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Newfoundland & Labrador | **Terre-Neuve et Labrador**

The status of the Northern shrimp (*Pandalus borealis*) resource off Labrador and northeastern Newfoundland as of March 2010

État du stock de la crevette nordique (*Pandalus borealis*) au large du Labrador et au nord-est de Terre-Neuve en mars 2010

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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 (CPUE), fishing pattern and size/sex/age composition of the catches. Fisheries independent data include an autumn multispecies research bottom trawl survey into SFAs 5 and 6 (1996-2009). 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 five summers (2005–09). Surveys in SFAs 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 114,000 t by 2007-08 due mainly to increases in Total Allowable Catch (TAC). The TAC for the 2009-10 management year was set at 120,345 t and catches for that year equaled 80,700 t. The TAC was not met due to operational/commercial constraints.

Annual catches within SFA 6 increased from 11,000 t during 1994 to 80,700 t by 2007-08. The TAC for the 2009-10 management year was set at 85,725 t. Catches for the 2009-10 management year equaled 45,100 t as of April 7, 2010. Spatial distribution of the resource and large vessel fishery changed little over recent years. The spatial distribution of the small vessel fishery increased from 1998 to 2007 then decreased to 2009. The large (>500 t) vessel CPUE remained at a high level between 1995 and 2006 after which it decreased to 2009. The small vessel (<100 ft) CPUE increased to 2003, remained high until 2007 and then decreased to 2009.

Biomass and abundance indices (total, fishable and female) from fall multi-species surveys generally increased from 1997 to peak levels in 2006 but have since decreased by 50%. These indices dropped below the long term average in 2009. Recruitment indices have been variable, peaking in 2006, but have since declined to the long term average. The apparently strong 2004 year class (2006 index) did not lead to increased fishable biomass. The relationship between recruitment index and fishable biomass is uncertain.

Even though catches remained high over the period 2004–07, the exploitation rate index decreased as a result of increased fishable biomass over the 2003–06 period.

In terms of the precautionary approach framework, SSB is presently within the cautious zone at 97% of the provisional upper stock reference point (USR).

Catches within SFA 5 (Hopedale + Cartwright Channels) increased from 15,000 t over the period 1997 to 2002 to around 23,000 t in 2004-05 to 2008-09. The 2009-10 TAC

was set at 23,300 t and 24,900 t were taken. CPUE has been trending upward from 1992 to 2001 and has been above the long term average since 1995. Percent total area fished within SFA 5 for the large (>500 t) vessel fleet to obtain 95% of their catch increased from 5–11% over the period 1985 to 2006, but has since decreased compared to the long term mean. It is a concern that the area fished has been decreasing while the CPUE is being maintained at a high level, suggesting the resource may be locally aggregated.

The SFA 5 survey fishable biomass index declined by 17% from 2006 to 2008. Fishable biomass in Cartwright Channel decreased by 40% in 2009; however, broad confidence intervals in 2009 indicate uncertainty. Recruitment in the short-term, while uncertain, appears average. The exploitation rate index is approximately 20%, slightly above the long term mean. In terms of the precautionary approach framework, SSB in SFA 5 was in the healthy zone in 2008, well above the provisional USR.

Catches within SFA 4 increased from 4000 t in 1994 to 9,600 t by 2004-05. Approximately 10,700 t of shrimp were caught against a 11,320 t TAC during 2009-10. CPUE has increased since 2004-05 and is now well above the long term mean.

The NSRF-DFO research survey biomass indices (female and fishable) have been increasing throughout the five-year time period. The recruitment index increased from 2005 to 2008 and has changed little in 2009. Exploitation rate index has decreased from 16% in 2005 to 6% in 2009. In terms of the precautionary approach framework, SSB in SFA 4 was in the healthy zone in 2009, well above the provisional USR.

In conclusion, the resource appears to have been decreasing in the south but increasing in the north.

RÉSUMÉ

Des mises à jour des évaluations de la crevette nordique (*Pandalus borealis*) ont été effectuées pour 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 de la crevette (ZPC) 4, 5 et 6. L'état de la ressource dans chaque zone a été déduit en partie de l'examen des tendances relatives aux prises commerciales, à l'effort, aux prises par unité d'effort (PUE), au régime de pêche et à la composition des prises en fonction de la taille, du sexe et de l'âge. Les données indépendantes de la pêche comprennent une série de relevés plurispécifiques automnaux de recherche au chalut de fond dans les ZPC 5 et 6 (1996 à 2009). La Northern Shrimp Research Foundation, en partenariat avec le ministère des Pêches et des Océans, a effectué un relevé de recherche sur les crevettes dans la division 2G (ZPC 4) chaque été durant la période de 2005 à 2009. Une série de relevés a fourni de l'information sur la répartition, l'abondance, la biomasse, la composition en fonction de la taille et du sexe et la structure d'âge des crevettes dans les ZPC 4-6.

Les prises sont passées de 22 000 t en 1994 à plus de 114 000 t en 2007-08, principalement en raison des hausses des totaux autorisés des captures (TAC). Le TAC pour l'année de gestion 2009-10 a été fixé à 120 345 t et les prises pour cette année ont été de 80 700 t. Le TAC n'a pas été atteint en raison des contraintes opérationnelles/commerciales.

Les prises annuelles dans la ZPC 6 sont passées de 11 000 t durant la période de 1994 à 1996 à 80 700 t en 2007-2008. Le TAC pour l'année de gestion 2009-10 a été fixé à 85 725 t. Les prises pour l'année de gestion 2009-10 se sont chiffrées à 45 100 t en date du 7 avril 2010. La répartition spatiale de la ressource et de la pêche des navires de grande taille a peu changé au cours des dernières années. La répartition spatiale de la pêche des navires de petite taille a augmenté de 1998 à 2007 pour ensuite diminuer jusqu'en 2009. Les PUE des grands navires (> 500 t) sont demeurées à un niveau élevé entre 1995 et 2006, et ont diminué jusqu'en 2009. Les PUE des petits navires (< 100 pi) ont augmenté jusqu'en 2003, sont restées élevées jusqu'en 2007, et ont ensuite diminué jusqu'en 2009.

Les indices de biomasse et d'abondance (totales, exploitables et des femelles) des relevés plurispécifiques automnaux ont en général augmenté à partir de 1997 jusqu'à des niveaux records en 2006, mais ils ont diminué depuis lors de 50 %. Ces indices ont chuté sous la moyenne à long terme en 2009. Les indices du recrutement ont été variables, atteignant un niveau record en 2006, mais ils ont diminué depuis lors pour atteindre la moyenne à long terme. La classe d'âge de 2004 apparemment plus abondante (indice de 2006) n'a pas augmenté la biomasse exploitable. La relation entre l'indice de recrutement et la biomasse exploitable est incertaine.

Même si les prises sont restées élevées durant la période de 2004 à 2007, l'indice du taux d'exploitation a diminué en raison de l'augmentation de la biomasse exploitable au cours de la période de 2003 à 2006.

Pour ce qui est du cadre de l’approche de précaution, la biomasse du stock reproducteur (BSR) est actuellement dans la zone prudente à 97 % du niveau de référence supérieur du stock provisoire.

Les prises dans la ZPC 5 (chenaux Hopedale et Cartwright) sont passées de 15 000 t en 1997-2002 à environ 23 000 t entre 2004-2005 et 2008-2009. Le TAC pour 2009-2010 a été fixé à 23 300 t et des prises de 24 900 t ont été effectuées. Les PUE ont suivi une tendance à la hausse de 1992 à 2001 et sont au-dessus de la moyenne à long terme depuis 1995. Le pourcentage de la zone totale pêchée de la ZPC 5 pour les navires de grande taille (>500 t) devant obtenir 95 % de leur prise a augmenté de 5 à 11 % entre 1985 à 2006, mais a diminué depuis par rapport à la moyenne à long terme. On s’inquiète du fait que la zone pêchée a diminué alors que la PUE est maintenue à un niveau élevé, indiquant que la ressource peut être agrégée localement.

L’indice de la biomasse exploitable dérivé du relevé de la ZPC 5 a diminué de 17 % de 2006 à 2008. La biomasse exploitable dans le chenal de Cartwright a diminué de 40 % en 2009; toutefois, de vastes intervalles de confiance en 2009 montrent une incertitude. Le recrutement à court terme, bien qu’incertain, semble se situer dans la moyenne. L’indice du taux d’exploitation est d’environ 20 %, légèrement au-dessus de la moyenne à long terme. Pour ce qui est du cadre de l’approche de précaution, la BSR dans la ZPC 5 était située dans la zone saine en 2008, bien au-dessus du niveau de référence supérieur du stock provisoire.
Les prises dans la ZPC 4 sont passées de 4 000 t en 1994 à 9 600 t en 2004-05. Environ 10 700 t de crevettes ont été pêchées sur un TAC de 11 320 t en 2009-10. Les PUE ont augmenté depuis 2004-05 et sont maintenant bien au-dessus de la moyenne à long terme.

Les indices de la biomasse dérivés du relevé de recherche NRSF-MPO (des femelles et exploitable) ont augmenté tout au long de la période de cinq ans. L’indice du recrutement a augmenté de 2005 à 2008 et n’a guère changé en 2009. L’indice du taux d’exploitation est passé de 16 % en 2005 à 6 % en 2009. Pour ce qui est du cadre de l’approche de précaution, la BSR dans la ZPC 4 était située dans la zone saine en 2009, bien au-dessus du niveau de référence supérieur du stock provisoire.

En conclusion, la ressource semble avoir diminué dans le sud, mais avoir augmenté dans le nord.

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 4000 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 14,000 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 84,700 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. During that year, industry was granted a change in fishing season from a calendar (Jan 1-Dec. 31) year to a fiscal (Apr.1-Mar. 31) year. To facilitate this change, an additional 20,229 t interim quota was allocated to the large vessel fleet and the 2003-04 fishing season became 15 months in length. The 2004-05 fishing season was 12 months in duration and total allocations, within SFA's 4, 5 and 6, equaled 111,552 t. Without accounting for bridging and adjustments, this TAC was maintained throughout to the 2007-08 fiscal year. TACs increased during 2008-09 to 11,320 t in SFA 4 and 85,725 t in SFA 6 and were maintained at those levels through to 2009-10. Total catches for all SFAs peaked at 114,500 t in 2007-08 but have subsequently declined to 80,700 t by 2009-10 due mainly to operational/ commercial considerations.

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 ressource assessment, conducted during March 2010, 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:

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

Where: $CPUE_{ijkml}$ is the CPUE for vessel k, fishing in area i in month using gear m during year l

(k=1,…..,a; j=1,…..,s; i=1,…..,y);
ln(u) is the overall mean ln(CPUE);
A_I 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_{ijkml} is the error term assumed to be normally distributed $N(0,\sigma^2/n)$ where n is the number of observations in a cell and σ^2 is the variance.

The standardized CPUE indices are the antilog of the year coefficient. 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 thus increasing 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 2009 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 9.0 (Golden Software 2010). 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 accounting 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 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.

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.

