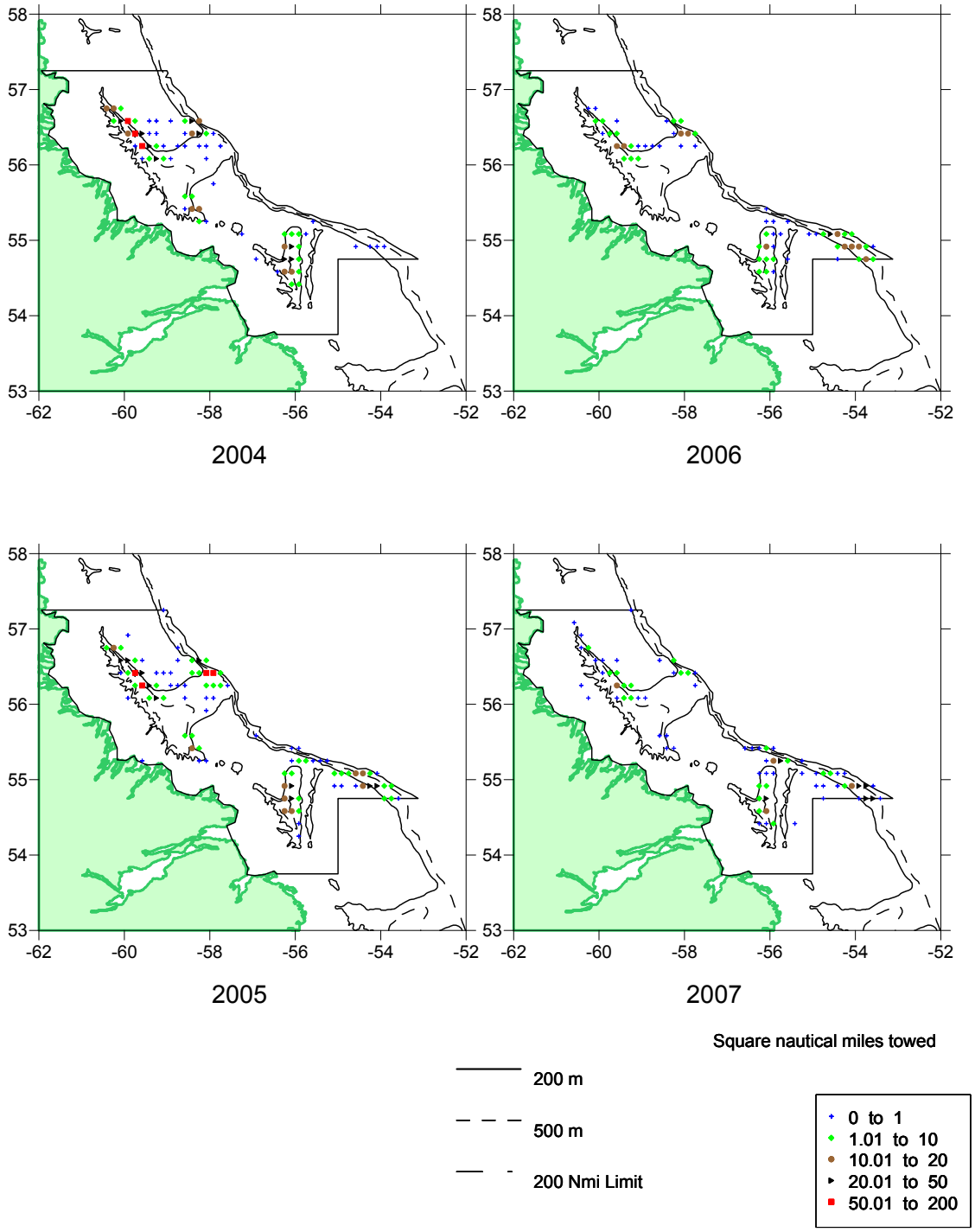


Figure 30. Distribution of large vessel (>500 t) towed areas in Hopedale + Cartwright Channels (SFA 5). (Observer data aggregated into 10 min X 10 min cells).

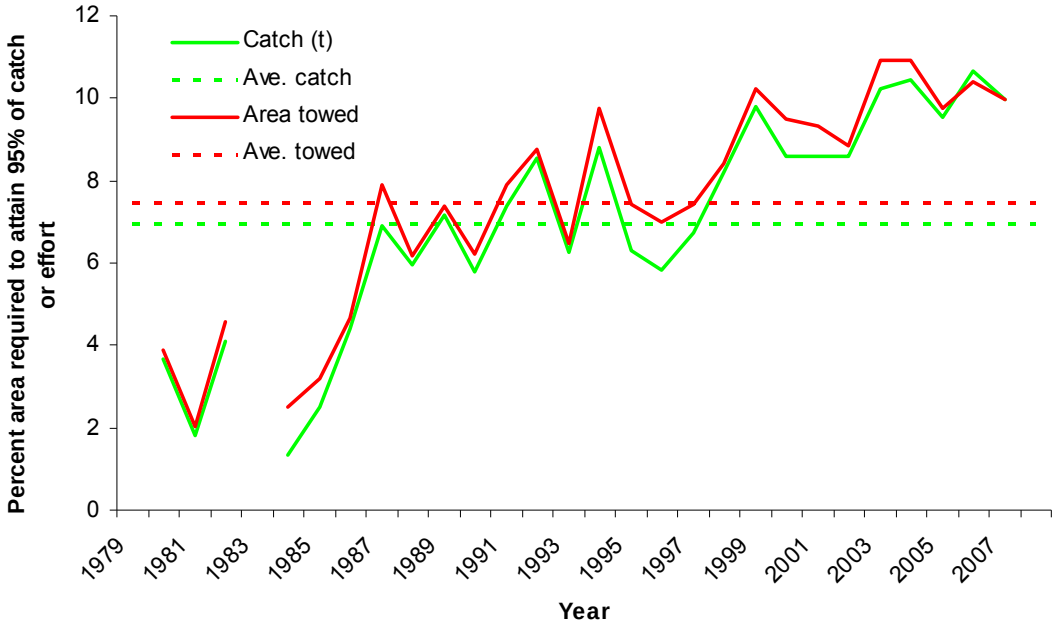


Figure 31. The percent total area within SFA 5 necessary to obtain 95% of the fishery catches as well as 95% of the bottom contact by the large vessel fleet.

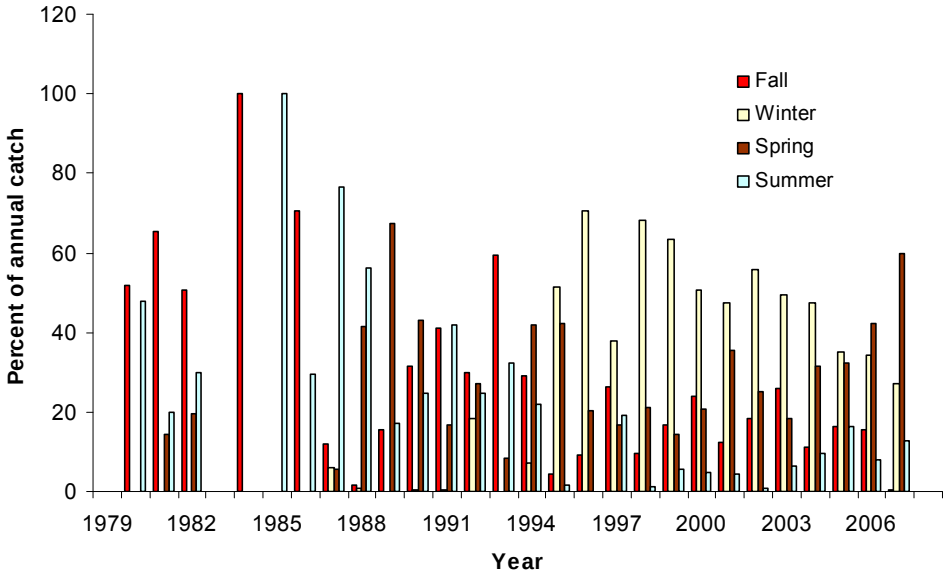


Figure 32. Seasonality of the large vessel (>500 t) shrimp fishery within Hopedale + Cartwright Channels (SFA 5) as determined from percent annual catch by season.

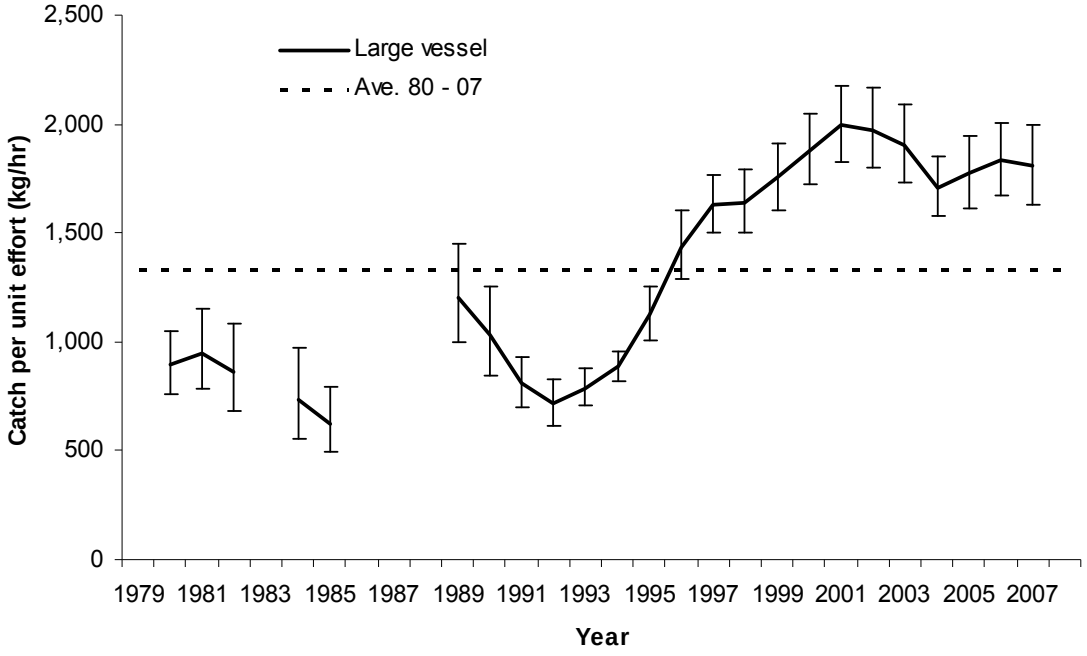


Figure 33. SFA 5 large vessel CPUE (error bars indicate 95% confidence intervals).

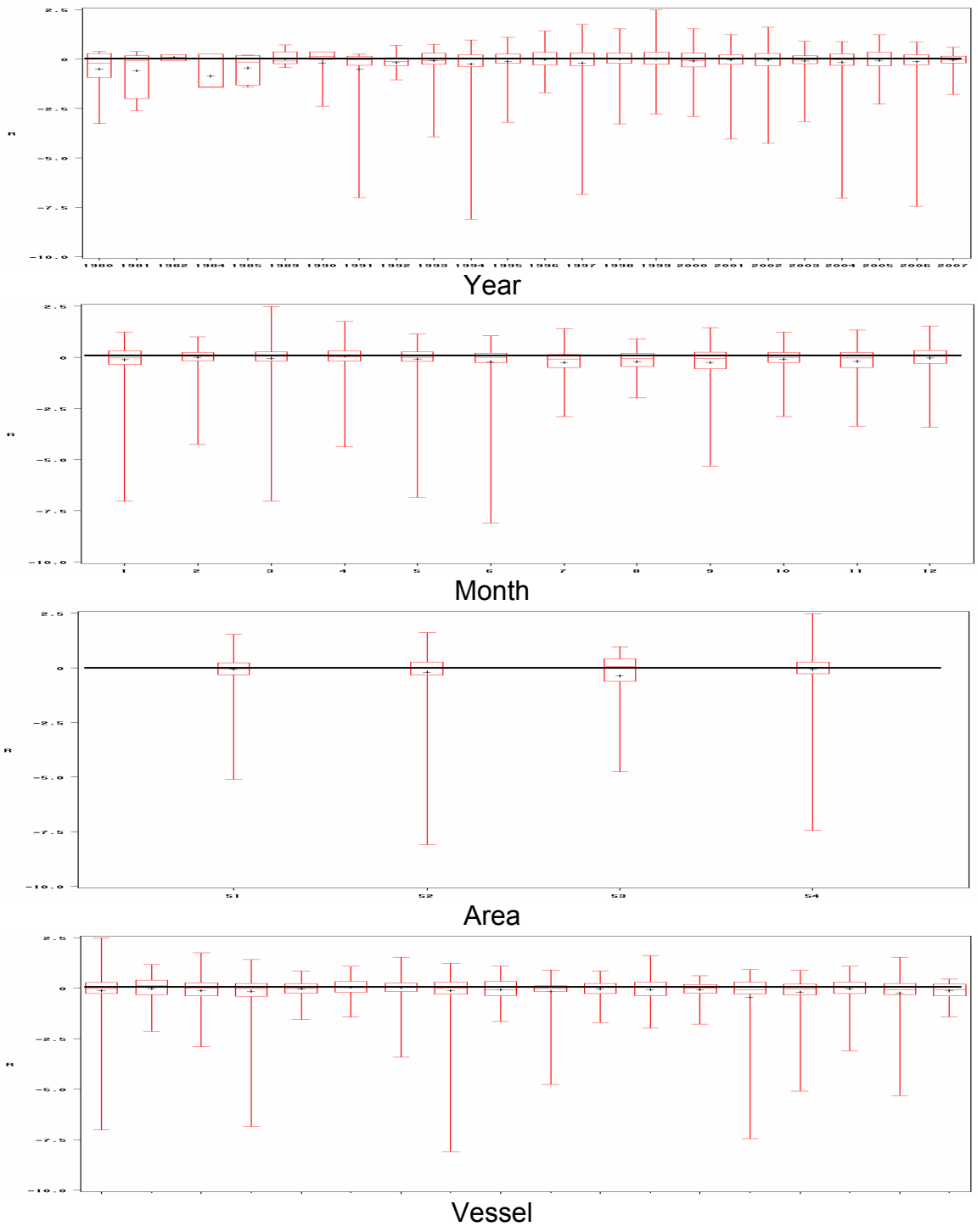


Figure 34. The distribution of residuals around estimated values for parameters used in the large vessel (>500 t) shrimp catch rate model for Hopedale and Cartwright Channels (SFA 5), 1977-2007.