The Teleost normally begins the survey by fishing in NAFO Division 3O at depths >750 m and continues eastward until the deepwater in NAFO Division 3N is complete. The Teleost then proceeds to the northern limit of NAFO Division 2J and fishes southward in all depths. The Wilfred Templeman and Alfred Needler are sister ships and begin the fall survey in waters shallower than 750 m in NAFO Divisions 3ONL and finally meets with the Teleost in 3K at the end of the survey, normally during December. Details of the survey design and fishing protocols are outlined in (Brodie, 1996, Brodie, 2005, McCallum and Walsh, 1996, Brodie, and Stansbury, 2007).

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 northern limit of 2H in alternate years. During intervening years, the survey would extend to northern limit 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 northern limit of 2J. However, due to vessel problems, both the 2004 and 2005 surveys were completed during January of 2005 and 2006 respectively. All strata within SFA 5 were surveyed during 2006 and 2008.

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) during the summers of 2005 - 2009. 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 5-6. 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. Fishable biomass was determined by converting, within set, abundances at length to weights (carapace lt=> 17.5 mm) using the following length/weight relationships:

Males $Wt(g) = 0.000544*lt(mm)^{3.020}$
Females $Wt(g) = 0.000708*lt(mm)^{2.968}$

These length weight relationships were estimated from live males and ovigerous females obtained within NAFO Div. 2JK3L combined during autumn 2004.

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 shrimp within the Campelen trawl is not known. However, these indices allow one to monitor trends in exploitation over the years.

The triangulation and parameter files used in Ogmap calculations were revised because the original files were created using the limited amount of depth at position data and short time series of biomass trajectories. Consequently all of the survey estimates were determined twice; once using the original triangulation and parameter files and once using the revised files.

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. 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

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

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

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

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, (DFO, 2010)) were set at 11,050 t and catches increased to 11,000 t. The TAC for 1997, the first year of the 1997-99 multi-year IFMP, was raised to 23,100 t as a first step toward increasing exploitation within a healthy resource. Most of the increase was reserved for the development of a small vessel component. Catches in 1997 were estimated to be approximately 21,000 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 5% to 61,632 t. Approximately 63,000 t were taken, 20,000 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 32,700 t were taken by the small vessel fleet (Tables 1-3 and 7; Figs. 3- 5). The small vessel fleet did not take its entire quota because shrimp were relatively small, and there was an international glut in the market for peeled, frozen shrimp. This led to a short industry imposed closure throughout July-August, 2001. The closure was also induced by seasonal variances in shrimp yield. On average, yield drops by 5% over the summer period (A. O'Rielly, pers. comm. NL. Depart. Fish. Aquacult.). 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. NL Depart. Fish. Aquacult.). 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. The TAC was increased by 9% to 85,725 t in 2008-09 and maintained at that level until 2009-10. Catches decreased to 75,000 t in 2008-09 and further to 45,100 t in 2009-10. These decreases in catch were mainly due to commercial/ operational factors (Tables 1 and 2; Fig. 2-5).

Large vessels primarily fish during the first six months of the year (Fig. 6) while small vessels fish primarily during the summer months (Fig. 7).

The large vessel fleet fished along the shelf edge during the early 1990's. The fishery extended as far south as the St. Anthony Basin and Funk Island Deep because of the establishment of exploratory areas on the shelf slope in 1992 and 1993, and the discovery of dense concentrations of shrimp within these areas. Assessments at that time suggested there was no reason to divide SFA 6 into separate management units. Therefore, the 1994-96 management plan allowed flexibility to fish anywhere within the combined management area. As a result catch and effort shifted away from the St. Anthony Basin and Funk Island Deep areas. Over the years, the large vessel fleet has taken most of their catch from the entrance to Hawke Channel and within the 500 m contour along the northern portion of SFA 6 (Fig. 8). 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 small vessel fishery covers vast areas of SFA 6 with concentrations along the 500 m contour in northern 2J, St. Anthony Basin, as well as, southeastern 3K (Fig. 9).

Percent total area within SFA 6 necessary for resource survey and the large (>500 t) vessel fleet to obtain 95% of their catches has varied little over the period 1998–2009. A similar index for the small vessel fleet increased from 1998 and 2007 before decreasing to 2009 (Fig. 10).

Catch Per Unit Effort (CPUE)

Two catch rate models were created for the large vessel fleet fishing in SFA 6 over the period 1989–2009. The original model which made use of the 2008 formulation: gear (single + double trawl), year, month, area; Observer data, no windows, history> 3 years.). The proposed model made use of the original formulation but also attempted to standardize the fishing sets by area towed, double trawl effort was multiplied by 1.3 (the original model indicated that 1.3 was the correction factor between single and double trawl catches), Funk Island Deep fishing sets were removed as this area was voluntarily closed to fishing in 2005, as well, the model was limited to the first 6 months of the year corresponding to the seasonality of the fishery (Fig. 6). Figure 11 provides a comparison between original and proposed model CPUEs and their respective raw CPUEs. According to the original model, catch rates increased steadily from 1992 to 1995, fluctuated at a high level until 2006 after which it decreased to 2009 (Table 4). The model accounts for approximately 62% of the variance in the data. Figure 12 clearly indicates that there are no trends in the scatter of residuals around the parameter estimates.

The original model indicated that 1989 and 1994 catch rates were similar to the 2009 catch rate (P>0.05), the 1995-2008 values were significantly higher than the 2009 value

(P<0.05) while all other values were significantly lower than the 2009 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, then another inflection point since 2006 as the catch rates decreased and are now below the long term mean (Table 4).

The proposed model accounted for 79% of the variance in the data. Catch rates during 2004 and 2005 were similar to the 2009 value, however, values between 2006–08 were above the 2009 value while all other values were statistically lower. The proposed model was not accepted by the peer review because it did not include all months and all areas.

Tables 7 and 8 provide the small vessel CPUE model output for the original model (logbook data; history>3 years, size class, month area) while figure 13 provides a graphical comparison between the original and proposed models. Tables 9 and 10 provide the proposed model (logbook data; history>3 years, size class, year*month interactions) output.

The original model accounted for 68% of the variance in the data, with 2000 and 2001 catch rate values being similar to the 2009 value. The 2004–08 catch rates were significantly higher than the 2009 catch rate with all others being significantly lower than 2009. Figure 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 proposed model accounted for 79% of the variation in explanatory parameters. The 2009 catch rate estimate was significantly different from all other years (P<0.05). Catch rates increased from 2002 to 2007 and then decreased to 2009 (Tables 9 and 10). This model was not accepted by the peer review.

Figure 15 provides a graphical illustration of the large and small vessel catch rate model trajectories, using the original model formulations.

Size Composition

Several length frequency observations were taken from large and small vessel catches (Fig. 16 and 17). 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 17.69 mm and 18.98 mm, while the weighted average carapace lengths for females ranged between 22.07 mm and 22.84 mm. There were no trends in the average size of either males or females. Catch rates for small vessel had been maintained at over 63,000 animals per hour. The within year frequency weighted average carapace lengths for non-ovigerous shrimp ranged between 16.2 mm and 18.91 mm, while the weight average carapace length for ovigerous females ranged between 20.94 mm and 22.75 mm. Carapace lengths of non-ovigerous shrimp from small vessels have been decreasing since 2007 while the carapace lengths of ovigerous shrimp has been decreasing since 2006. The implication of the decreasing trend in size of shrimp is that the number of shrimp killed per tonne of shrimp caught is increasing. This trend in decreasing size of shrimp and the concern over the increasing number of shrimp killed was also voiced by the small vessel fishers and plant owners.

Biomass from fishery data

Fishery catch per unit effort data were applied to stratified areal expansion techniques with the goal of estimating biomass. This effort had the following assumptions:

1. sets could be standardized between years and ships;
2. the fishing sets within each strata would be treated as being random and independent of each other, and
3. the catches are normally distributed.

Table 11 shows the outcome of the stratified analysis using the large vessel catch per unit effort data. This analysis shows certain strata, but not all strata, have been consistently important since 1989. Table 12 shows that most of the commercial fishery takes place in 200–500 m depths. Both tables indicate no obvious signs of resource contraction.

Since all strata were not consistently fished throughout the history of the fishery, it was necessary to re-run the analysis using index strata (Fig. 18). Unfortunately during the first three years of the fishery, there was insufficient data to complete this analysis and therefore the analysis began in 1992. Tables 13 and 14 provide the biomass estimates from the six consistently fished strata at the mouth of Hawke Channel, at northern edge of St. Anthony Basin and along the 2J3K shelf edge (Fig. 8 and 18). In general, biomass remained low (averaged = 102,000 t) until 1999 then increased to a peak in 2006, remained high until 2008 (averaged 167,000 t) and then dropped to pre 2000 levels in 2009 (115,000 t).

Regression analysis of large vessel CPUE, total fishery biomass and index strata fishery biomass against research survey fishable biomass were conducted with various lags. Regressions with the greatest fit (r^2) are presented in figure 19. The model with index strata biomass against survey fishable biomass provided the greatest predictive capability (r^2 = 73%).

The small vessel fleet fishes over a much broader area than the large vessel fleet (Tables 11 and 15; Fig 8-10), but does not completely overlap the area fished by the large vessels. The small vessel fleet has rarely fished in either Hawke Channel or the northern half of the 3K shelf edge. Due to different gear used and fishing powers of the different fleets, and the difference in spatial distribution of the fisheries, it would not be appropriate to make direct comparisons between the large and small vessel or autumn research survey biomass estimates. However, certain generalities may be made. For instance, the large and small vessel stratified analyses indicate that there are strata that have been consistently important over the time series and that the bulk of both fisheries take place in 200–500 m depths (Tables 11-14 and 16-18). Similar to the large vessel stratified analysis, the small vessel analysis does not show obvious evidence of resource contraction.

Figure 20 provides the locations of the small vessel index strata, while tables 17 and 18 provide the stratified analyses. Biomass estimates averaged 143,000 t over the period 1998 – 2003, then increased in 2004 averaging 203,000 t over the period 2004–08 before decreasing to 130,000 t in 2009. Tables 17 and 18 indicate that strata at 200–400 m were the most important ones for this fishery and showed no signs of obvious contraction.

The regression between small vessel index biomass estimates and research survey fishable biomass provided the greatest correlation (r^2 = 70%) (Fig. 21).

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 2009 fall multi-species research survey indicate that shrimp continue to be widely distributed throughout Hawke Channel + Div. 3K (Fig. 10 and 22).

Figure 23 provides a comparison between the old and new triangulation files used in Ogmap calculations. The old triangulation file extended into the southwestern corner of SFA 5 as well as into deepwater at the southeastern edge of NAFO Division 3K. The new triangulation file remains within the SFA 6 shrimp depths and has a much denser set of triangles because several more years of survey data provided depth and location information were used in development of this file.

Indices from autumn multi-species surveys have generally increased from 1997 (429,000 t; 96 billion animals) to peak levels in 2006 (895,000 t; 208 billion animals) then decreased by 55% between 2006 and 2009 (404,000 t; 102 billion animals) (Table 19; Fig 24 and 25). The 2009 biomass index is presently the lowest in the time series while the abundance index is the second lowest in the time series. The lower 95% confidence limit of the biomass estimates averaged 570,500 t (108 billion animals) over the period 2006-09.