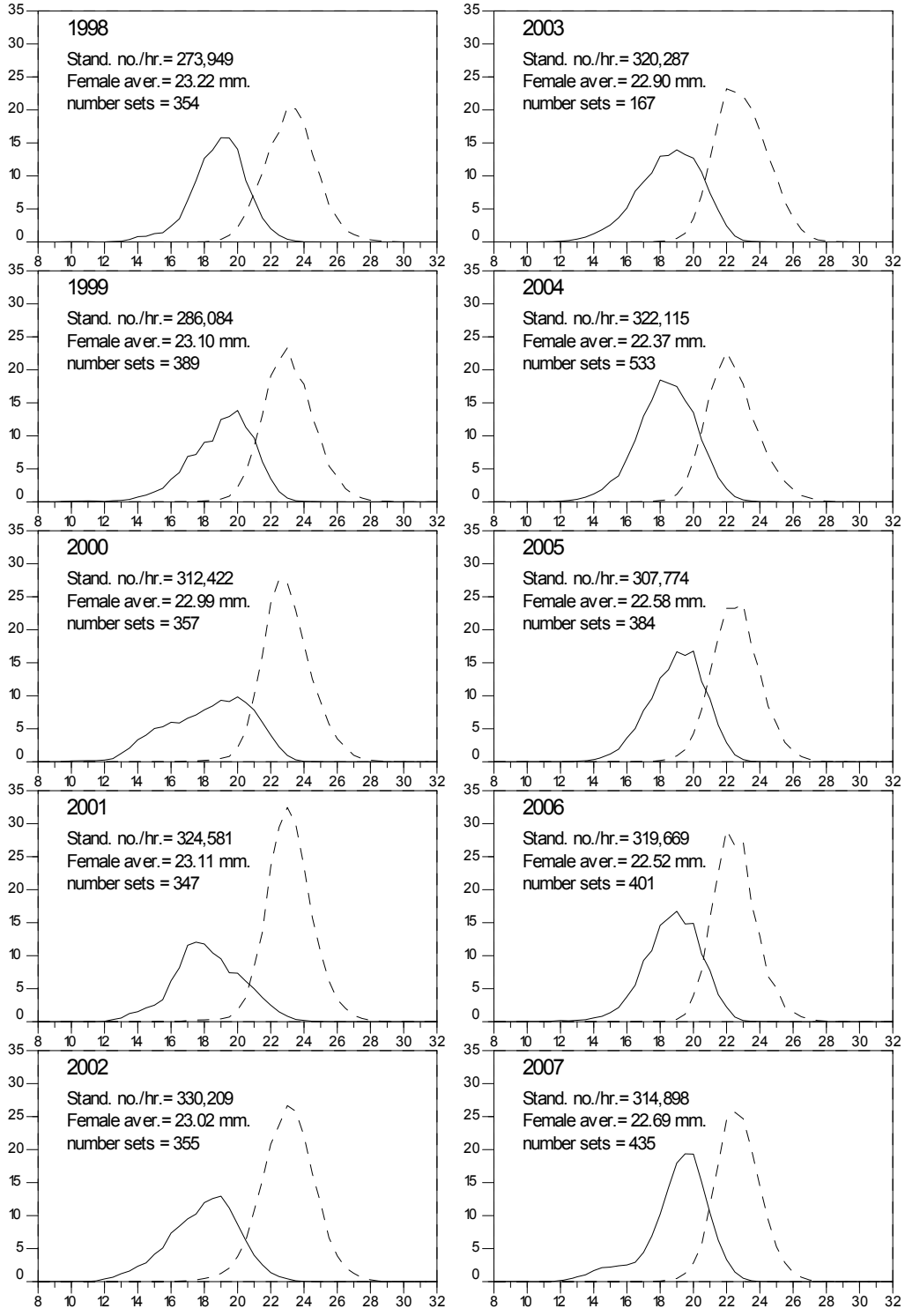


Figure 35. Observed northern shrimp length frequencies (000's per hour) from the Canadian large vessel (>500 t) fleet fishing in Hopedale and Cartwright Channels (SFA 5) over the period 1998–2007. Solid lines = males; dotted lines = females.

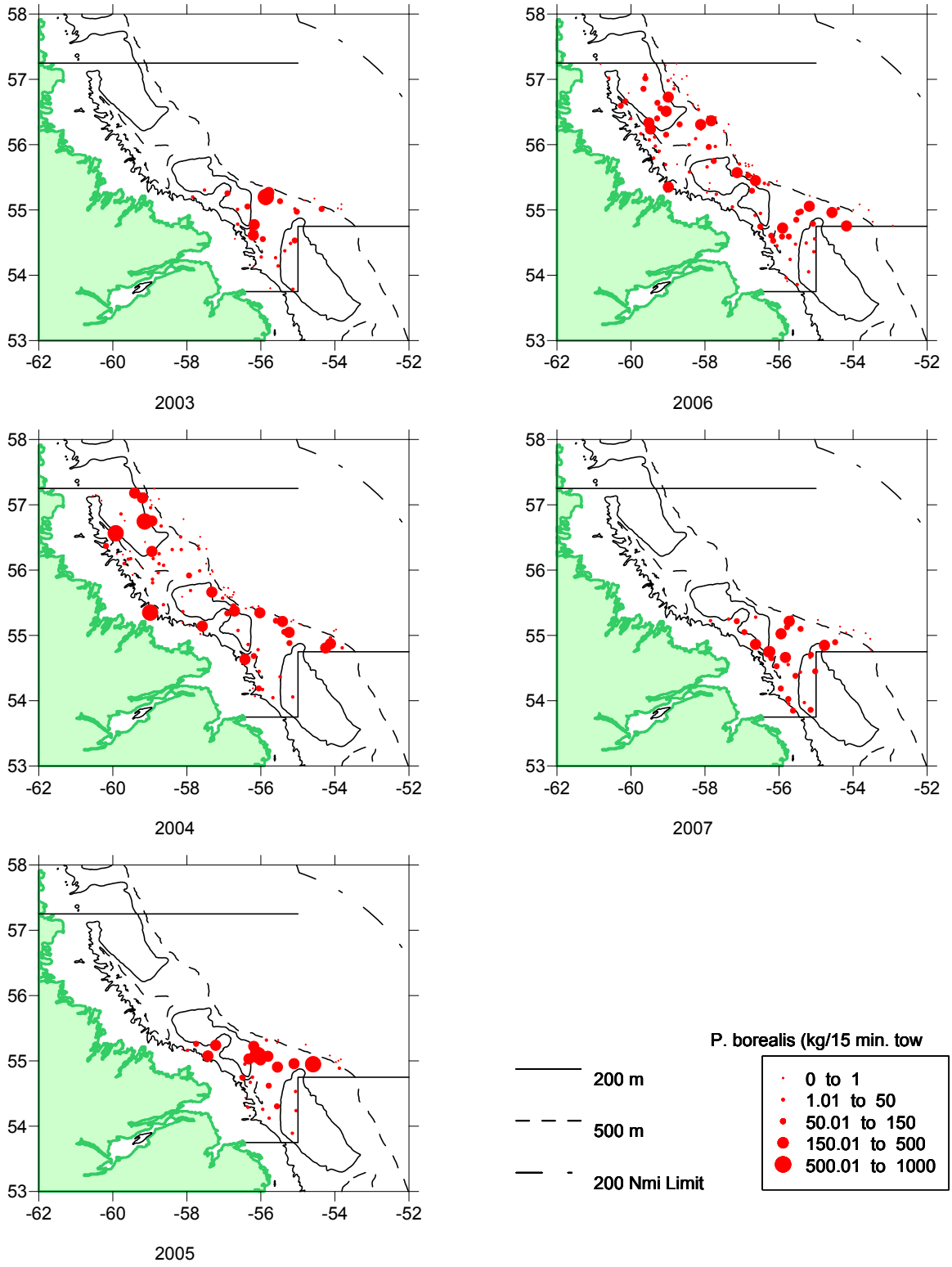
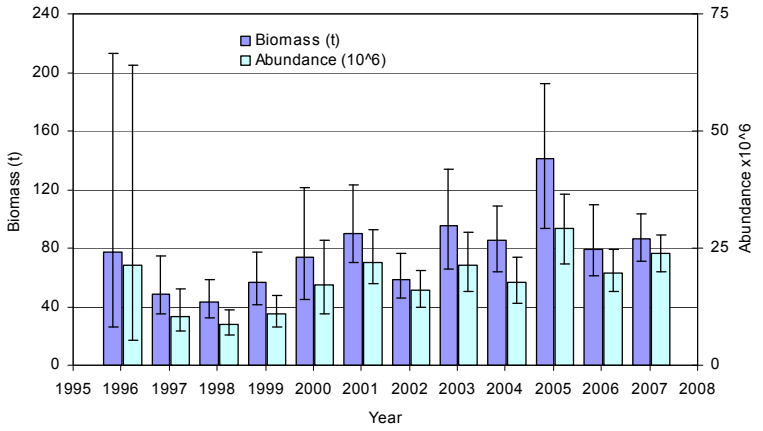
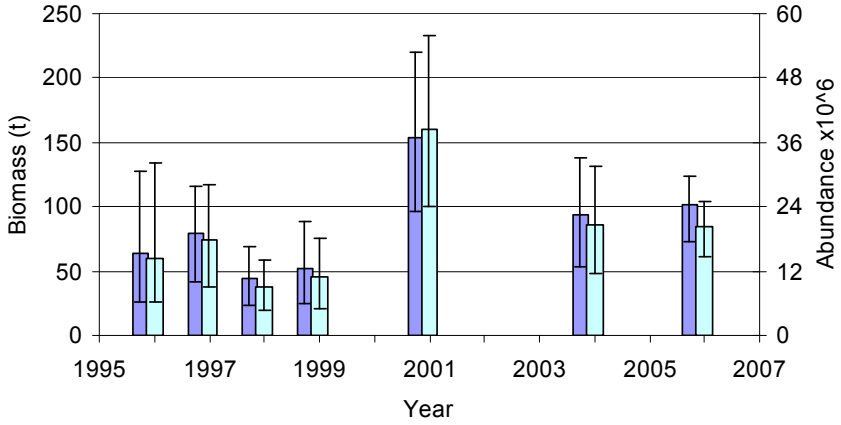


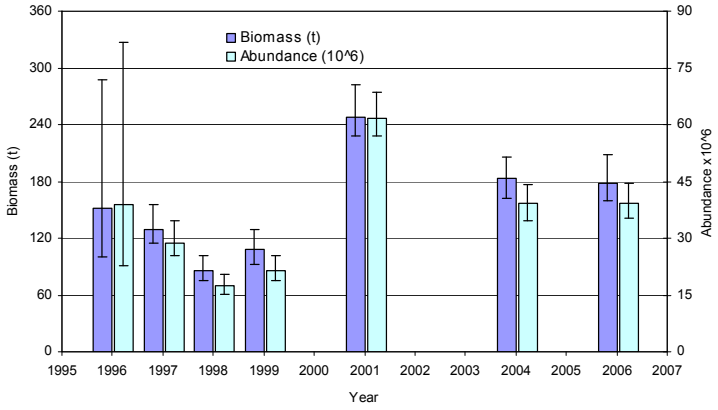
Figure 36. Distribution of Hopedale and Cartwright Channels (SFA 5) Northern Shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from autumn research bottom trawl surveys conducted over the period 2003–2007.



A) Cartwright Channel

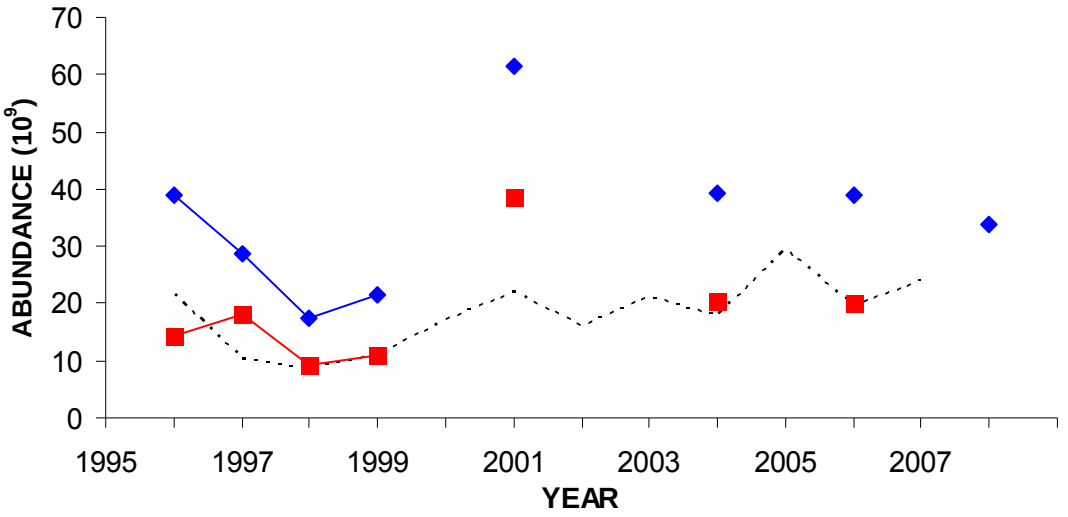


B) Hopedale Channel

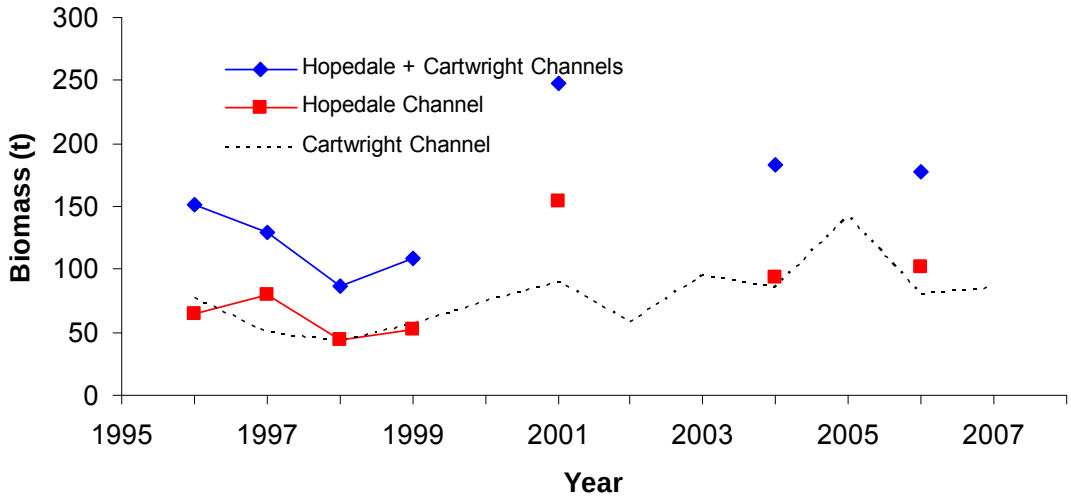


C) Entire SFA 5

Figure 37. Autumn northern shrimp (*Pandalus borealis*) biomass and abundance indices within Hopedale + Cartwright Channels (SFA5), as determined using OGive MAPped calculations. Data were from the annual Canadian multi-species bottom trawl surveys using Campelen 1800 shrimp trawl.

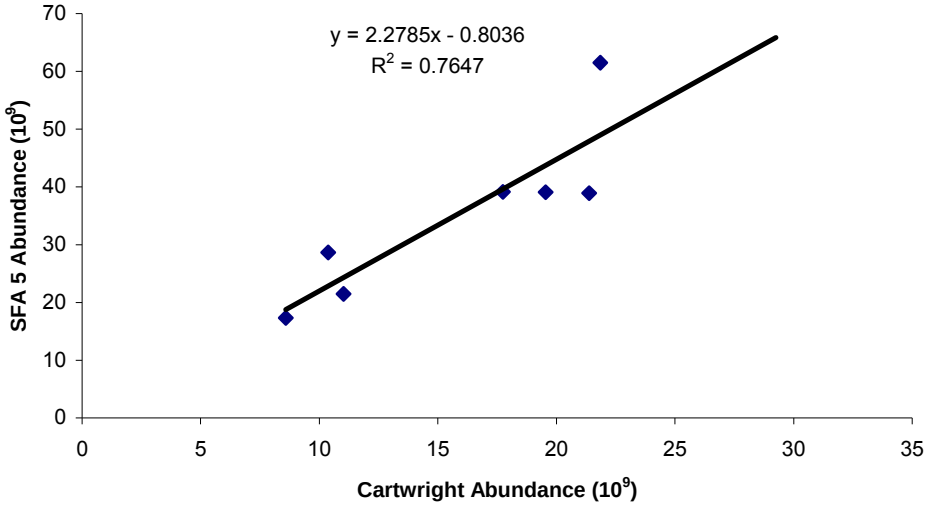


A) Abundance

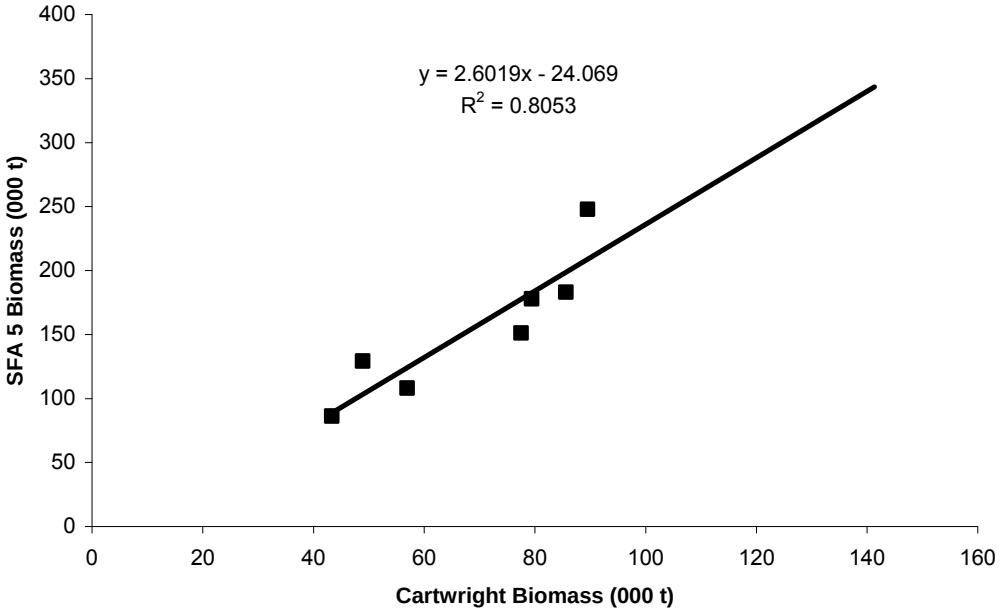


B) Biomass

Figure 38. Overlays of Cartwright Channel abundance and biomass indices with those from Hopedale Channel and the entire of SFA 5 with the goal of determining whether Cartwright Channel indices can be used as proxy indices for the entire of SFA 5.

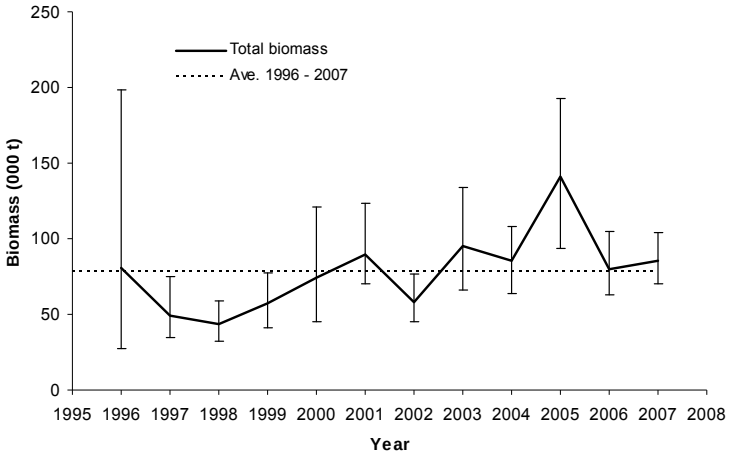


A) Abundance

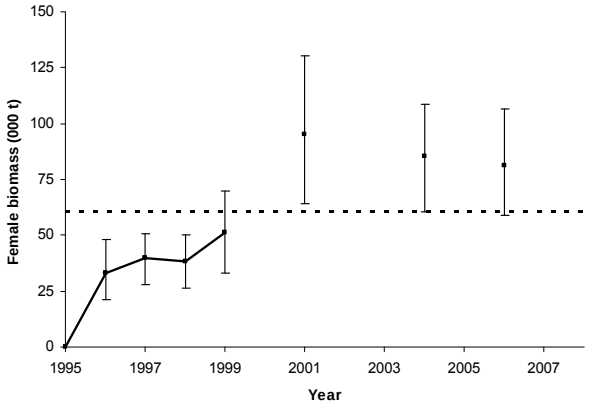


B) Biomass

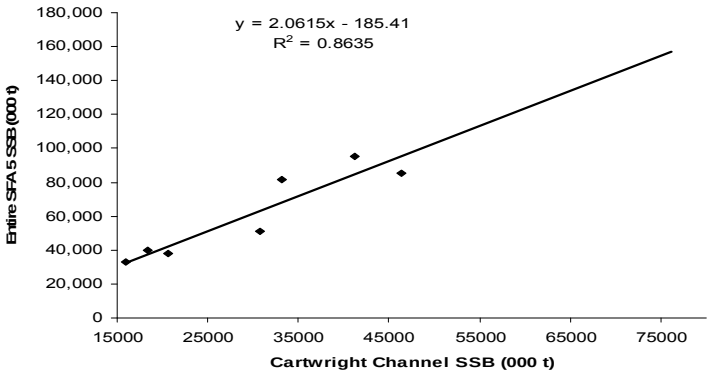
Figure 39. Preliminary relationships between Cartwright Channel abundance and biomass indices with the respective indices for the entire of SFA 5.



A) Cartwright Channel

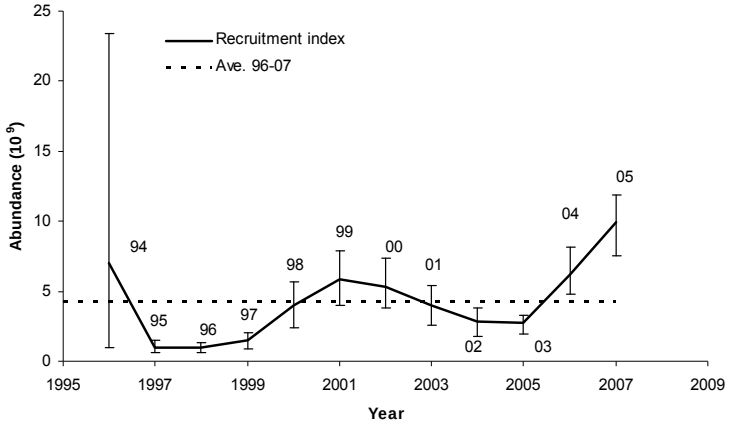


B) Entire SFA 5

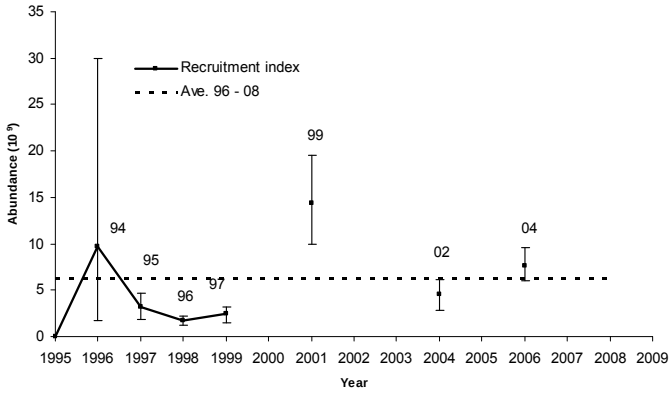


C) SFA 5 vs Cartwright Channel relationship

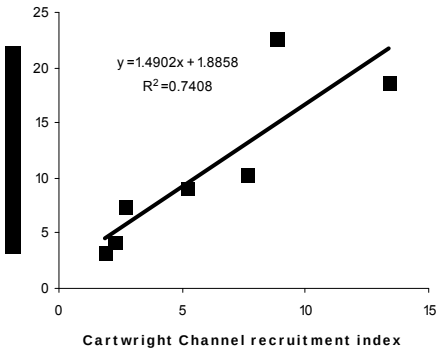
Figure 40. Cartwright Channels (A) and SFA 5 (b) female spawning stock biomass (t) as estimated using Ogmap calculations from autumn multi-species bottom trawl surveys. (C) presents Cartwright Channel and SFA 5 female spawning stock biomass female spawning stock relationship.



A) Cartwright Channel

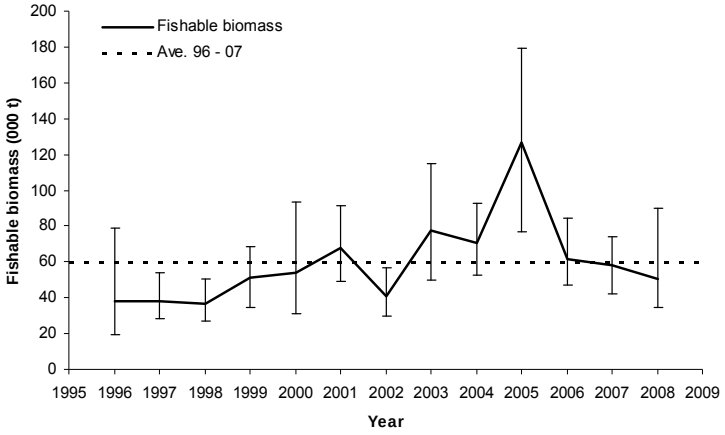


B) SFA 5

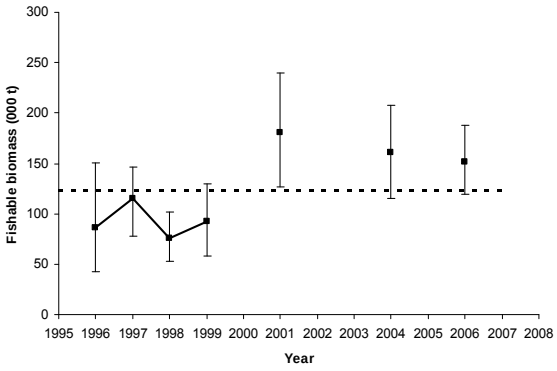


C) SFA 5 vs Cartwright Channel relationship

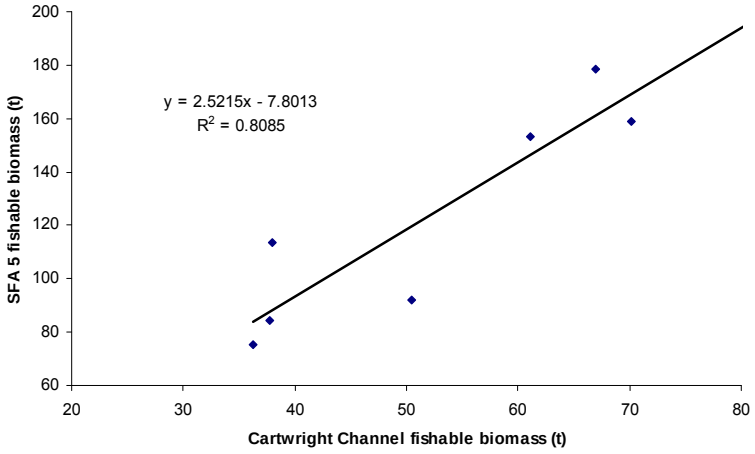
Figure 41. Cartwright Channels (A) and SFA 5 (b) recruitment index (abundances of males with 11.5–17 mm carapace lengths.as estimated using Ogmap calculations from autumn multi-species bottom trawl surveys. (C) presents Cartwright Channel and SFA 5 recruitment indices relationship. The numbers within graphs A and B indicate year-class.