Confidence intervals are relatively tight suggesting a relatively uniform distribution throughout the survey area (Table 19; Fig. 24 and 25). This is in agreement with the areal index used to track changes in the commercial fishing and research survey data (Fig. 10). This is further confirmed by Tables 20–22 which provide various presentations of stratified analyses by stratum and depth to determine whether the stock is expanding or contracting into certain area. All of these tables indicate that most of the shrimp have consistently been found in 200–500 m depths. The consensus at the meeting was no sign of contraction into certain strata or depths. Figure 26 indicates that there is good agreement between the stratified and Ogmap analyses of the survey catch data (r^2 = 97%), however, the regression analysis has an intercept of 43.284 indicating that the stratified analysis produced higher biomass estimates than did Ogmap.

The female stock increased from an estimated 183,000 t in 1997 to 463,000 t in 2006 but had decreased linearly to 205,000 t by 2009 (Table 23; Fig. 27 and 28). Similarly, fishable biomass increased from 310,000 t in 1997 to peak at 670,000 t in 2006 but then decrease by 54% to 311,000 t in 2009 (Table 24; Fig. 29 and 30).

It has long been recommended that we extend our knowledge of shrimp biomass to a time prior to 1996, when the present survey time series began. This was attempted by standardizing the index large and small vessel and research survey fishable biomass mass indices to their means and then combining through averaging their values (Fig. 31). However, the peer review did not accept this work because we were only able to extend the series by 4 years to 1992, and there was concern that fishery data were the primary source. Fishery data can be biased by several known and unknown factors.

<u>Stock Composition</u>

Length distributions representing abundance–at–length from the autumn 1996-2009 surveys are compared in Figure 32. Modes increase in height as one moves from ages 1-3 indicating that catchability of shrimp in 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 25 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. 32), at 10.04 mm, as two year old shrimp in the 1999 survey at 14.94 mm, as three year old shrimp in the 2000 survey at 17.66 mm and as four year olds in the 2001 survey at 19.16 mm (Table 25). 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 25; Fig. 32). Shrimp aged 2-4 dominated the male component of the length frequencies in 2009 (2007, 2006 and 2005 year-classes) survey with carapace length frequency modes at 13.17, 16.23 and 18.62 mm respectively.

Female length frequency distributions are broad indicating that they probably consist of more than one year-class. However, there is concern because female biomass and abundance indices have been reduced by over 50% since 2006 (Tables 23 and 25; Fig. 27, 28 and 32).

Northern shrimp recruitment indices are determined as the abundance of age 2 animals from the modal analysis (MacDonald and Pitcher, 1993) of Northern Shrimp Ogmapped length frequencies from research survey data (Table 25; Fig. 32), as well as the abundance of all animals with carapace lengths between 11.5 and 16 mm (Table 26; Fig. 33 and 34). Recruitment indices have been variable, peaking in 2006, but have since declined to the long term mean (1996–2009). The apparently strong 2004 year class (2006 index) did not lead to increased fishery biomass. The relationship between recruitment and fishable biomass is uncertain.

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 as well as fishable biomass and fishable abundance. In general, exploitation has been low even though catches have increased over time because the stock parameters also increased (Table 27). Figure 35 presents the exploitation rate index determined from catch/ previous year's fishable biomass index and previous year's fishable abundance. The 2008 exploitation rate indices were 13.16% and 15.09% in terms of fishable biomass and fishable abundance respectively. The 2009 exploitation rate index in terms of weight caught was 9% (Table 27: Fig 35). Exploitation in terms of count was not calculated for the 2009-10 fishery due to insufficient length frequency data at the time of writing this report. Using fishable biomass, it is possible to predict the exploitation in the future because the TAC is based upon weights and not counts. If the 85,725 t TAC was maintained through to 2010-11 and was taken, the exploitation rate index would rise to 28%.

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 shrimp in the survey gear is unknown but believed to be <1).

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 0.75, 0.25 and 0.29 respectively (Table 28). 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). This table indicates that survival has decreased by 10% in recent years (.77 in 2005 to .68 in 2007).

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 (Orr *et al.,* 2009). 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 0.36, 0.64 and 1.02 respectively (Table 29).

These mortality rates indices may appear high, implying that a large number of females die each year. However, they may be reasonable because it must be very stressful to produce, extrude and then hold eggs. The females are also the older animals and many may die from senescence. Additionally these mortality rates are similar to those found in the Gulf of St. Lawrence (L. Savard, *pers. comm.*). This table also indicates that survival has decreased by 12% since 2004 (.40 in 2004 to .28 in 2007).

The third mortality estimation method used the length based parameters presented in Figure 36. Observed lengths yielded L_∞, K, and t_0 values of 32.9546, 0.1927 and -0.9166 respectively. Median survival, annual mortality and instantaneous mortality for all shrimp (males and females over the entire length range) were 0.54, 0.46 and 0.62 respectively. Survival using this method is lower than it was using the ratio method presented in Table 28. The median survival, annual mortality and instantaneous mortality for female shrimp were 0.52, 0.48 and 0.65 respectively. Survival using this method is higher than it is using the ratio method presented in Table 29 and Figure 36 presents the changes in instantaneous mortality by size for all shrimp and females only as well as 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.

The peer review accepted the mortality estimates derived from comparisons of abundances of primiparous females with abundances of multiparous females in the next year. There was however, concern that the results could have been confounded by varying samples sizes.

<u>Precautionary Approach</u>

A plot of female spawning stock biomass (SSB) and catch presented over time, is put in the context of the provisional precautionary approach framework (Northern Shrimp IFMP, 2009) within Figure 37. In terms of the precautionary approach framework, SSB is presently within the cautious zone at 97% of the provisional Upper Stock Reference (USR).

Environmental influences upon SFA 6 Northern Shrimp population dynamics

<u>Temperature</u>

A Seabird 19 CTD (Conductivity, Temperature and Depth) probe attached to the headrope of the trawl provides bottom temperatures at each set location. Figure 38 provides a plot of shrimp catch by temperature contour as well as an area weighted shrimp catch at temperature percent cumulative frequency. Weighting was conducted to account for the stratified random sample design (several samples taken in large strata could bias the outcome therefore analysis made use of area weighting). The percent cumulative frequency made use of all data obtained from the autumn surveys over the period 1996–2009. These plots indicate that at least 75% of the shrimp are found in 2–4^{o}C bottom temperatures.

An annual areal plot of bottom temperatures (Fig 39) was constructed from all historic bottom temperature data collected during the September to December surveys. Bottom temperatures were coolest during the early to mid 80’s but have been warming since. For the purposes of this exercise, the amount of area occupied by 2–4 ^{o}C bottom temperatures was used as an environmental index.

Regression analysis was used to determine the appropriate lag for both the fishable biomass and the combined biomass index when overlaying biomass upon a plot of the environmental index over time. In both cases, a three year lag provided the greatest fit (Fig 40). When the fishable and combined biomass indices were lagged by three years and overlain upon the environmental index the trajectories of both indices fit the environmental index with a correlation coefficient of 72% between 1992 and 2006 (Fig. 41). After 2006 the fits dropped off considerably. It is important to note that the area occupied by bottom temperatures appeared to be stable at a high level, therefore it is unlikely that the drop in shrimp biomass was caused by changes in bottom temperatures.

Parasitology

Figure 42 provides a baseline of prevalence of various numerically important parasites that are visually obvious on Northern Shrimp within SFA 6. The most common parasite, since 1999, has been *Synophyra hypertrophica*, a ciliate that feeds upon hemolymph. Figure 43 is a plot of the percent of shrimp infected with *S.* hypertrophica. This parasite is broadly distributed with the highest incidence in Hawke and Funk Island Deep Channels.

In general, the prevalence of shrimp with single parasites has been low, while up to 16% of the shrimp may have more than one parasite.

It is important to note that there is no way of knowing how parasites affect catchability of shrimp in the trawl. Possibly they become too weak to become available to the trawl. These plots only provide an indication of what has been seen during autumn research surveys.

Status of the shrimp resource

There is concern for the current status. The resource continues to be distributed over a broad area as inferred from the spatial distribution of commercial effort and survey catches (Fig1, 8–10). However, over the past 3 or 4 years, both the large and small vessel catch rates have been decreasing and are presently near their respective long term means (Tables 3 and 7; Fig. 15). Biomass indices from fall multi-species surveys generally increased from 1997 to peak levels in 2006 but have since decreased by 50% (Tables 11–24; Fig 24–30). The present catch levels may not be sustainable given the declining biomass. If the current TAC is taken in 2010-11, the exploitation rate index would increase to between 20 and 37% (based on an 85,725 t TAC and 2009-10 fishable biomass 95% confidence intervals) (Table 27; Fig. 35). SSB is presently within the cautious zone at 97% of the provisional Upper Stock Reference (Fig. 37).

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 2000-02 plan. In 2003, the TAC increased 52% to 23,300 t. (In 2003, the fishing season changed to April 1-March 31, and an additional interim quota of 9,784 t was set for the period January 1-March 31, 2004. The 2003-04 fishing season was 15 months long and had a 33,084 t TAC. The 2003-04 management year TAC (23,300 t) was maintained for the 2004-05 to 2009-10 seasons. The history of the total fishery within SFA 5 is presented in tables 1 and 2, as well as figure 44. 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 23,300 t. Preliminary data indicate that 24,900 t of shrimp were taken from a TAC of 23,300 t during the 2009-10 management year (Tables 1, 2 and 30; Fig. 44). 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. 45); however, as illustrated in figure 44 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. 46). Percent total area fished within SFA 5 for the large (>500 t) vessel fleet to obtain 95% of their catch increased from 5–11% over the period 1985–2006, but has since decreased to the long term mean (Fig. 47). It is a concern that the area fished has been decreasing while the CPUE is being maintained at a high level, suggesting the resource may be becoming locally aggregated. However, the decrease has been over a short time period and could be part of natural variation.

Since 1995, the seasonality of the fishery switched from a spring - fall to an all year operation (Fig. 48).

Catch per unit effort (CPUE)

Two CPUE models were produced, an original and a proposed model. The original model made use of single trawls only, no windows and vessels with at least a three year history in the fishery (Tables 30 and 31). The proposed model also made use of single + double trawls, year, month, area, observer data, no windows and vessels with a history greater than three years, but also was restricted to classes that have a minimum of 10 hours of fishing activity data weighted by effort. Area 53 (south eastern corner of Cartwright Channel) was dropped as it was rarely fished. As well there was an attempt to standardize tow data by time, footrope length and tow speed (Tables 32 and 33). Figure 49 compares the raw filtered CPUE with the original and proposed modeled CPUEs.

The original model model accounted for approximately 77% of the variance in data. The scatter of residuals around parameter estimates is provided in figure 50. 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 cursory 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.

CPUE has been trending upward from 1992 to 2001 and has been above the long term average since 1995 (Fig. 51). The 1996-99, 2004, 2005 and 2008 catch rates were statistically similar (P>0.05) to 2009 (Table 31). It is a concern that the area fished has been decreasing while the CPUE is being maintained at a high level, suggesting the resource may be locally aggregated. However, the decrease in area fished has been over a short time period and could be part of natural variation.