A) Cartwright Channel



B) SFA 5



C) SFA 5 vs Cartwright Channel relationship

Figure 42. Cartwright Channels (A) and SFA 5 (B) fishable biomass index (biomass of males with17 mm carapace lengths + biomass of all females) as estimated using Ogmap calculations from autumn multi-species bottom trawl surveys. (C) presents Cartwright Channel and SFA 5 fishable biomass indices relationship.

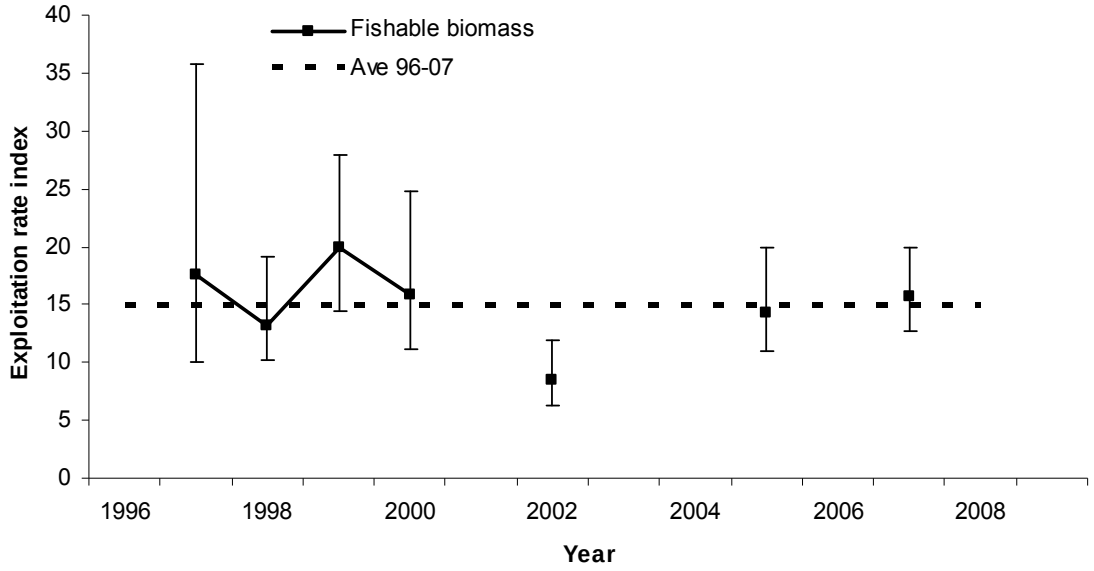


Figure 43. SFA 5 exploitation rate indices over the period 1996–2007(total catch/fishable biomass index from the previous year; error bars indicate 95% confidence intervals).

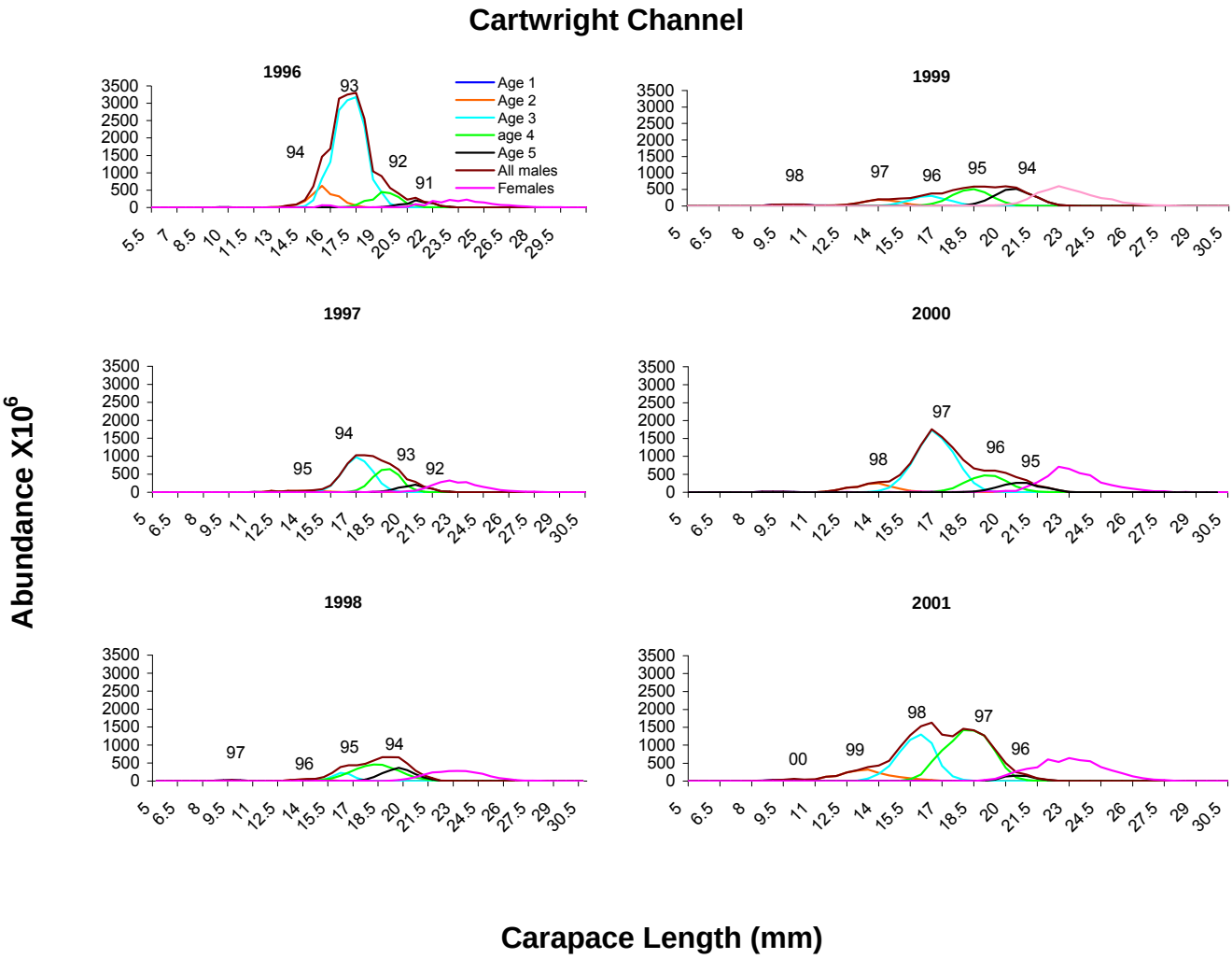


Figure 44. Abundance at length for Cartwright Channel (SFA 5) northern shrimp (*Pandalus borealis*) estimated using Ogmap calculations of autumn multi-species bottom trawl survey data, 1996–2007.

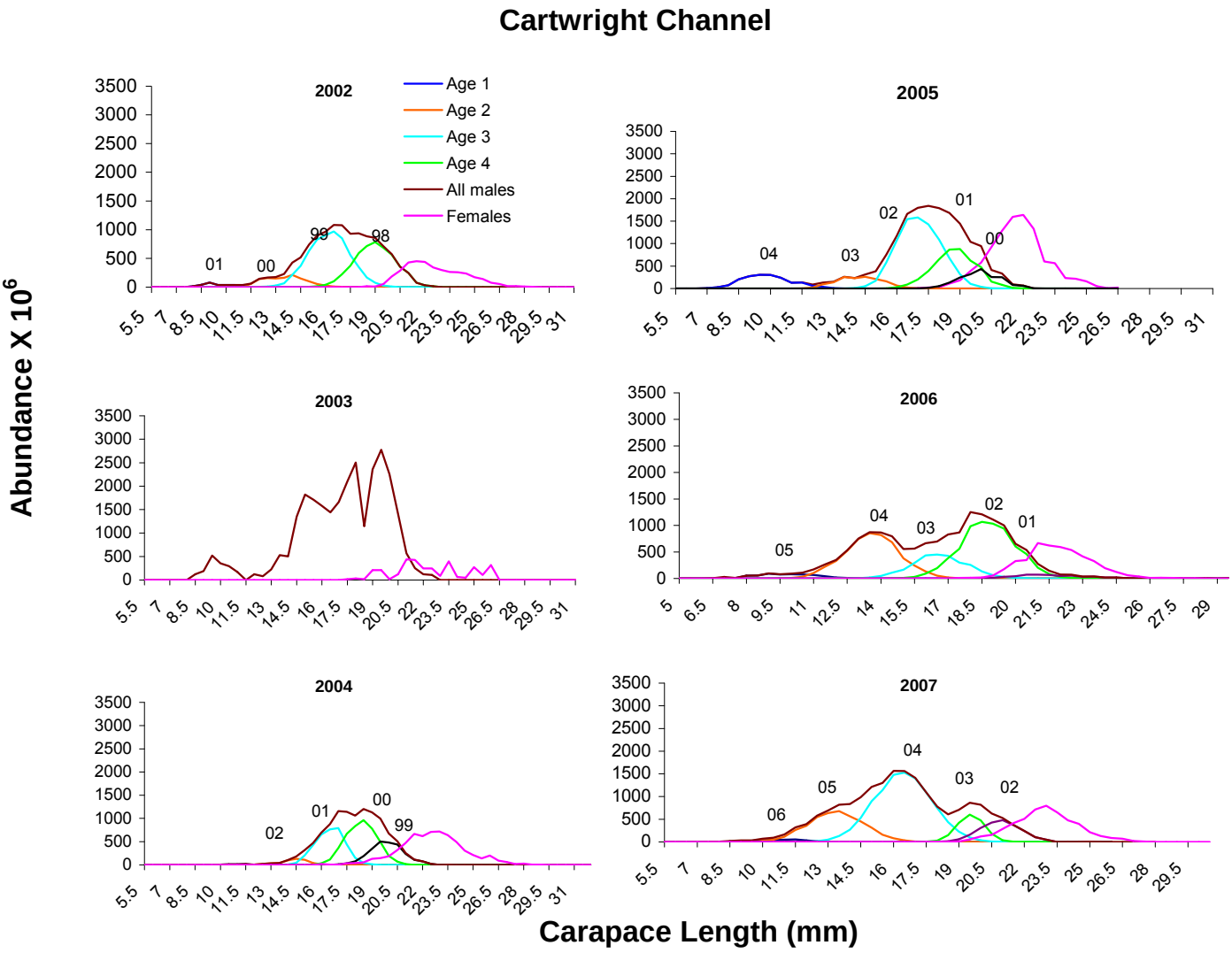


Figure 44. (Cont'd.)

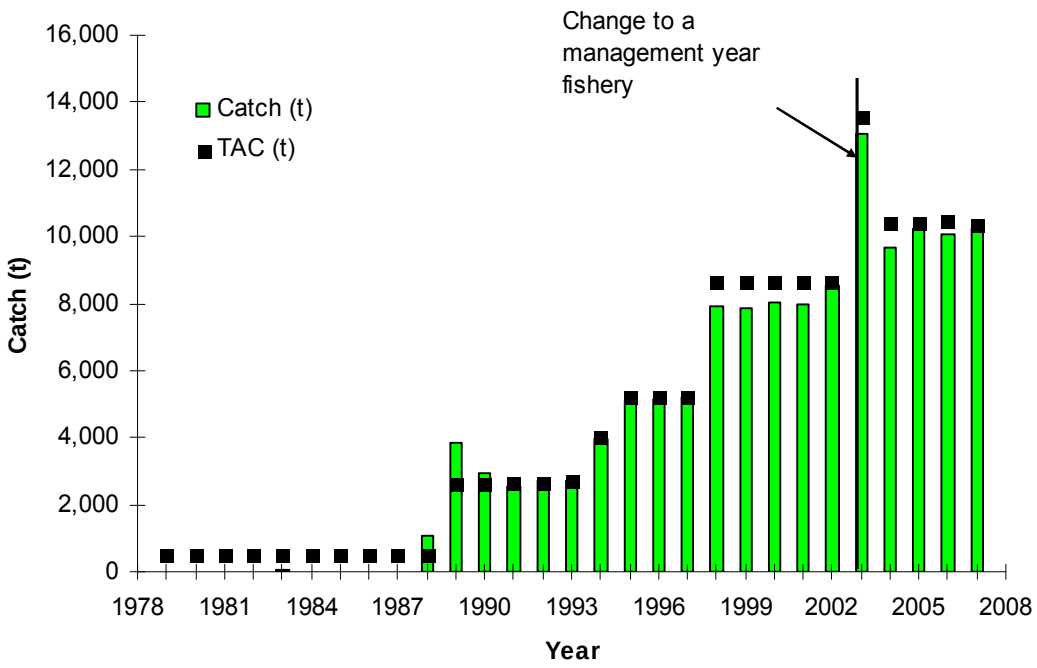


Figure 45. Historic northern shrimp catches and TAC's in NAFO Division 2G (SFA 4) for the period 1978–2007. Note that beginning in 2003, TAC's have been allocated by fiscal year (Apr.1–Mar.31).

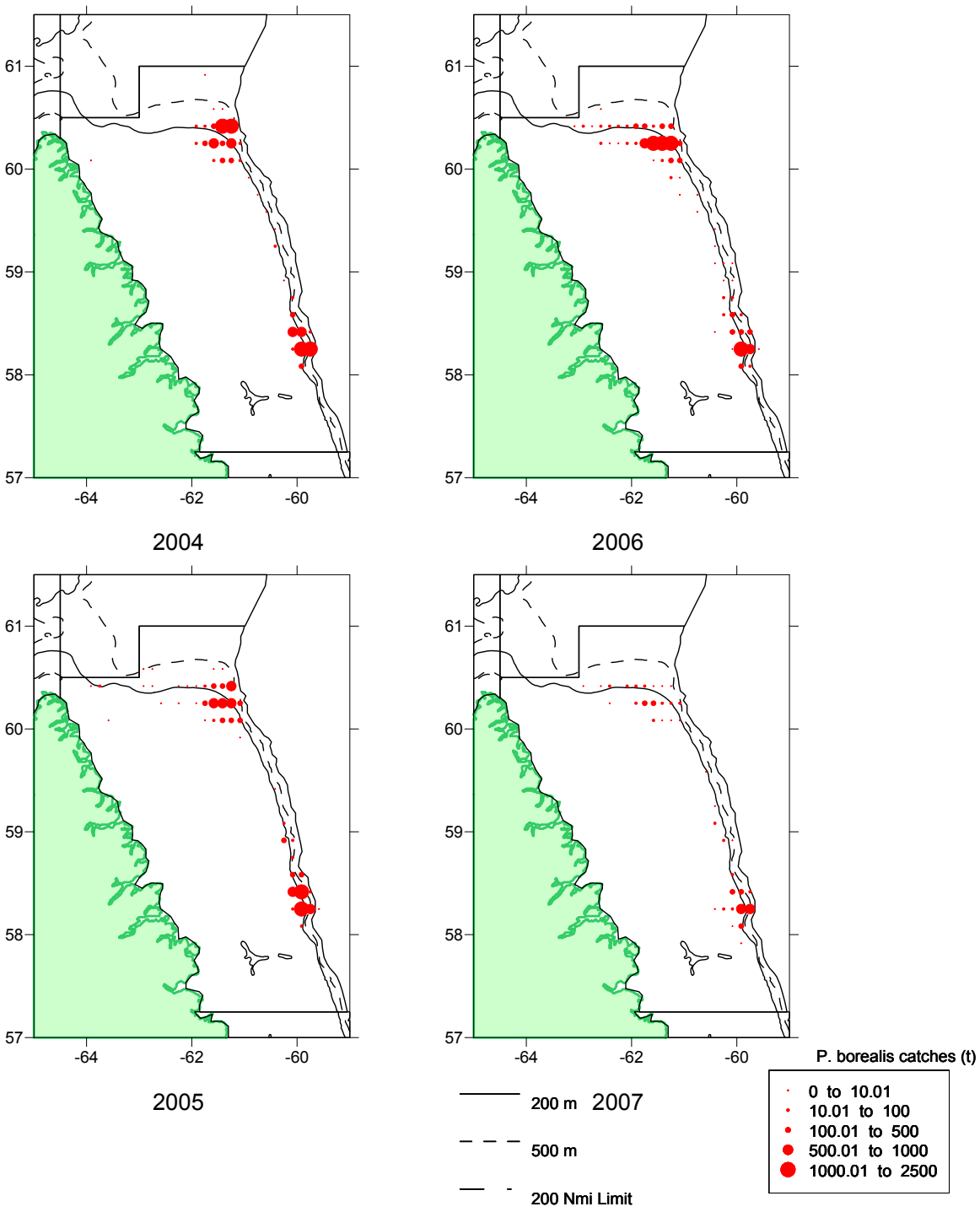


Figure 46. Distribution of large vessel (>500 t) shrimp catches in NAFO Division 2G (SFA 4). (Observer data aggregated into 10 min X 10 min cells).

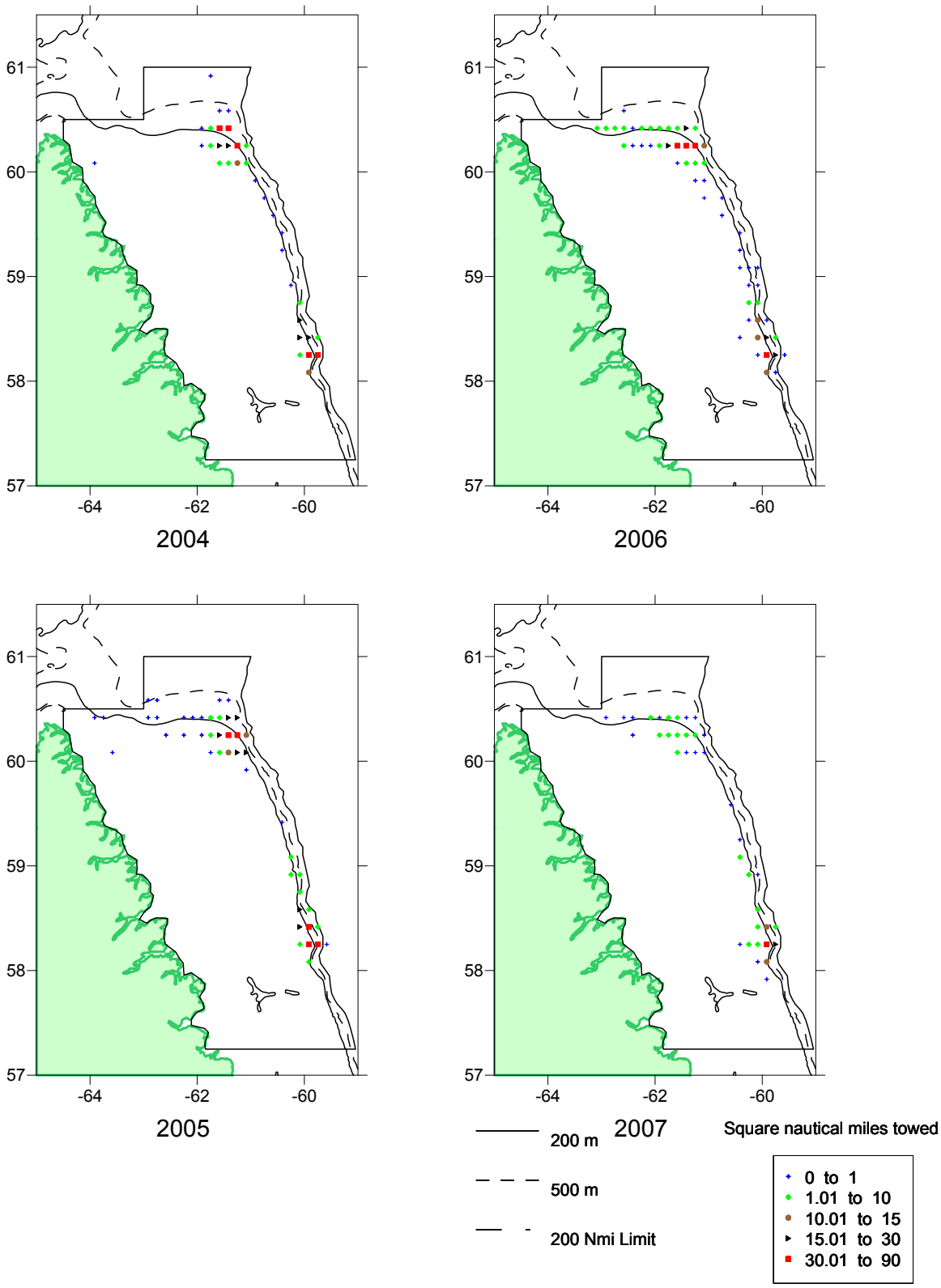


Figure 47. Distribution of large vessel (>500 t) towed areas in NAFO Division 2G (SFA 4). (Observer data aggregated into 10 min X 10 min cells).

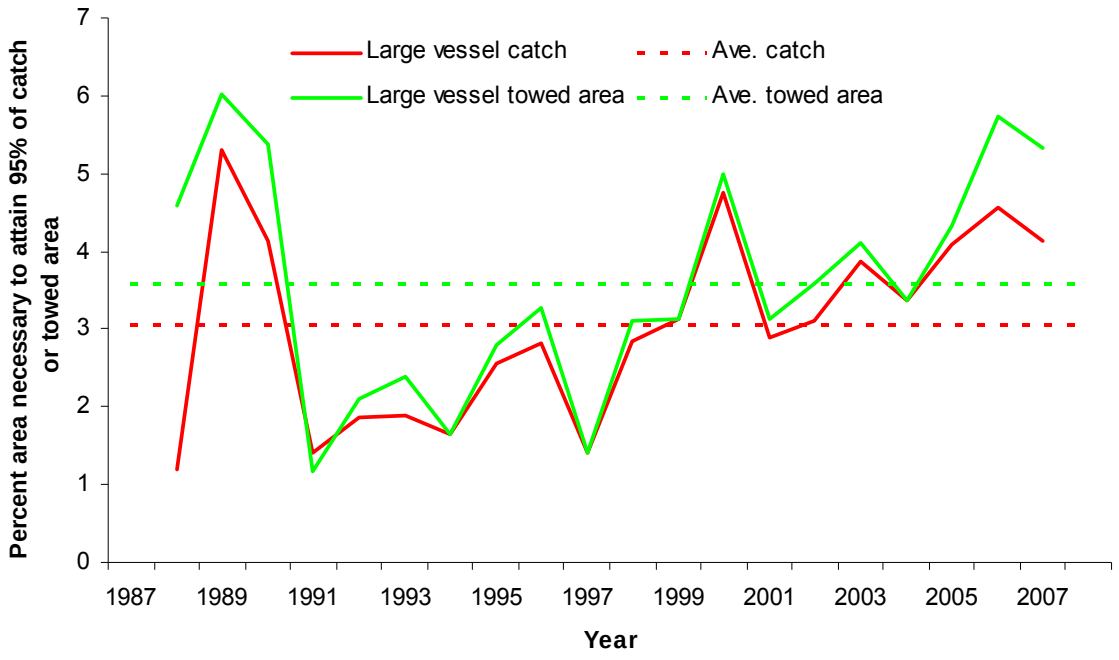


Figure 48. The percent total area within SFA 4 necessary to obtain 95% of fishery catches as well as 95% of the bottom contact by the large vessel fleet.

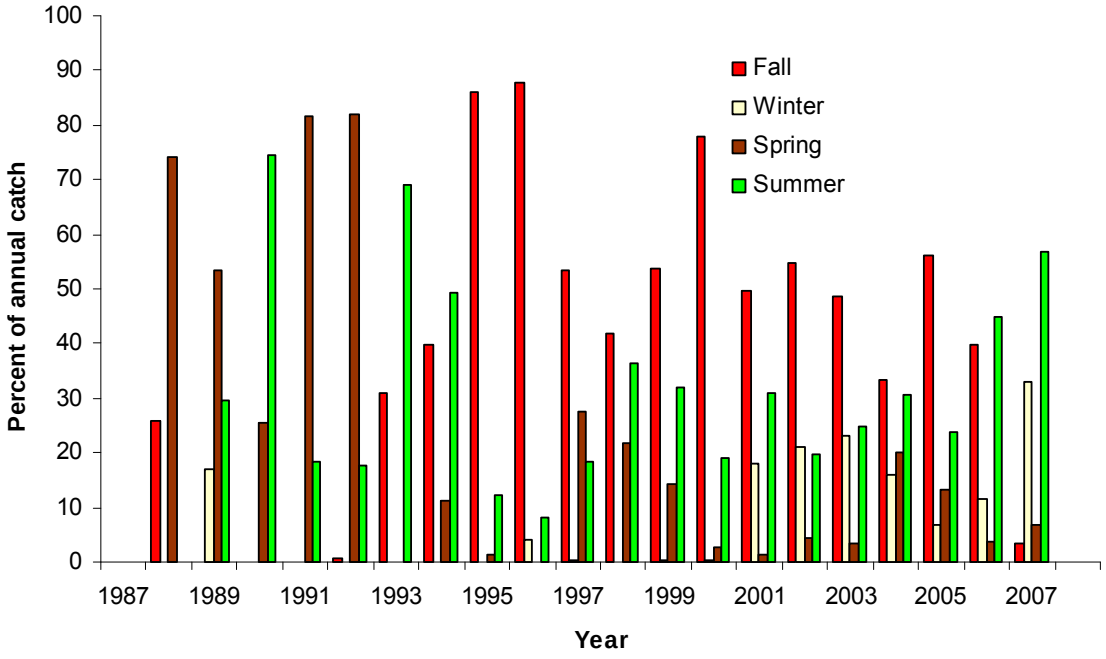


Figure 49. Seasonality of the large vessel (>500 t) shrimp fishery within NAFO Division 2G (SFA 4) as determined from percent annual catch by season.

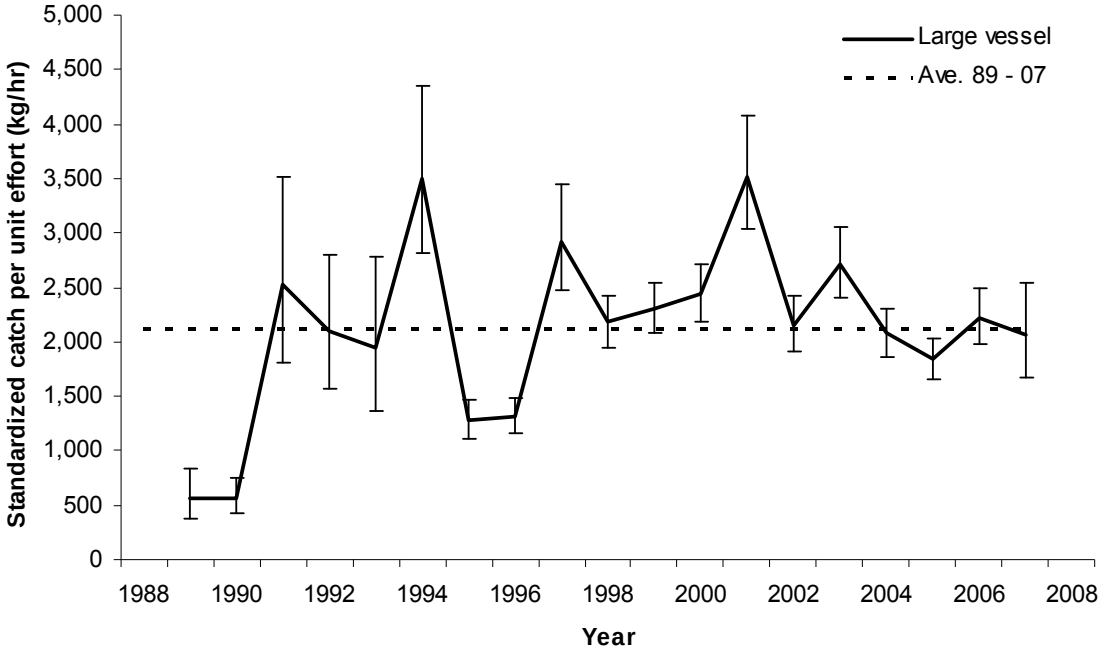


Figure 50. SFA 4 large vessel CPUE (error bars indicate 95% confidence intervals).