The proposed CPUE model is presented in tables 32 and 33. It accounted for 83% in the variance in data; however, this model was not accepted because area 53 was dropped from the analysis.

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. 52). Catch rates have been maintained at more than 290,000 animals per hour. The within year frequency weighted average carapace lengths for males ranged between 17.96 mm and 19.00 mm, while the weighted average carapace lengths for females ranged between 22.30 mm and 23.11 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 was dominated by 16-20 mm animals that are probably from the 1999, 1998 and 1997 year classes (16 mm, 19 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 2005 year-class was relatively strong and could be seen as 16 mm animals in the 2008 distribution.

Biomass from fishery data

As in SFA 6, the stratified analysis of large vessel commercial catch data indicates all strata are not consistently occupied throughout the history of the fishery, that important strata appear to remain important through much of the history (Table 34). However, the important commercial depths range between 200-750 m which is much broader than it was in SFA 6 (Tables 11–18 and 34–37). Figure 53 indicate the index strata consistently fished by the large vessel fleet and used in the stratified areal expansion calculations presented in Table 36. Tables 34–37 showed no signs of resource contraction.

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 four (2001, 2004, 2006, 2008) of the last ten years. However, the lower part of SFA 5 (Cartwright Channel) has been surveyed during all years since 1996. Autumn research survey catches from 2005 to 2009 are presented in Figure 54.

Figure 55 provides a comparison between the old and new triangulation files used in Ogmap calculations. The old triangulation files extended into the northwestern corner of SFA 6 as well as into deepwater at the southeastern edge of NAFO Divisions 2GH. There was a gap between the Hopedale and Cartwright Channels triangulation files. The new triangulation files remain within the SFA 5 shrimp depths and has a much denser set of triangles because several more years of survey data provided depth and location information were used in development of this file as well because of new data, the gap between Hopedale and Cartwright Channels has been filled.

Trends in total biomass and abundance indices and biological characteristics from SFA 5 and Cartwright Channel were broadly consistent with at least 70% of the variance accounted for in linear regressions between SFA 5 and Cartwright Channel estimates (Table 38; Fig. 56-58).

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, 2006 and 2008 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, 2005 or 2007 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 43,600 t (9 billion animals) in 1998 to 142,300 t (29 billion animals) during 2005, decreased in 2006 to 80,200 t (20 billion animals), then increased to 86,200 t (24 billion animals) in 2007 before steadily declining to 56,500 t (16 billion animals) in 2009 (Table 25; Fig. 37A). The lower 95% confidence limit of the biomass estimates averaged 50,800 t (14 billion animals) over the period 2006-09.

Biomass within the entire of SFA 5 increased from 86,00 t (17 billion animals) in 1998 to 249,300 t (62 billion animals) during 2001, then decreased to 186,000 t (40 billion animals) by 2004, remaining near that level in 2006, and then further decreasing to 158,900 t (35 billion animals) by 2009. The lower 95% confidence limit of the biomass estimates averaged 128,900 t (30 billion animals) over the 2006–08 period.

A comparison between figures 8, 9, 10 and 22 with 46, 47 and 54 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 accounts for the broad confidence limits around the research survey point estimates (Table 38; Fig. 56 and 57). The SFA 5 fishery takes place in areas of high research catches (Fig. 46 and 54).

Tables 39–42 summarize the biomass by depth over the entire survey time series. Unfortunately, the autumn multi species covered the entire of SFA 5 during 1996–99 and in four (2001, 2004, 2006 and 2008) of the last ten years; therefore, it is not possible to compare across all years. As with similar tables for SFA 6 (Tables 19-22), there is no indication that shrimp distributions are contracting.

In general, the female spawning stock biomass index, within Cartwright Channel, increased from 15,000 t (2 billion animals) in 1996 to 73,400 t (10 billion animals) in 2005 before declining to 31,900 t (4 billion animals) in 2006 and remaining near that level until 2008 before decreasing to 19,200 t (3 billion animals) in 2009 (Table 43; Fig. 59 and 60). The lower 95% confidence limit of the Cartwright Channel female spawning stock biomass index averaged 18,200 t (2 billion animals) between 2006 and 2009 (Table 43).

The female spawning stock biomass index for the entire of SFA 5 increased from 33,200 t (4 billion animals) in 1996 to 96,500 t (13 billion animals) in 2001 and then decreased to 86,500 t (12 billion animals) in 2004 remaining near that level through to 2008 (Table 43).

Trends in female spawning stock biomass from SFA 5 and Cartwright Channel were broadly consistent with 85% of the variance accounted for in a linear regression between SFA 5 and Cartwright Channel female spawning stock biomass estimates (Table 43; Fig. 60).

Fishable biomass indices were estimated to be 55,900 t (11 billion animals) and 155,300 t (29 billion animals) in Cartwright Channel and the entire of SFA 5 respectively during 2006 but declined by 38% to 34,400 t in Cartwright Channel between 2006 and 2009 and by 17% to 128,400 t in the entire of SFA 5 over the period 2006-08. Approximately 83% of the variance in the relationship between SFA 5 and Cartwright Channel fishable biomass indices is accounted for in a linear relationship (Fig. 62).

Figure 63 provides the predictive linear relationships between commercial fishery catch rates and biomass indices lagged by the number of years providing the best fit to research survey fishable biomass. The commercial catch rate and index strata commercial biomass indices, both lagged by two years against SFA 5 research survey fishable biomass gave the best fit (60% and 55.8% respectively).

In an effort to extend our knowledge previous to 1996, the best linear relationships were used in creating two combined indices. One index is an average of survey fishable biomass and large vessel CPUE lagged by two years while the other is an average of survey fishable biomass and large vessel index strata biomass also lagged by two years. In each case, the input indices were standardized by dividing each index by its long term mean. These combined indices were rejected by the peer review because the extension was based soley upon commercial catch data.

Recruitment indices within Cartwright Channel and the entire of SFA 5 appear to follow similar trajectories (Tables 45, 46; Fig. 65-67). Recruitment oscillated around the long term mean (Fig 66 and 67). The indices, within the entire of SFA 5, were high during 1996, decreased over the next three years before increasing to 15.9 billion animals in 2001, then decreasing to 4.8 billion in 2004. Subsequent to 2004 the recruitment indices increased to 8.5 billion animals remaining near that level through to 2008. Recruitment indices increased to the highest recorded level in Cartwright Channel (10.3 billion animals) in 2007, but subsequently decreased by 43% to 5.9 billion animals by 2009. Seventy three percent of the variance is accounted for in the relationship between SFA 5 and Cartwright Channel recruitment indices (Fig. 67).

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 47). There was no attempt to determine exploitation in terms of count because the length frequency data from the small vessel fleet was not sufficient to be confident that it was representative of fleet activities. Figure 68 presents the exploitation rate index determined as catch/ previous year's fishable biomass index. The 2009-10 exploitation rate index, for SFA 5 ($catch_{year}$/fishable $biomass_{previous\ year}$), has been near the long term mean since 2004-05 and was 19.4% in 2009-10.

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 shrimp in the survey gear is unknown but believed to be <1).

Stock Composition

Figure 65 provides the Cartwright Channel length frequency distributions over the 1996–2009 period. Modes were found near 10, 14, 16, 18 and 20 mm along the male length frequencies (Table 45; Fig. 65). It is noteworthy that there is one additional mode that was not present among the Hawke Channel + 3K (SFA 6) male distributions (Table 25; Fig. 32). 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 10.41 mm, 13.84 mm and 16.04 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) (Table 25; Fig. 31) and 2005 NAFO Div. 3LNO length frequencies (Orr *et al.* 2009). The 2004 year class appeared strong in the 2006 recruitment index (2004 cohort abundance of males with 11.5–16 mm carapace lengths) from SFA 6 (Fig. 31) and NAFO Divs. 3LNO (Orr *et al*. 2009), but appeared to be of average strength in Cartwright Channel and the entire SFA 5 (Fig 66 and 67).

Female length frequency distributions are broad indicating that they probably consist of more than one year class. The SFA 5 female spawning stock biomass (SSB) indices after 2000 have been somewhat higher than before 2000; however, broad confidence intervals in 2008 indicate uncertainty (Table 43; Fig. 59 and 60). Cartwright Channel SSB was near the long term mean between 2006 and 2008 before declining by 46% to 19,200 t in 2009 (Table 43). The regression analysis (Fig 60) of SFA 5 SSB against Cartwright Channel SSB indicates that 85% of the variance in the data can be accounted for in a simple linear relationship.

Recruitment in the short term has been oscillating but appears to be average in both SFA 5 and Cartwright Channel (Tables 45 and 46; Fig. 65–67). The recruitment index for SFA 5 was approximately 8.0 billion animals in 2008 and approximately 5.9 billion animals in Cartwright Channel during 2009.

Survival and Mortality Rate Indices

The age based mortality rate analysis was based solely upon research survey data in Cartwright Channel. 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 0.67, 0.33 and 0.39 respectively (Table 48). As in SFA 6, these values appear reasonable as they do not imply excessively high densities of shrimp necessary to maintain the populations determined from research surveys and are similar to those found for the Gulf of St. Lawrence *P. borealis* (Frechette and LaBonte, 1981). This table indicates that survival has decreased by 17% in recent years (.69 in 2004 to .52 in 2007).

The analysis of primiparous and multiparous female abundance was conducted on observer length frequency data from the large and small vessel fishery. 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 0.36, 0.64 and 1.03 respectively (Table 19). This table indicates that survival has remained near the long term median for the past years.

Precautionary Approach

A plot of female spawning stock biomass (SSB) and catch presented over time, is put in the context of the provisional precautionary approach framework (Northern Shrimp IFMP, 2009) within figure 69. In terms of the precautionary approach framework, SSB was in the healthy zone in 2008, well above the provisional Upper Stock Reference (Fig. 69).

Status of the shrimp resource

Current status is uncertain. The distribution of the fishery has decreased over the last two years while the large vessel CPUE continues to fluctuate above the long term mean. There is concern that the SFA 5 survey fishable biomass index declined by 17% from 2006 to 2008 and decreased by 38% in 2009 in Cartwright Channel. The SFA 5 SSB index after 2000 was somewhat higher than before 2000; however, broad confidence intervals indicate uncertainty. Recruitment in the short-term, while uncertain, appears average. Exploitation rate index was 20% in 2008, slightly above the long term mean.

The 2009-10 exploitation rate index, for SFA 5 ($catch_{year}$/fishable $biomass_{previous\ year}$), has been near the long term mean since 2004 and was 19.4% in 2009-10.

In terms of the precautionary approach framework, SSB in SFA 5 was in the healthy zone in 2008, well above the provisional USR.

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 8,320 t in 1998 (Table 1; Fig. 70). The 1998 TAC allocated 2,184 t to the area south of 60°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 13,122 t TAC. The 2003-04 management year TAC (10,320 t) was maintained through to 2008-09 then increased to 11,320 t for the 2008-09 and 2009-10 management years. Preliminary data indicate that 10,700 t were taken during the 2009-10 management year (Table 2; Fig. 70 and 71).