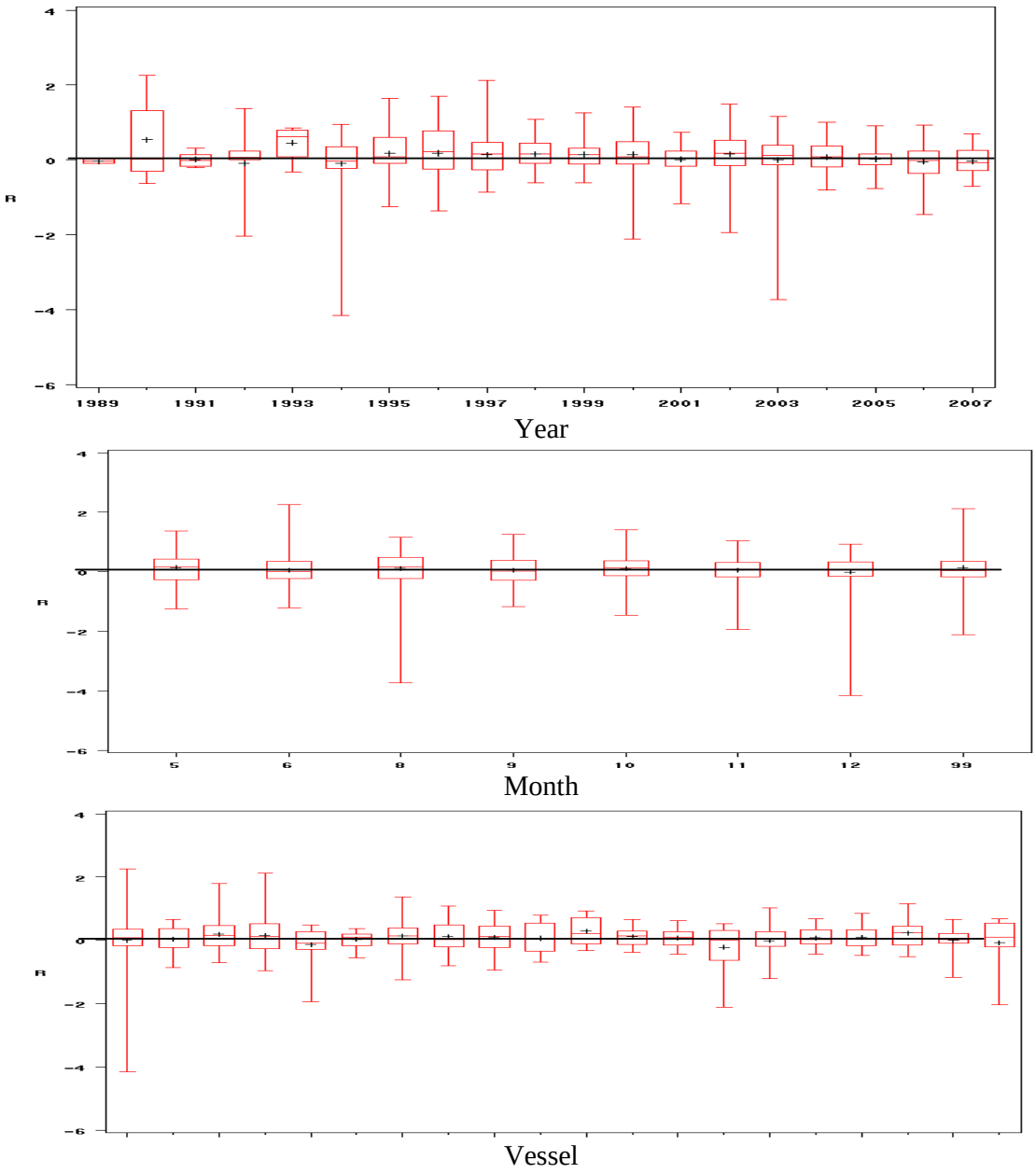


Figure 51. The distribution of residuals around estimated values for parameters used to model large vessel (>500 t) SFA 4 shrimp catch rates, 1989–2007.

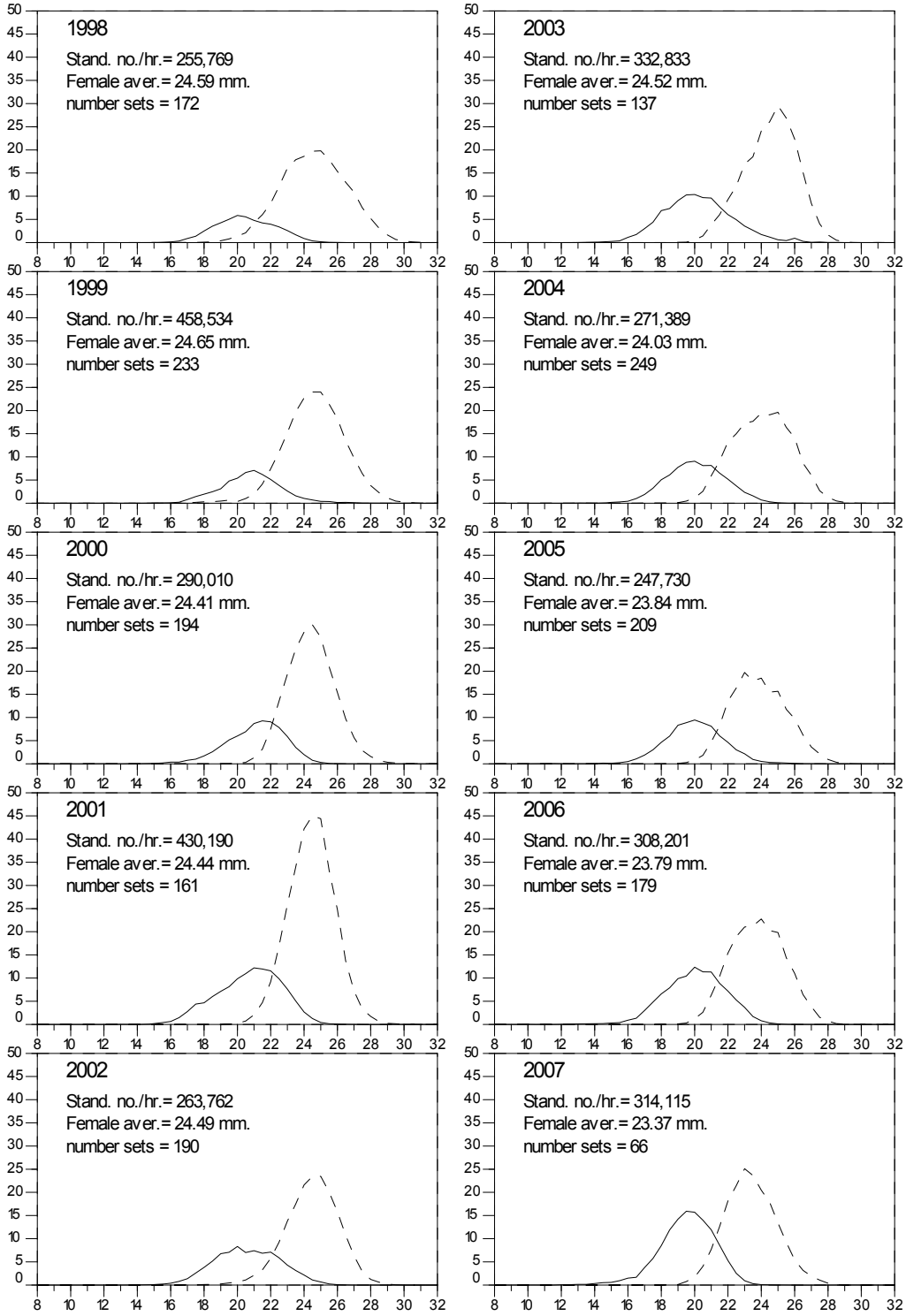


Figure 52. Observed northern shrimp length frequencies (000's per hour) from the Canadian large vessel (>500 t) fleet fishing in NAFO Divisions 2G (SFA 4) over the period 1998–2007. Solid lines = males; dotted lines = females.

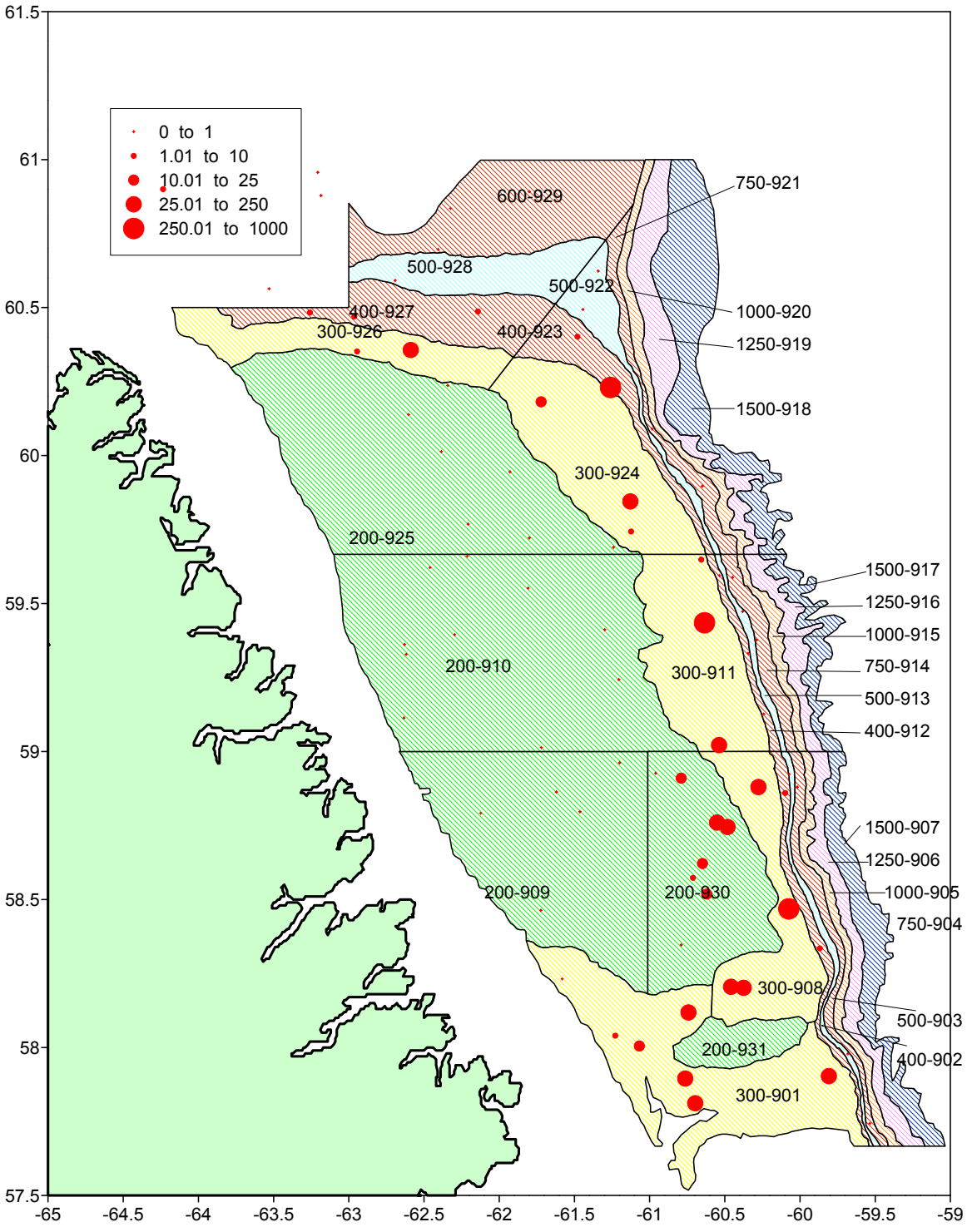


Figure 53. Distribution of NAFO Division 2G (SFA 4) northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from the July 2005 Northern Shrimp Research Foundation – DFO joint northern shrimp bottom trawl survey. Tows were 15 minutes in duration and made use of a Campelen 1800 research trawl.