The seasonality of the fishery has changed greatly over the years as ice conditions have changed. Prior to 2001, very little fishing occurred during the winter. After 2000, there has been an increased amount of fishing during the winter (Fig. 72).

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. 73). Percent total area within SFA 4 necessary for the large (>500 t) vessel fleet to obtain 95% of their catch has changed little since 1998 (Fig. 74) indicating that the fishery has been neither expanding nor contracting.

Catch Per Unit Effort (CPUE)

Two CPUE models were produced, an original and a proposed model. The original model made use of single trawls only, no windows, all months and vessels with at least a three year history in the fishery (Tables 50 and 51; Fig. 75 and 77). The proposed model made use of single trawl, July - December area, observer data, with no windows but vessels with a history greater than three years. As well there was an attempt to standardize tow data by time, footrope length and tow speed (Tables 52 and 53; Fig. 75).

The original model model accounted for approximately 63% of the variance in the data. The scatter of residuals around parameter estimates is provided in figure 76. 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. The catch rate has been oscillating along the long term mean with catch rates from 1991, 1994, 1997, 2001 being similar to 2009 catch rates while all other values, with the exception of 2001, were significantly below the 2009 catch rate (Table 51; Fig. 77).

The proposed CPUE model is presented in tables 52 and 53. It accounted for 83% in the variance in data; however, this model was not accepted because the model was restricted to certain months.

Size composition

Catch-at-length data for the 2000-09 period showed variable size distributions between years (Fig. 78). 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 300,000 animals per hour. The within year frequency weighted average carapace lengths for males ranged between 18.89 mm and 21.10 mm while the weighted average carapace lengths for females ranged between 23.23 mm and 24.61 mm. The average carapace length for males has decreased from 20.18 mm in 2006 to 18.89 mm in 2009. Similarly, the average size of females has been decreasing over time from 24.61 mm in 2003 to 23.23 mm in 2008 and remaining near that size in 2009. The decrease in size could be related to geographic shifts in the fishery. Licence conditions require that at least a certain percentage of the shrimp to be fished south of 60^{o}N.

Biomass from fishery data

As with the SFAs further south, the stratified analysis of large vessel commercial catch data indicates that not all strata are consistently occupied throughout the history of the fishery, and that important strata appear to remain important through much of the history (Table 54).   The important commercial depths range between 200-500 m which is similar to the more southerly SFAs. There was no analysis using index strata as there were only two strata that were consistently fished over time.

RESEARCH SURVEY DATA

Stock Size

Since 2005, five 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. Figures 79–81 present the NSRF-DFO research survey catches over the 2007–09 surveys.

Figure 82 presents the original and revised triangulation files used in Ogmap calculations. Please note that the original triangulation file extended into the Resolution Island Study Area, into depths greater than 800 m and south into SFA 5. The proposed triangulation file is restricted to the area within SFA 4 and depths shallower than 800 m, as well the triangulations are much denser because there were several more years of depth and positional data that could be used. Total biomass increased from 71,000 t (14 billion animals) in 2005 to 205,200 t (42 billion animals) in 2009 (Table 56; Fig. 83 and 84). The lower 95% confidence limit of the NAFO Division 2G total biomass index averaged 86,300 t (17 billion animals) between 2006 and 2009 (Table 56).

Most shrimp were found in 200-400 m depths (Tables 57–58; Fig. 79-81) and as in the more southern SFA's there was no evidence that the resource was becoming restricted either in depth or location.

Female spawning stock biomass (SSB) increased from 34,500 t (5 billion animals) in 2005 to 131,000 t (19 billion animals) in 2009. The lower 95% confidence limit of the NAFO Division 2G SSB index averaged 51,200 t (7 billion animals) between 2006 and 2009 (Table 59; Fig 85 and 86).

Fishable biomass increased from 62,300 t (12 billion animals) in 2005 to 179,500 t (33 billion animals) in 2009. The lower 95% confidence limit of the NAFO Division 2G fishable biomass index averaged 71,700 t (13 billion animals) between 2006 and 2009 (Table 60; Fig. 87 and 88).

Recruitment increased from 1 billion animals in 2005 to 4.7 billion in 2008 then decreased slightly to 4.3 billion animals in 2009 (Table 61; Fig. 89). 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 (Fig 32, 65 and 90). As numbers decrease, the amount of clogging of the net, by shrimp and other organisms, decreases resulting a greater loss of small shrimp through the large 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 91 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 always 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. Juvenile shrimp net samples may provide a reliable recruitment index, in the future.

Exploitation Rates

Exploitation rate indices were determined using ratios of catch divided by the within year's survey index. The within year survey indices is 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 62). Figure 92 presents the exploitation rate index determined as catch/ previous year's fishable biomass index. The 2009 exploitation rate index, for SFA 4 ($catch_{year}$/fishable biomass $_{year}$), was 5.94%. If the exploitation rate index was based upon number of shrimp taken versus fishable abundance (proposed method) then the 2009 exploitation rate index would have been 4.92%.

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 Division 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 and that the present fishery has not had enough of an impact to halt this increase.

Survival and Mortality Rate Indices

The analysis of primiparous and multiparous female abundance was conducted on observer length frequency data from the large and small vessel fishery. 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 0.64, 0.36 and 0.45 respectively (Table 63). This table indicates that survival is higher in SFA 4 than in either SFA 5 or 6. This is reasonable because shrimp are larger and are believed to live longer in the north.

Precautionary Approach

A plot of female spawning stock biomass (SSB) and catch presented over time, is put in the context of the provisional precautionary approach framework (Northern Shrimp IFMP, 2009) within figure 93. In terms of the precautionary approach framework, SSB was in the healthy zone in 2009, well above the provisional Upper Stock Reference.

RESOURCE STATUS

Current status appears positive from fishery and survey indices. Recent catch rates have been increasing and are above the long term mean (Tables 50 and 51; Fig. 77). All of the survey indices are trending upward; however, confidence intervals around the 2009 survey indices are broad indicating uncertainty (Tables 56, and 59–61. Fig. 83–89).

In terms of the precautionary approach framework, SSB in SFA 4 was in the healthy zone in 2009, well above the provisional USR (Fig. 93).

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 (SFAs 5 and 6) because, due to vessel problems, they were finished in January or early February rather than during December.

While there is an attempt to standardize the surveys both in terms of Campelen trawl measurement and fishing protocols, there is the persistent problem of various vessels surveying the study area from NAFO Divisions 2H–3K. The CGGS Teleost starts the survey in October in the northern part of 2J and works south until it meets either the CGGS Wilfred Templeman or the CGGS Alfred Needler as they survey northward.

While the CGGS Wilfred Templeman and CGGS Alfred Needler are sister ships, there has been no attempt to model the comparative abilities of these ships to capture shrimp.

Various methods were explored to determine shrimp mortality rates; however, only mortality rates for females were accepted. Further work must be completed before male mortality rates become available.

Lack of complete research surveys in SFA 5 is a substantial source of uncertainty for this area.

The shortness of the survey time series, lack of dynamic range and lack of stock-recruit relationship within these data, 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 and work to date on reference points has been provisional.

Harvest control rules within the precautionary approach framework (DFO, 2010) are based upon percentages of F_{msy}. However, F_{msy} has not been estimated and a Management Strategy Evaluation should be completed before the provisional framework can be accepted.

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

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Table 1. Quotas (t) Northern shrimp (*Pandalus borealis*) by Shrimp Fishing Area (SFA), 1978 - 2009

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			23,125	43,625
1998	8,320	15,300			46,200	69,820
1999	8,320	15,300			58,632	82,252
2000	8,320	15,300			60,357	83,977
2001	8,359	15,300			61,623	85,282
2002	8,320	15,300			61,632	85,252
2003	13,122***	33,084**			85,575**	131,781
2004	10,320	23,300			77,932	111,552
2005	10,330	23,301			78,517	112,148
2006	10,240	22,987			76,728	109,955
2007	10,319	23,300			77,932	111,551
2008	11,319	23,300			85,725	120,344
2009	11,320	23,300			85,725	120,345

** 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 - 2009

YEAR	DIV2G	HOPE	CART	HAWKE	DIV3K	TOTAL
	SFA4	SFA5		SFA6		
1977	-	1,272	1,414	<1	<1	2,686
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	-	1,988
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		7,650		10,914	23,668
1996	5,160		7,650		10,923	23,733
1997	5,216		15,103		21,018	41,337
1998	8,051		15,170		46,337	69,558
1999	7,884		15,109		51,260	74,253
2000	7,382		14,694		62,581	84,657
2001	8,117		15,116		52,590	75,823
2002	8,387		15,339		60,384	84,110
2003	13,020		30,437		71,227	114,684
2004	9,644		22,690		77,820	110,154
2005	10,247		22,904		75,231	108,382
2006	10,084		22,612		75,673	108,369
2007	10,009		23,768		80,736	114,513
2008	10,735		21,658		75,080	107,473
2009 [1]	10,664		24,883		45,117	80,664

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

¹ Preliminary data

TABLE 3. ORIGINAL MODEL NORTHERN SHRIMP LARGE VESSEL (>500 t) SHRIMP FISHERY DATA FOR HAWKE CHANNEL + 3K (SFA 6), 1977 - 2009. (08 model; single double trawl, observer data, no windows, history>3yrs)

YEAR	TAC[1] (t)	FLEET CATCH[2] (t)	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE RELATIVE TO 2009	EFFORT[3] (HR)	STANDARDIZED CPUE RELATIVE TO 2009	STANDARDIZED 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	829	0.55	8,040	0.86	852	7,819
1990	5,600	5,598	592	0.39	9,452	0.60	595	9,414
1991	4,301	5,500	454	0.30	12,126	0.49	489	11,255
1992	7,565	6,609	574	0.38	11,511	0.50	501	13,189
1993	9,180	8,035	724	0.48	11,102	0.70	694	11,572
1994	11,050	10,978	1,204	0.80	9,117	0.93	924	11,878
1995	11,050	10,914	1,521	1.01	7,175	1.25	1,241	8,795
1996	11,050	10,923	1,518	1.01	7,198	1.32	1,311	8,332
1997	15,360	14,954	1,470	0.98	10,171	1.61	1,607	9,303
1998	16,360	16,264	1,377	0.91	11,808	1.39	1,387	11,729
1999	17,603	17,587	1,402	0.93	12,545	1.37	1,361	12,925
2000	18,828	20,021	1,480	0.98	13,524	1.53	1,527	13,112
2001	20,103	19,905	1,581	1.05	12,593	1.53	1,527	13,038
2002	20,103	20,520	1,450	0.96	14,156	1.33	1,326	15,479
2003	33,276	29,371	1,686	1.12	17,424	1.32	1,310	22,412
2004	25,333	24,504	1,746	1.16	14,036	1.31	1,304	18,794
2005	26,031	25,500	1,800	1.19	14,166	1.35	1,346	18,945
2006	24,888	24,856	1,948	1.29	12,762	1.51	1,505	16,513
2007	27,706	27,518	1,871	1.24	14,708	1.42	1,410	19,518
2008	19,906	17,316	1,848	1.23	9,372	1.28	1,274	13,590
2009	31,737	18,205	1,508	1.00	12,075	1.00	995	18,288

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

[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.

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

Table 4. **Original Multiplicative** year, month, vessel, gear, area CPUE model for large vessels (>500 t) fishing for shrimp in Hawke Channel + 3K (SFA 6), 1989-2009, weighted by effort (Single + double trawls, observer data, no windows, history > 3 years). The results came from the same model specifications used in the 2008 Northern Shrimp assessment.

```
                                       The GLM Procedure
                                    Class Level Information
Class       Levels  Values
year            21  1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002
                         2003 2004 2005 2006 2007 2008 2009
month           12  1 2 3 4 5 7 8 9 10 11 12 13 Standardized to June
CFV             20
gear             2  2 10 (code 2 = single trawl while 10 = double trawl)
Area           6  67 68 69 90 92 99 Standardized to Hawke Channel

                            Number of Observations Read        2643
                            Number of Observations Used        2643
Dependent Variable: lncpue
Weight: effort
                                               Sum of
      Source                      DF          Squares     Mean Square    F Value    Pr > F
      Model                       56      23002.64744       410.76156      76.82    <.0001
      Error                     2586      13828.36313         5.34739
      Corrected Total           2642      36831.01057

                      R-Square     Coeff Var      Root MSE    lncpue Mean
                      0.624546      30.95307      2.312443       7.470805

      Source                      DF        Type I SS     Mean Square    F Value    Pr > F
      year                        20      8277.934519      413.896726      77.40    <.0001
      month                       11      6927.951048      629.813732     117.78    <.0001
      CFV                         19      6436.068626      338.740454      63.35    <.0001
      gear                         1      1035.021496     1035.021496     193.56    <.0001
      area                         5       325.671753       65.134351      12.18    <.0001

      Source                      DF      Type III SS     Mean Square    F Value    Pr > F
      year                        20      4160.635132      208.031757      38.90    <.0001
      month                       11      5858.326164      532.575106      99.60    <.0001
      CFV                         19      4958.459461      260.971551      48.80    <.0001
      gear                         1      1063.749234     1063.749234     198.93    <.0001
      area                         5       325.671753       65.134351      12.18    <.0001
```

Table 4 (cont'd)

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		7.116860388 B	0.04979468	142.92	<.0001
year	1989	-0.155655278 B	0.12782538	-1.22	0.2234
year	1990	-0.515225600 B	0.13114444	-3.93	<.0001
year	1991	-0.711542610 B	0.08641447	-8.23	<.0001
year	1992	-0.686426545 B	0.09987032	-6.87	<.0001
year	1993	-0.360239167 B	0.06405542	-5.62	<.0001
year	1994	-0.074294203 B	0.04671144	-1.59	0.1118
year	1995	0.220399192 B	0.04953263	4.45	<.0001
year	1996	0.275286223 B	0.05117058	5.38	<.0001
year	1997	0.479124713 B	0.04835529	9.91	<.0001
year	1998	0.331402887 B	0.04555826	7.27	<.0001
year	1999	0.312554801 B	0.04424723	7.06	<.0001
year	2000	0.427809654 B	0.04323131	9.90	<.0001
year	2001	0.427584935 B	0.04418237	9.68	<.0001
year	2002	0.286433903 B	0.04230547	6.77	<.0001
year	2003	0.274924662 B	0.04236873	6.49	<.0001
year	2004	0.269854145 B	0.04221027	6.39	<.0001
year	2005	0.301625353 B	0.04037716	7.47	<.0001
year	2006	0.413468908 B	0.04146325	9.97	<.0001
year	2007	0.348040214 B	0.03951795	8.81	<.0001
year	2008	0.246804400 B	0.04402070	5.61	<.0001
year	2009	0.000000000 B	.	.	.
month	1	0.403754793 B	0.03437939	11.74	<.0001
month	2	0.628588087 B	0.03069867	20.48	<.0001
month	3	0.501872967 B	0.02935050	17.10	<.0001
month	4	0.416350906 B	0.03015959	13.80	<.0001
month	5	0.076308199 B	0.03151327	2.42	0.0155
month	7	0.025069177 B	0.03712556	0.68	0.4996
month	8	0.082909191 B	0.03892141	2.13	0.0333
month	9	0.032453436 B	0.03882319	0.84	0.4033
month	10	0.049193571 B	0.03987042	1.23	0.2174
month	11	0.066271742 B	0.05848011	1.13	0.2572
month	12	-0.062032782 B	0.04025092	-1.54	0.1234
month	13	0.000000000 B	.	.	.
CFV		0.294329635 B	0.03898585	7.55	<.0001
CFV		0.178936945 B	0.03462685	5.17	<.0001
CFV		-0.003837749 B	0.03607629	-0.11	0.9153
CFV		0.199315072 B	0.04551539	4.38	<.0001
CFV		0.143234854 B	0.05515043	2.60	0.0095
CFV		0.114840755 B	0.03443944	3.33	0.0009
CFV		0.001956598 B	0.04066054	0.05	0.9616
CFV		0.167628760 B	0.03132614	5.35	<.0001
CFV		-0.090373340 B	0.04230375	-2.14	0.0327
CFV		0.055912543 B	0.04248750	1.32	0.1883
CFV		0.120795983 B	0.04046428	2.99	0.0029
CFV		-0.377858698 B	0.04850553	-7.79	<.0001
CFV		0.288416505 B	0.04280043	6.74	<.0001
CFV		0.211932683 B	0.03614950	5.86	<.0001
CFV		0.328595024 B	0.03694389	8.89	<.0001
CFV		-0.237582573 B	0.03730382	-6.37	<.0001
CFV		-0.242950257 B	0.03681852	-6.60	<.0001
CFV		-0.547710920 B	0.04023361	-13.61	<.0001
CFV		-0.300509610 B	0.05030109	-5.97	<.0001
CFV		0.000000000 B	.	.	.
gear	2	-0.291251098 B	0.02064995	-14.10	<.0001

Table 4 (cont'd)

Parameter		Estimate		Standard Error	t Value	Pr > |t|
gear	10	0.000000000	B	.	.	.
area	67	-0.060253184	B	0.01821730	-3.31	0.0010
area	68	-0.062129938	B	0.01966165	-3.16	0.0016
area	69	-0.366825548	B	0.06473413	-5.67	<.0001
area	90	-0.057583196	B	0.03283083	-1.75	0.0796
area	92	-1.063120713	B	0.24442905	-4.35	<.0001
area	99	0.000000000	B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
1989	6.747576	6.492462	7.002690
1990	6.388006	6.128505	6.647506
1991	6.191689	6.019442	6.363935
1992	6.216805	6.015691	6.417919
1993	6.542992	6.412226	6.673759
1994	6.828937	6.725239	6.932636
1995	7.123630	7.015154	7.232107
1996	7.178518	7.066887	7.290148
1997	7.382356	7.277309	7.487403
1998	7.234634	7.133430	7.335839
1999	7.215786	7.116464	7.315108
2000	7.331041	7.232515	7.429567
2001	7.330816	7.230755	7.430877
2002	7.189665	7.092143	7.287187
2003	7.178156	7.078095	7.278217
2004	7.173085	7.076192	7.269979
2005	7.204857	7.111375	7.298338
2006	7.316700	7.218536	7.414864
2007	7.251272	7.156057	7.346486
2008	7.150036	7.046975	7.253096
2009	6.903231	6.795729	7.010733

TABLE 5. PROPOSED MODEL NORTHERN SHRIMP LARGE VESSEL (>500 t) SHRIMP FISHERY DATA FOR HAWKE CHANNEL + 3K (SFA 6), 1977 - 2009. (Single + double trawl, observer data, no windows, history>3yrs, Jan - June data)

YEAR	TAC [1] (t)	FLEET [2] CATCH (t)	UNSTANDARDIZED CPUE (KG/HR)	CPUE RELATIVE TO 2009	EFFORT [3] (HR)	STANDARDIZED CPUE RELATIVE TO 2009	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	1,150	0.56	5,794	0.64	1,169	5,698
1990	5,600	5,598	708	0.34	7,902	0.42	772	7,254
1991	4,301	5,500	664	0.32	8,282	0.37	676	8,131
1992	7,565	6,609	1,452	0.71	4,553	0.74	1,355	4,878
1993	9,180	8,035	920	0.45	8,730	0.50	911	8,821
1994	11,050	10,978	1,453	0.71	7,554	0.72	1,323	8,300
1995	11,050	10,914	1,325	0.64	8,237	0.69	1,268	8,605
1996	11,050	10,923	1,619	0.79	6,745	0.81	1,487	7,348
1997	15,360	14,954	1,299	0.63	11,516	0.72	1,314	11,377
1998	16,360	16,264	1,520	0.74	10,702	0.84	1,534	10,599
1999	17,603	17,587	1,583	0.77	11,107	0.89	1,634	10,761
2000	18,828	20,021	1,698	0.82	11,792	0.89	1,628	12,298
2001	20,103	19,905	1,690	0.82	11,777	0.87	1,583	12,571
2002	20,103	20,520	1,752	0.85	11,712	0.88	1,612	12,731
2003	33,276	29,371	1,972	0.96	14,897	0.92	1,691	17,370
2004	25,333	24,504	2,064	1.00	11,871	1.00	1,823	13,443
2005	26,031	25,500	2,218	1.08	11,495	1.07	1,952	13,062
2006	24,888	24,856	2,229	1.08	11,151	1.09	1,997	12,444
2007	27,706	27,518	2,259	1.10	12,181	1.13	2,075	13,263
2008	19,906	17,316	2,370	1.15	7,306	1.15	2,101	8,241
2009	31,737	18,205	2,059	1.00	8,843	1.00	1,829	9,955

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

[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.