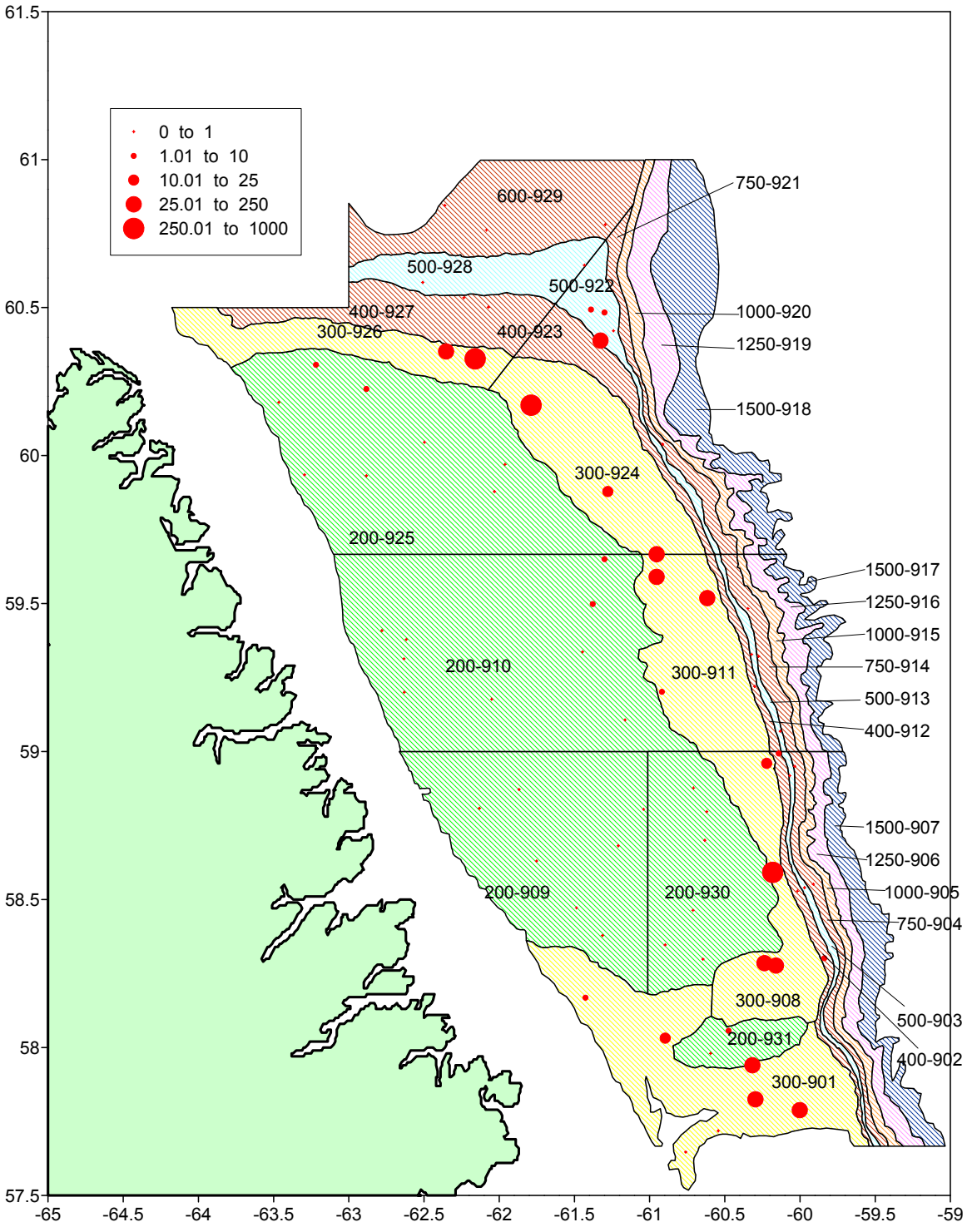


Figure 54. Distribution of NAFO Division 2G (SFA 4) northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from the July 2006 Northern Shrimp Research Foundation – DFO joint northern shrimp bottom trawl survey. Tows were 15 minutes in duration and made use of a Campelen 1800 research trawl.

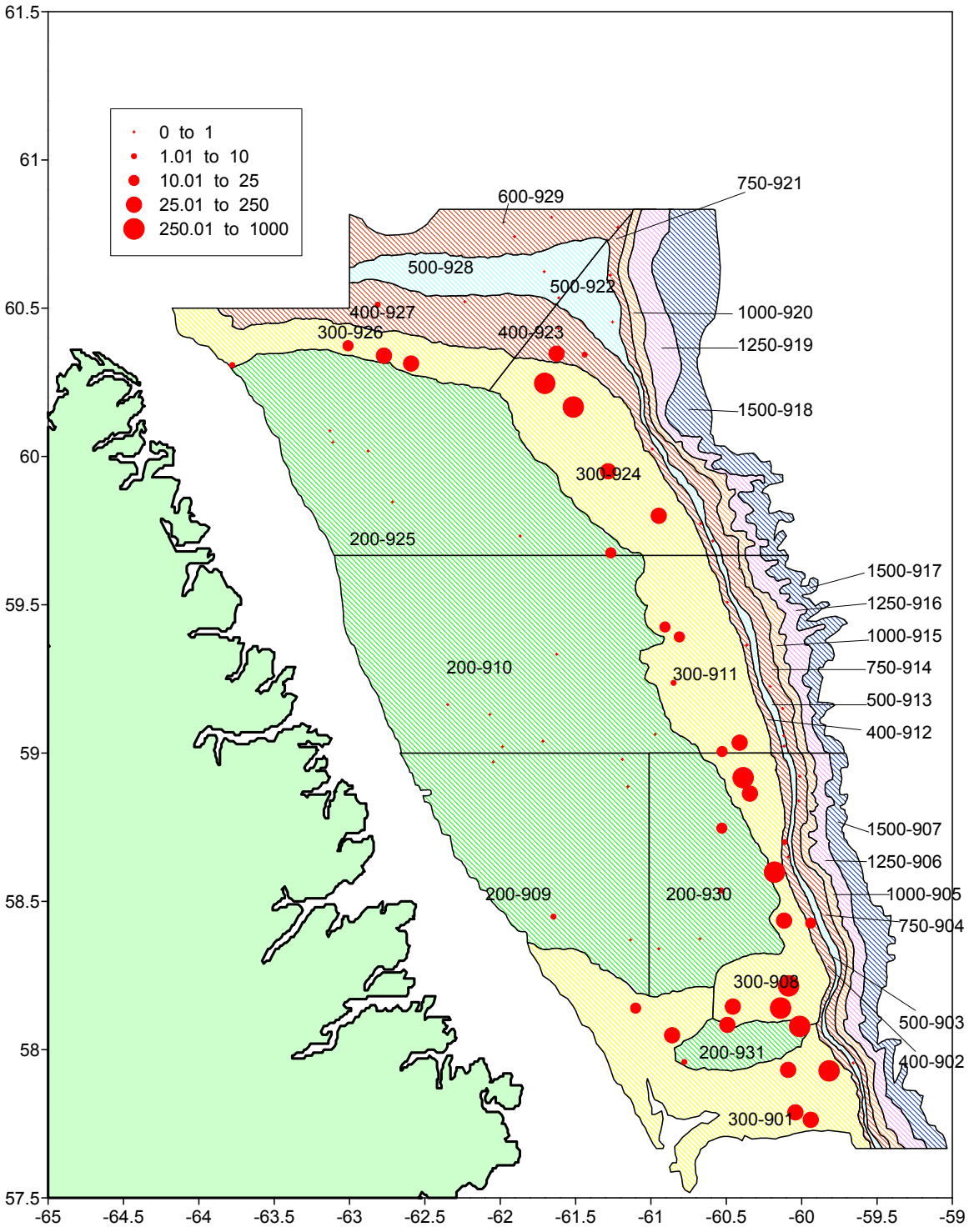


Figure 55. Distribution of NAFO Division 2G (SFA 4) northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from the July 2007 Northern Shrimp Research Foundation – DFO joint northern shrimp bottom trawl survey. Tows were 15 minutes in duration and made use of a Campelen 1800 research trawl.

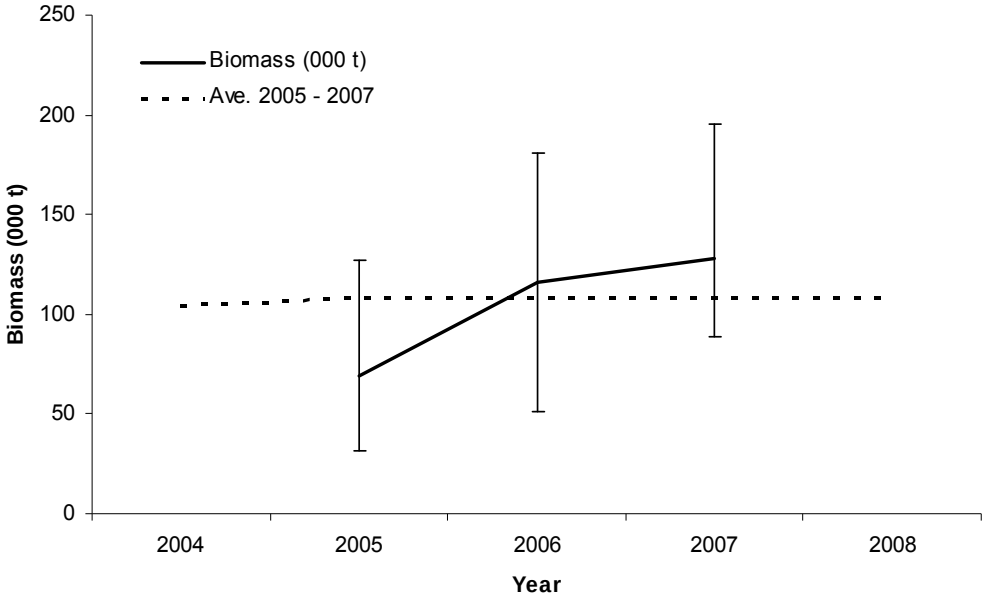


Figure 56. Northern shrimp (*Pandalus borealis*) biomass indices within Div 2G (SFA 4) as determined using ogmap calculations. Data were from the joint NSRF – DFO northern shrimp surveys using a Campelen 1800 research shrimp trawl.

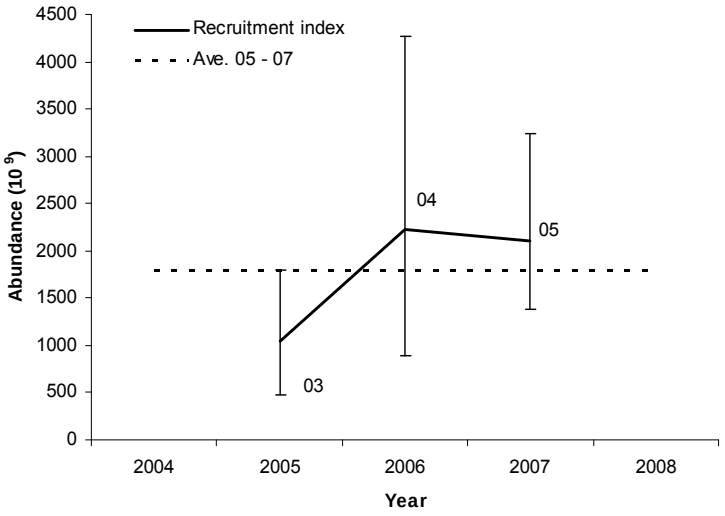


Figure 57. July northern shrimp (*Pandalus borealis*) recruitment indices (abundance of males with 11.5-16 mm carapace lengths) within NAFO Division 2G (SFA4), as determined using OGive MAPped calculations. Data were from the annual joint Northern Shrimp Research Foundation (NSRF) – DFO shrimp bottom trawl surveys using Campelen 1800 shrimp trawl.

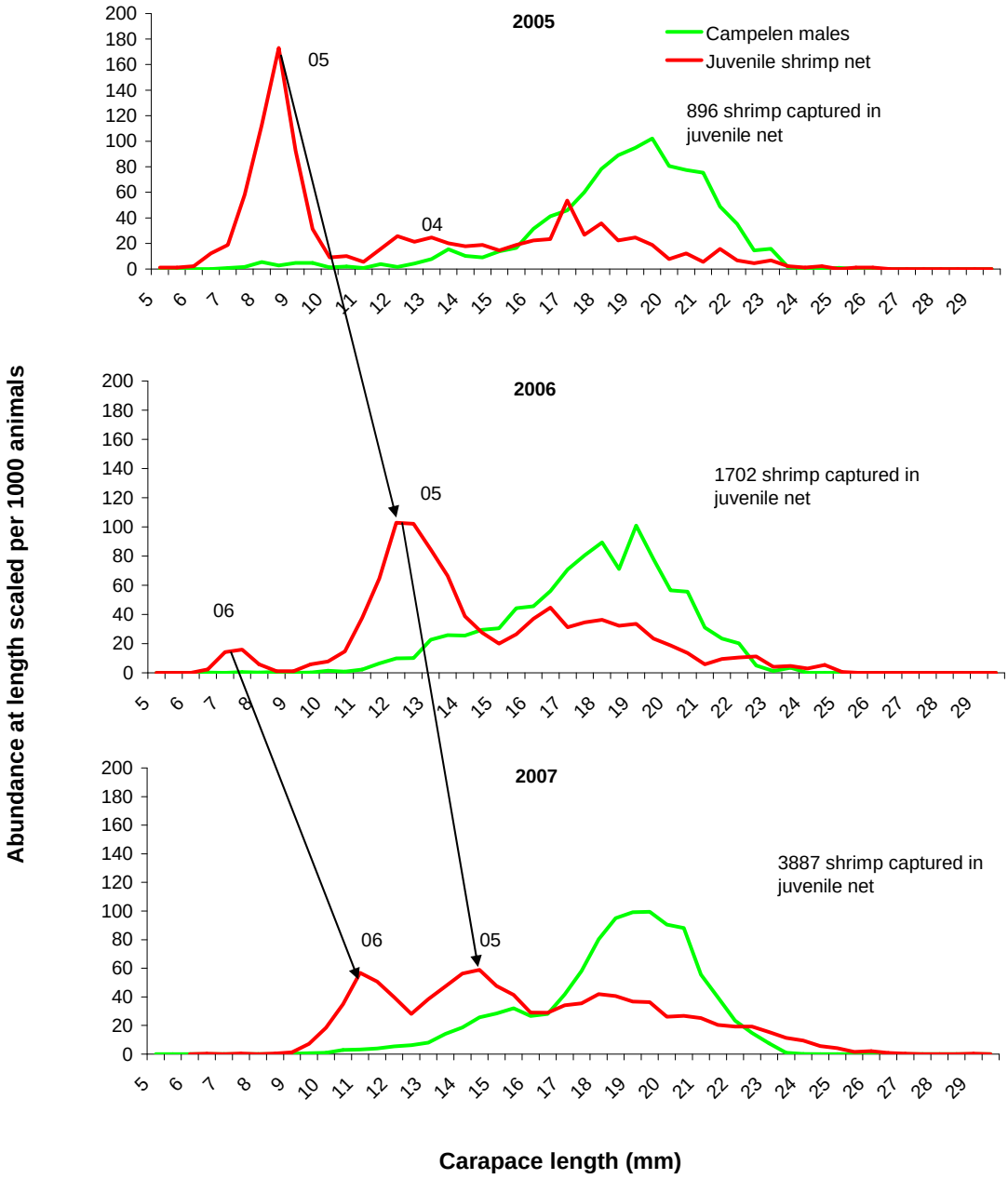


Figure 58. An overlay of juvenile shrimp net length frequencies from with those from the Campelen codend. All data are from the NAFO Division 2G (SFA 4) joint NSRF-DFO shrimp survey conducted between 2005 and 2007. The arrows indicate the progression of modes from one year to the next while the numbers at each mode indicate year-class.