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

Table 6 **PROPOSED** Multiplicative year, month, vessel, gear, area CPUE model for large vessels (>500 t) fishing for shrimp in Hawke Channel + 3K (SFA 6), 1989-2009, weighted by effort (Single + double trawls, year, month area, observer data, no windows, history > 3 years; Funk Island Deep removed from analysis). This model differs from that presented in Table 3 by being restricted to the first six months of the year, classes had to have a minimum of at least 10 hours of activity and activity within Funk Island Deep was removed as it was not fished to a great extent by the large vessels and in latter years was voluntarily closed. As well there was an attempt to standardize tow data by time, footrope length and tow speed.

```
                                    The GLM Procedure
                                 Class Level Information
Class       Levels  Values

year            21  1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002    2003
                       2004 2005 2006 2007 2008 2009
month            6  1 2 3 4 5 6  *Standardized to June
CFV             20
Area             5  67 68 69 90 99 *Standardized to Hawke Channel; note that Funk Island
             Deep has been removed from this formulation

                         Number of Observations Read        1210
                         Number of Observations Used        1210

Dependent Variable: lncpue
Weight: effort
                                              Sum of
      Source                      DF         Squares     Mean Square    F Value    Pr > F
      Model                       48     14345.88265       298.87256      91.48    <.0001
      Error                     1161      3792.94990         3.26697
      Corrected Total           1209     18138.83255

                      R-Square     Coeff Var      Root MSE    lncpue Mean
                      0.790893      24.04719      1.807476       7.516368

      Source                      DF       Type I SS     Mean Square    F Value    Pr > F
      year                        20     7701.576007      385.078800     117.87    <.0001
      month                        5      822.262578      164.452516      50.34    <.0001
      CFV                         19     5773.701011      303.879001      93.02    <.0001
      area                         4       48.343050       12.085762       3.70    0.0053

      Source                      DF     Type III SS     Mean Square    F Value    Pr > F
      year                        20     2351.741911      117.587096      35.99    <.0001
      month                        5      538.107816      107.621563      32.94    <.0001
      CFV                         19     5777.080218      304.056854      93.07    <.0001
      area                         4       48.343050       12.085762       3.70    0.0053
```

Table 6 (Cont'd)

Parameter		Estimate	Standard Error	t Value	Pr > |t|
Intercept		7.452365754 B	0.04056859	183.70	<.0001
year	1989	-0.447310914 B	0.10164816	-4.40	<.0001
year	1990	-0.862758119 B	0.10898840	-7.92	<.0001
year	1991	-0.994499482 B	0.07012295	-14.18	<.0001
year	1992	-0.299946913 B	0.12383487	-2.42	0.0156
year	1993	-0.696956734 B	0.05755238	-12.11	<.0001
year	1994	-0.323908976 B	0.03839349	-8.44	<.0001
year	1995	-0.365871446 B	0.04068785	-8.99	<.0001
year	1996	-0.207137765 B	0.04221964	-4.91	<.0001
year	1997	-0.330204107 B	0.04599002	-7.18	<.0001
year	1998	-0.175422338 B	0.03909790	-4.49	<.0001
year	1999	-0.112384027 B	0.03719400	-3.02	0.0026
year	2000	-0.116240179 B	0.03691760	-3.15	0.0017
year	2001	-0.144037617 B	0.03724334	-3.87	0.0001
year	2002	-0.126197881 B	0.03754435	-3.36	0.0008
year	2003	-0.078321430 B	0.03572197	-2.19	0.0285
year	2004	-0.003234005 B	0.03833210	-0.08	0.9328
year	2005	0.065370103 B	0.03483524	1.88	0.0608
year	2006	0.088255900 B	0.03618178	2.44	0.0149
year	2007	0.126232942 B	0.03318214	3.80	0.0001
year	2008	0.138892020 B	0.03684793	3.77	0.0002
year	2009	0.000000000 B	.	.	.
month	1	0.169947838 B	0.02761504	6.15	<.0001
month	2	0.249640575 B	0.02409902	10.36	<.0001
month	3	0.204372867 B	0.02327546	8.78	<.0001
month	4	0.176766218 B	0.02415578	7.32	<.0001
month	5	0.044329984 B	0.02531249	1.75	0.0802
month	6	0.000000000 B	.	.	.
CFV		0.197785158 B	0.03435897	5.76	<.0001
CFV		0.112807747 B	0.02952602	3.82	0.0001
CFV		0.044420581 B	0.02966842	1.50	0.1346
CFV		0.266651210 B	0.03872627	6.89	<.0001
CFV		0.240232534 B	0.04987207	4.82	<.0001
CFV		0.191926851 B	0.03045774	6.30	<.0001
CFV		-0.106968137 B	0.03474634	-3.08	0.0021
CFV		0.223524107 B	0.02660916	8.40	<.0001
CFV		-0.239463232 B	0.03903755	-6.13	<.0001
CFV		-0.016442932 B	0.03668228	-0.45	0.6541
CFV		0.036064673 B	0.03848412	0.94	0.3489
CFV		-0.655804423 B	0.04342591	-15.10	<.0001
CFV		0.247450114 B	0.03443688	7.19	<.0001
CFV		0.250260784 B	0.03155076	7.93	<.0001
CFV		0.285818769 B	0.03313168	8.63	<.0001
CFV		-0.486813013 B	0.03375601	-14.42	<.0001
CFV		-0.554931343 B	0.03115328	-17.81	<.0001
CFV		-0.207992373 B	0.04060969	-5.12	<.0001
CFV		-0.159101875 B	0.04438923	-3.58	0.0004
CFV		0.000000000 B	.	.	.
Area	67	-0.036512137 B	0.01810153	-2.02	0.0439
Area	68	-0.043762872 B	0.01832311	-2.39	0.0171
Area	69	-0.210811370 B	0.07244917	-2.91	0.0037
Area	90	-0.035526683 B	0.02807438	-1.27	0.2060
Area	99	0.000000000 B	.	.	.

Table 6. (Cont'd)

year	lncpue LSMEAN	95% Confidence Limits	
1989	7.064046	6.871249	7.256843
1990	6.648599	6.442050	6.855148
1991	6.516858	6.389954	6.643762
1992	7.211410	6.973802	7.449018
1993	6.814401	6.718486	6.910315
1994	7.187448	7.131646	7.243251
1995	7.145486	7.083904	7.207068
1996	7.304220	7.238419	7.370020
1997	7.181153	7.106127	7.256179
1998	7.335935	7.276518	7.395352
1999	7.398973	7.344928	7.453018
2000	7.395117	7.338829	7.451405
2001	7.367320	7.309889	7.424751
2002	7.385159	7.326044	7.444275
2003	7.433036	7.376137	7.489935
2004	7.508123	7.449524	7.566723
2005	7.576727	7.529061	7.624394
2006	7.599613	7.542348	7.656879
2007	7.637590	7.587928	7.687252
2008	7.650249	7.593204	7.707295
2009	7.511357	7.449012	7.573702

TABLE 7. ORIGINAL MODEL NORTHERN SHRIMP SMALL VESSEL (<500 t; loa<100') SHRIMP FISHERY DATA FOR HAWKE CHANNEL + 3K (SFA 6), 1997 - 2009. (Single trawl, year, size-class, month and area logbook data)

YEAR	[1] TAC (t)	FLEET[2] CATCH (t)	UNSTANDARDIZED CPUE (KG/HR)	CPUE RELATIVE TO 2009	[3] EFFORT (HR)	STANDARDIZED CPUE RELATIVE TO 2009	MODELLED CPUE	EFFORT (HRS)
1997	7,765	6,064						
1998	29,840	30,073	333	0.90	90,420	0.88	330	91,054
1999	41,029	33,673	317	0.86	106,173	0.87	326	103,274
2000	41,529	42,560	378	1.03	112,575	1.00	375	113,552
2001	41,520	32,685	350	0.95	93,451	1.00	375	87,212
2002	41,529	39,863	310	0.84	128,428	0.89	333	119,624
2003	52,299	41,856	332	0.90	126,010	0.91	341	122,650
2004	52,599	53,316	490	1.33	108,919	1.30	486	109,698
2005	52,487	49,732	515	1.40	96,632	1.37	513	96,959
2006	51,293	50,817	526	1.43	96,547	1.37	514	98,930
2007	52,599	53,218	546	1.48	97,409	1.43	537	99,115
2008	59,613	57,764	492	1.34	117,442	1.26	474	121,787
2009	58,823	26,922	368	1.00	73,080	1.00	375	71,785

[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 8. **ORIGINAL** Multiplicative year, month, vessel size and area CPUE model for small vessels (<=500 t; LOA<=100') fishing shrimp in Hawke Channel + 3K, 1998-2009, weighed by effort (Logbook data, history > 3 yrs). 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	12	1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
month	6	5 6 8 9 10 13 Standardized against July
size_class	3	1 2 3
area	7	67 68 80 90 91 92 100 Standardized against area 69 which is in the southeastern portion of the SFA

Number of Observations Read 1052
Number of Observations Used 1017

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	24	56230.18376	2342.92432	89.18	<.0001
Error	992	26062.25682	26.27244		
Corrected Total	1016	82292.44057			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.683297	84.71012	5.125664	6.050829

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Year	11	44209.64945	4019.05904	152.98	<.0001
Month	5	2760.03585	552.00717	21.01	<.0001
size_class	2	5889.85011	2944.92506	112.09	<.0001
area	6	3370.64836	561.77473	21.38	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Year	11	29565.83315	2687.80301	102.31	<.0001
Month	5	3699.23288	739.84658	28.16	<.0001
size_class	2	5982.48546	2991.24273	113.85	<.0001
area	6	3370.64836	561.77473	21.38	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		6.127092610	B	0.03024089	202.61	<.0001
Year	1998	-0.127089417	B	0.03400588	-3.74	0.0002
Year	1999	-0.139955788	B	0.03250640	-4.31	<.0001
Year	2000	-0.000614351	B	0.03217473	-0.02	0.9848
Year	2001	-0.000691168	B	0.03337108	-0.02	0.9835
Year	2002	-0.118158746	B	0.03123322	-3.78	0.0002
Year	2003	-0.094357046	B	0.03086229	-3.06	0.0023
Year	2004	0.259237303	B	0.03160012	8.20	<.0001
Year	2005	0.313087172	B	0.03209356	9.76	<.0001
Year	2006	0.314549134	B	0.03206741	9.81	<.0001
Year	2007	0.358852296	B	0.03197703	11.22	<.0001
Year	2008	0.234835601	B	0.03091389	7.60	<.0001
Year	2009	0.000000000	B	.	.	.

Table 8 (Cont'd)

month	5	-0.065718328 B	0.02114191	-3.11	0.0019
month	6	-0.079109547 B	0.01677137	-4.72	<.0001
month	8	0.032143012 B	0.01548811	2.08	0.0382
month	9	-0.083084854 B	0.01719639	-4.83	<.0001
month	10	-0.196114201 B	0.02171403	-9.03	<.0001
month	13	0.000000000 B	.	.	.
size_class	1	-0.260029809 B	0.01862194	-13.96	<.0001
size_class	2	-0.103788710 B	0.01102077	-9.42	<.0001
size_class	3	0.000000000 B	.	.	.
area	67	0.055426540 B	0.02401100	2.31	0.0212
area	68	0.112822999 B	0.04583018	2.46	0.0140
area	80	-0.066079747 B	0.01845881	-3.58	0.0004
area	90	-0.148558613 B	0.01818849	-8.17	<.0001
area	91	0.044868236 B	0.06198839	0.72	0.4693
area	92	-0.092874368 B	0.01316816	-7.05	<.0001
area	100	0.000000000 B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
1998	5.799931	5.754748	5.845115
1999	5.787065	5.744457	5.829673
2000	5.926406	5.884793	5.968020
2001	5.926330	5.882147	5.970512
2002	5.808862	5.769473	5.848251
2003	5.832664	5.793041	5.872286
2004	6.186258	6.143969	6.228547
2005	6.240108	6.196273	6.283943
2006	6.241570	6.197567	6.285572
2007	6.285873	6.243167	6.328580
2008	6.161856	6.120798	6.202915
2009	5.927021	5.869291	5.984751

TABLE 9. PROPOSED MODEL NORTHERN SHRIMP SMALL VESSEL (<500 t; loa<100') SHRIMP FISHERY DATA FOR HAWKE CHANNEL + 3K (SFA 6), 1997 - 2009. (Single trawl, year, month, year X month interactions, size-class and area logbook data)