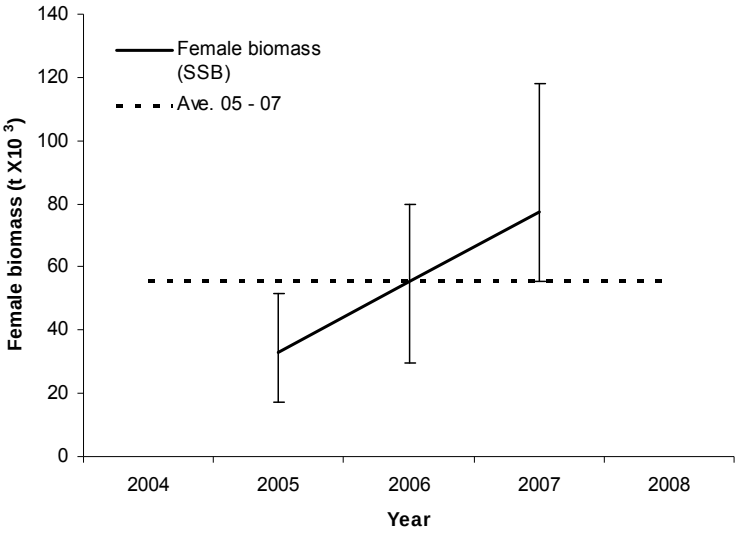


Figure 59. July northern shrimp (*Pandalus borealis*) female spawning stock biomass indices within NAFO Division 2G (SFA 4), as determined using OGive MAPped calculations. Data were from the annual joint Northern Shrimp Research Foundation (NSRF) – DFO shrimp bottom trawl surveys using Campelen 1800 shrimp trawl.

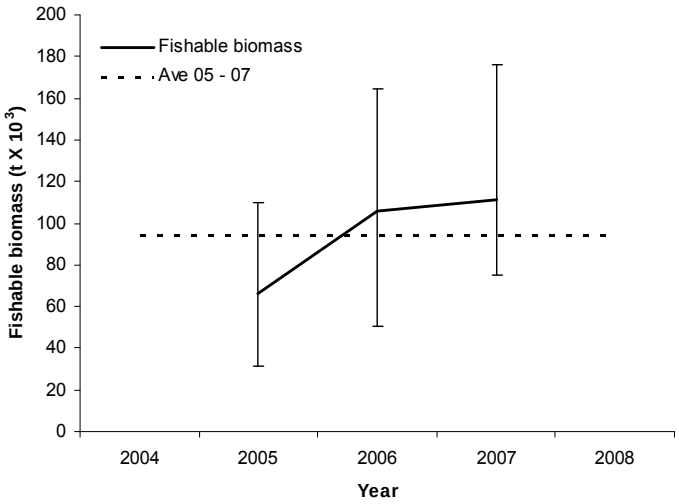


Figure 60. July northern shrimp (*Pandalus borealis*) fishable biomass indices (biomass of males with >17 mm carapace lengths + biomass of all females) within NAFO Division 2G (SFA4), as determined using OGive MAPped calculations. Data were from the annual joint Northern Shrimp Research Foundation (NSRF) – DFO shrimp bottom trawl surveys using Campelen 1800 shrimp trawl.

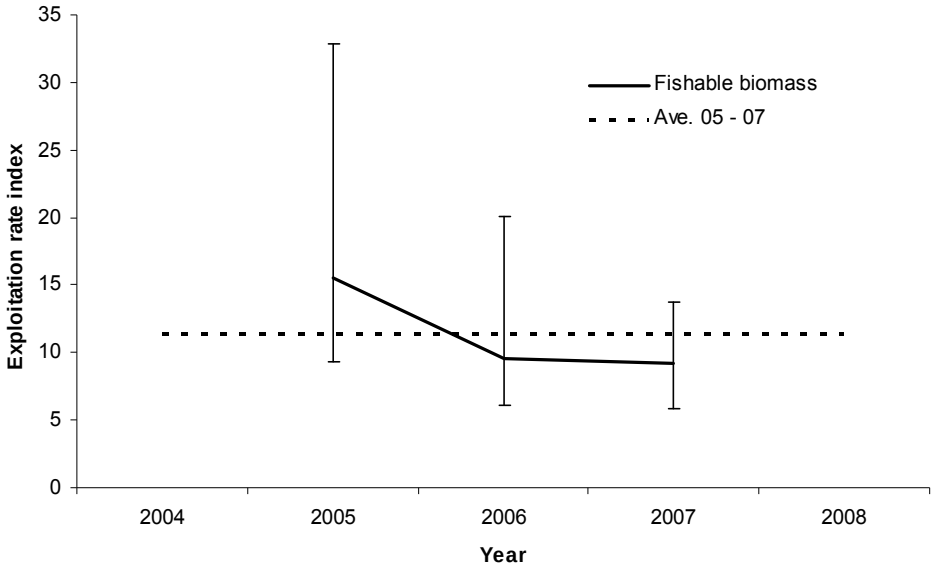


Figure 61. SFA 4 exploitation rate indices over the period 1996–2007 (total catch/ within year fishable biomass index; error bars indicate 95% confidence intervals).

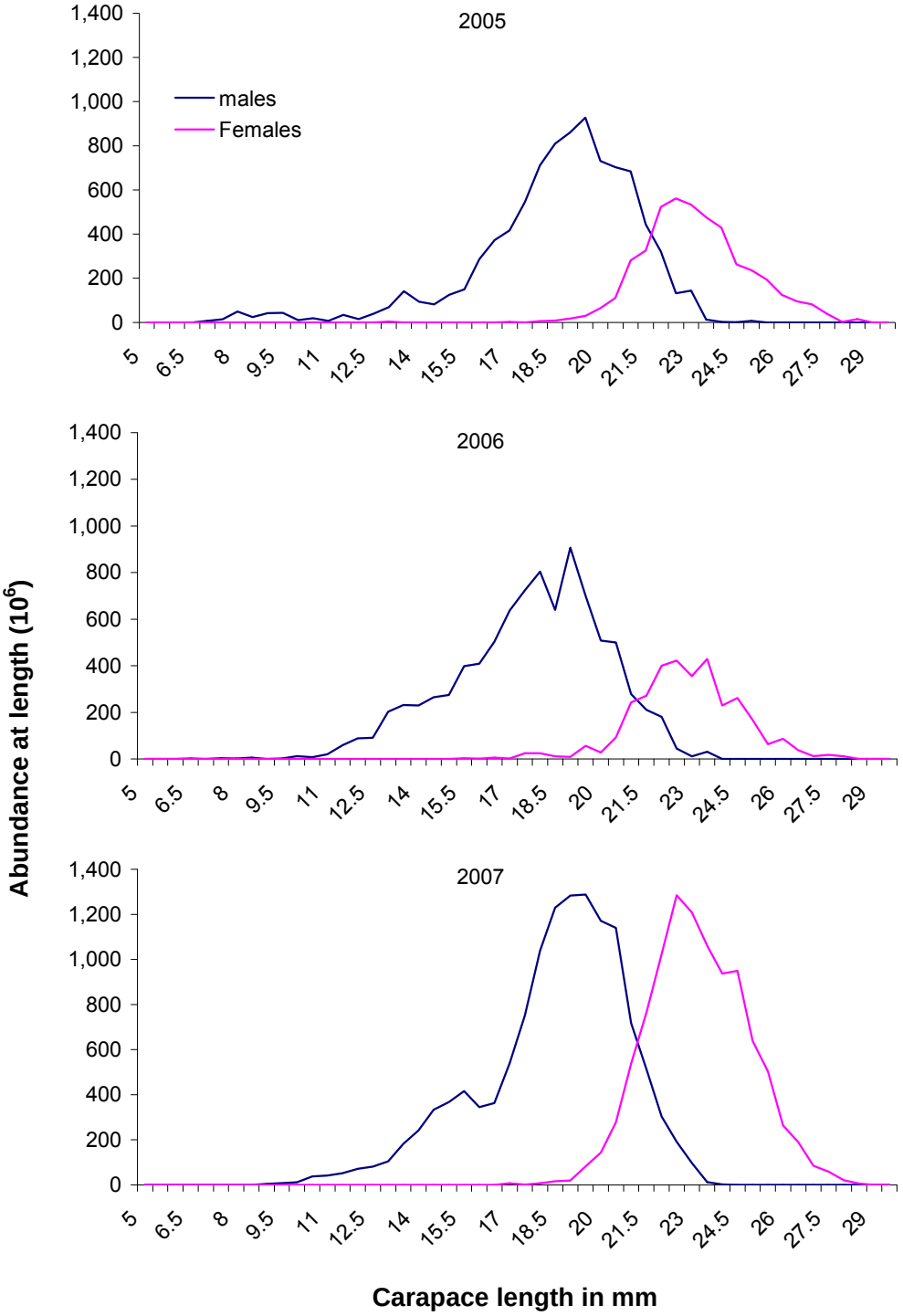


Figure 62. Abundance at length for NAFO Division 2G (SFA 4) northern shrimp (*Pandalus borealis*) estimated using Ogmap calculations of July, joint NSRF-DFO shrimp bottom trawl survey data, 2005-07.

APPENDIX 1: Performance report for Northern Shrimp (*Pandalus borealis*) – Hawke Channel + 3K (SFA 6)

Index	Observation	Interpretation
Production		
Survey fishable biomass	Fishable biomass indices from fall multi-species surveys have generally increased since 1997.	Healthy resource
Survey female biomass	Female biomass indices from fall multi-species surveys have generally increased since 1997.	Healthy resource
Large vessel CPUE	The large (>500 t) vessel CPUE remained at a high level since 1995.	Healthy, broadly distributed resource.
Small vessel CPUE	The small vessel (<100 ft) CPUE has increased significantly since 2003.	Healthy, broadly distributed resource.
Recruitment		
Recruitment index (11.5 – 16 mm C.L. males)	Recruitment indices in 2006 and 2007 were the highest in the time series.	Recruitment and female biomass expected to support fishery over next four years.
Fishery		
Exploitation rate index	Over the past two years, the exploitation rate indices were about 11% of survey fishable biomass. Recent catches have had no observable impact on the resource.	Low exploitation
Z	Not available	
Industry Perspectives	Able to harvest TAC; fish over a broad area, good catch rates; shrimp size variable depending upon area fished; belief that resource is healthy.	Healthy resource

Stock Status		Evaluation
Current Outlook	Remains positive; survey indices have generally increased since 1997; no observed impact from fishery; resource distributed over a broad area.	positive
Future Prospects	Recruitment and female biomass expected to support fishery over next four years; at the current TAC, the 2008/09 exploitation rate index is expected to be 11 - 15%. Any modest change in TAC expected to have a proportionate change in exploitation rate index.	positive

Status Definitions	
	Concern for Current Status or Prospect
	Intermediate
	Positive Evaluation
	Uncertainty of interpretation

APPENDIX 2: Performance report for Northern Shrimp (*Pandalus borealis*) – Hopedale + Cartwright Channels (SFA 5)

Index	Observation	Interpretation
Production		
Survey fishable biomass	Somewhat higher after 2000 than before 2000.	Resource appears healthy; however, incomplete surveys in 5 of the last 8 years creates uncertainty.
Survey female biomass	Somewhat higher after 2000 than before 2000.	Resource appears healthy; however, incomplete surveys in 5 of the last 8 years creates uncertainty.
Large vessel CPUE	Since 1996, CPUE has fluctuated above the long-term average.	Healthy resource distributed over a broad area.
Recruitment		
Recruitment index (11 – 16.5 mm C.L. males)	Recruitment in the short-term, while uncertain, appears average. Longer-term prospects are unknown.	Recruitment uncertain.
Fishery		
Exploitation rate index	The 2006/07 exploitation rate index was 15%. Recent catches have had no observable impact on the resource.	Low exploitation.
Z	Not available	
Industry Perspectives	Catch rates remain consistent; resource distributed over broad area; smaller size shrimp similar to that seen in SFA 6.	Healthy resource

Stock Status		Evaluation
Current Outlook	Current status remains positive; survey indices higher after 2000; no observed impact from fishery; resource distributed over broad area.	positive
Future Prospects	Recruitment in the short-term appears average. Due to incomplete survey in 5 out of 8 most recent years, there is uncertainy in recruitment and residual female biomass indices.	Uncertainty of interpretation

Status Definitions	
	Concern for Current Status or Prospect
	Intermediate
	Positive Evaluation
	Uncertainty of interpretation

APPENDIX 3: Performance report for Northern Shrimp (*Pandalus borealis*) – Division 2G (SFA 4)

Index	Observation	Interpretation
Production		
Survey fishable biomass	Fishable biomass index has ranged between 66,000 and 119,000 t.	Time series too short to infer trend.
Survey female biomass	Female biomass index has ranged between 33,000 and 76,000 t.	Time series too short to infer trend.
Large vessel CPUE	Since 2002 CPUE has varied along the long -term average.	Healthy resource; fishery able to maintain CPUE over broad area.
Recruitment		
Recruitment index (11 – 16.5 mm C.L. males)	Recruitment trends are unknown.	Not available
Fishery		
Exploitation rate index	Exploitation rate indices ranged between 8 and 15% during 2005 - 2007.	Low exploitation
Z	Not available	
Industry Perspectives	Catches rates remain good; no concern regarding abundance. Based on general knowledge, it is believe that the resource is healthy. Notable presence of smaller size shrimp may be related to the recruitment of young males.	Healthy resource

Stock Status		Evaluation
Current Outlook	Current status appears positive from fishery catch rate indices and survey exploitation rate indices.	positive
Future Prospects	Recruitment prospects are unknown and the survey time series is only three years in length.	Uncertainty of interpretation.

Status Definitions	
	Concern for Current Status or Prospect
	Intermediate
	Positive Evaluation
	Uncertainty of interpretation