YEAR	TAC [1] (t)	FLEET CATCH [2] (t)	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE RELATIVE TO 2009	EFFORT [3] (HR)	STANDARDIZED CPUE RELATIVE TO 2009	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1997	7,765	6,064						
1998	29,840	30,073	333	0.90	90,420	0.89	351	85,691
1999	41,029	33,673	317	0.86	106,173	0.89	350	96,173
2000	41,529	42,560	378	1.03	112,575	0.99	389	109,488
2001	41,520	32,685	350	0.95	93,451	0.95	374	87,501
2002	41,529	39,863	310	0.84	128,428	0.85	333	119,799
2003	52,299	41,856	332	0.90	126,010	0.88	346	120,806
2004	52,599	53,316	490	1.33	108,919	1.22	480	111,008
2005	52,487	49,732	515	1.40	96,632	1.31	514	96,699
2006	51,293	50,817	526	1.43	96,547	1.32	520	97,780
2007	52,599	53,218	546	1.48	97,409	1.43	562	94,770
2008	59,613	57,764	492	1.34	117,442	1.25	491	117,612
2009	58,823	26,922	368	1.00	73,080	1.00	394	68,375

[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 10. **PROPOSED** multiplicative year, month, year - month interactions, vessel size and area CPUE model for small vessels (<=500 t; LOA<=100') fishing shrimp in Hawke Channel + 3K, 1998-2009, weighed by effort (Logbook data, history > 3 yrs). 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             12    1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
     month             6    5 6 8 9 10 13  *Standardized to July
     size_class        3    1 2 3
     Area              7    67 68 80 90 91 92 100 Standardized against area 69 which is
                in the southeastern portion of the SFA
                           Number of Observations Read        1055
                           Number of Observations Used        1020
Dependent Variable: cpue
Weight: effort
                                         Sum of
      Source                      DF          Squares     Mean Square    F Value    Pr > F
      Model                       79      12202156354       154457675      43.72    <.0001
      Error                      940       3320822544         3532790
      Corrected Total           1019      15522978898

                     R-Square     Coeff Var      Root MSE     cpue Mean
                     0.786071      427.3100      1879.572      439.8614

      Source                      DF       Type I SS     Mean Square    F Value    Pr > F
      year                       11      8670108622       788191693     223.11    <.0001
      month                       5       680500109       136100022      38.52    <.0001
      year*month                 55      1252737871        22777052       6.45    <.0001
      size_class                  2      1024814443       512407221     145.04    <.0001
      area                        6       573995310        95665885      27.08    <.0001

      Source                      DF     Type III SS     Mean Square    F Value    Pr > F
      year                       11      3085708454       280518950      79.40    <.0001
      month                       5       335660862        67132172      19.00    <.0001
      year*month                 55      1307132704        23766049       6.73    <.0001
      size_class                  2      1020661159       510330580     144.46    <.0001
      area                        6       573995310        95665885      27.08    <.0001

                                                    Standard
         Parameter               Estimate              Error    t Value    Pr > |t|
         Intercept            501.4771169 B      21.0349996      23.84      <.0001
         year        1998    -120.8284429 B      26.0085642      -4.65      <.0001
         year        1999    -117.8436548 B      23.8531213      -4.94      <.0001
         year        2000     -53.7235240 B      23.1323651      -2.32      0.0204
         year        2001    -105.3097189 B      37.1662194      -2.83      0.0047
         year        2002    -119.5227269 B      26.3239214      -4.54      <.0001
         year        2003     -76.9086135 B      26.9349811      -2.86      0.0044
         year        2004     125.8410432 B      23.9202419       5.26      <.0001
         year        2005     120.3590403 B      23.8022717       5.06      <.0001
         year        2006     123.7790184 B      24.9732456       4.96      <.0001
         year        2007     118.8073312 B      23.8427685       4.98      <.0001
         year        2008     114.7953669 B      24.8553015       4.62      <.0001
         year        2009       0.0000000 B        .               .          .
```

Table 10. (cont'd)

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Month	5	-26.1871728	B	134.0382105	-0.20	0.8451
month	6	-97.7400783	B	41.1915581	-2.37	0.0179
month	8	-36.5462626	B	25.1311392	-1.45	0.1462
month	9	-112.4278638	B	27.7687397	-4.05	<.0001
month	10	-85.2362595	B	52.8037919	-1.61	0.1068
month	13	0.0000000	B	.	.	.
year*month	1998 5	22.4674112	B	137.7241548	0.16	0.8704
year*month	1998 6	148.0787889	B	51.0505583	2.90	0.0038
year*month	1998 8	35.4967248	B	32.3651627	1.10	0.2730
year*month	1998 9	153.5965796	B	37.2964156	4.12	<.0001
year*month	1998 10	108.5614126	B	58.5076080	1.86	0.0638
year*month	1998 13	0.0000000	B	.	.	.
year*month	1999 5	90.6286091	B	138.5008033	0.65	0.5130
year*month	1999 6	93.2346573	B	46.3237434	2.01	0.0444
year*month	1999 8	63.2549217	B	30.7080024	2.06	0.0397
year*month	1999 9	137.7289833	B	34.2958530	4.02	<.0001
year*month	1999 10	60.5403262	B	61.8223547	0.98	0.3277
year*month	1999 13	0.0000000	B	.	.	.
year*month	2000 5	76.5444125	B	135.4850240	0.56	0.5722
year*month	2000 6	46.7129928	B	45.1159550	1.04	0.3007
year*month	2000 8	56.1341353	B	29.8678712	1.88	0.0605
year*month	2000 9	55.6017210	B	49.8226916	1.12	0.2647
year*month	2000 10	57.2115651	B	101.6545327	0.56	0.5737
year*month	2000 13	0.0000000	B	.	.	.
year*month	2001 5	44.9903794	B	138.4226579	0.33	0.7452
year*month	2001 6	138.1235178	B	52.5999793	2.63	0.0088
year*month	2001 8	64.7717836	B	56.1374295	1.15	0.2489
year*month	2001 9	181.1160511	B	50.1167360	3.61	0.0003
year*month	2001 10	81.6509131	B	62.6464126	1.30	0.1928
year*month	2001 13	0.0000000	B	.	.	.
year*month	2002 5	50.5533851	B	135.6593854	0.37	0.7095
year*month	2002 6	127.7169741	B	45.5614653	2.80	0.0052
year*month	2002 8	40.4168394	B	50.5982219	0.80	0.4246
year*month	2002 9	112.0545862	B	34.3284589	3.26	0.0011
year*month	2002 10	20.4679292	B	57.3819954	0.36	0.7214
year*month	2002 13	0.0000000	B	.	.	.
year*month	2003 5	-23.4610596	B	136.0104248	-0.17	0.8631
year*month	2003 6	51.3378245	B	48.2226007	1.06	0.2873
year*month	2003 8	33.8124558	B	32.8884505	1.03	0.3042
year*month	2003 9	96.7563686	B	34.2928549	2.82	0.0049
year*month	2003 10	19.4144380	B	58.3614583	0.33	0.7395
year*month	2003 13	0.0000000	B	.	.	.
year*month	2004 5	-206.1538517	B	138.2203590	-1.49	0.1362
year*month	2004 6	-53.5660075	B	46.2062636	-1.16	0.2466
year*month	2004 8	15.0489697	B	29.8836176	0.50	0.6147
year*month	2004 9	38.9077640	B	34.1360833	1.14	0.2547
year*month	2004 10	-29.9764261	B	58.6725153	-0.51	0.6095
year*month	2004 13	0.0000000	B	.	.	.
year*month	2005 5	-49.4430350	B	140.5675611	-0.35	0.7251
year*month	2005 6	53.7864645	B	45.7624123	1.18	0.2402
year*month	2005 8	49.5733453	B	30.5874444	1.62	0.1054
year*month	2005 9	24.1549860	B	35.5615229	0.68	0.4971
year*month	2005 10	-76.8969493	B	57.5628233	-1.34	0.1819
year*month	2005 13	0.0000000	B	.	.	.

Table 10. (cont'd)

Parameter		Estimate		Standard Error	t Value	Pr > |t|
year*month	2006 5	-30.2513923	B	136.2795681	-0.22	0.8244
year*month	2006 6	57.1591380	B	46.1668860	1.24	0.2160
year*month	2006 8	33.7927845	B	31.5507475	1.07	0.2844
year*month	2006 9	40.6090593	B	34.6147728	1.17	0.2410
year*month	2006 10	-88.1740940	B	62.2088593	-1.42	0.1567
year*month	2006 13	0.0000000	B	.	.	.
year*month	2007 5	-101.6450413	B	139.0273141	-0.73	0.4649
year*month	2007 6	8.2660269	B	44.9743735	0.18	0.8542
year*month	2007 8	160.5788896	B	30.5604853	5.25	<.0001
year*month	2007 9	97.0783004	B	35.0701925	2.77	0.0057
year*month	2007 10	129.7109314	B	72.2465757	1.80	0.0729
year*month	2007 13	0.0000000	B	.	.	.
year*month	2008 5	31.0139540	B	137.1451998	0.23	0.8211
year*month	2008 6	14.0082755	B	45.5258398	0.31	0.7584
year*month	2008 8	20.4471205	B	30.8127873	0.66	0.5071
year*month	2008 9	-47.8357912	B	33.8335162	-1.41	0.1577
year*month	2008 10	-122.0010123	B	60.3283831	-2.02	0.0434
year*month	2008 13	0.0000000	B	.	.	.
year*month	2009 5	0.0000000	B	.	.	.
year*month	2009 6	0.0000000	B	.	.	.
year*month	2009 8	0.0000000	B	.	.	.
year*month	2009 9	0.0000000	B	.	.	.
year*month	2009 10	0.0000000	B	.	.	.
year*month	2009 13	0.0000000	B	.	.	.
size_class	1	-103.6410714	B	6.8286396	-15.18	<.0001
size_class	2	-47.0013079	B	4.0421607	-11.63	<.0001
size_class	3	0.0000000	B	.	.	.
area	67	37.8768349	B	9.0437594	4.19	<.0001
area	68	33.3757680	B	17.7200081	1.88	0.0599
area	80	-21.9634540	B	7.1315124	-3.08	0.0021
area	90	-60.5831574	B	6.8613925	-8.83	<.0001
area	91	58.8268396	B	23.0533703	2.55	0.0109
area	92	-32.3620874	B	4.9255008	-6.57	<.0001
area	100	0.0000000	B	.	.	.

The GLM Procedure
Least Squares Means

Year	cpue LSMEAN	95% Confidence Limits	
1998	350.945677	332.378029	369.513324
1999	350.128228	330.781674	369.474782
2000	388.717914	355.504501	421.931327
2001	373.539689	351.620759	395.458618
2002	332.752859	313.891431	351.614286
2003	346.475358	331.087388	361.863327
2004	480.291751	462.201482	498.382021
2005	514.295476	494.119521	534.471430
2006	519.708901	501.631381	537.786421
2007	561.546149	538.241244	584.851054
2008	491.141425	473.849808	508.433042
2009	393.740633	344.076621	443.404646

Table 11. Stratified analysis of commercial large vessel catch data from the observer dataset (January-June, single and double trawl; all strata), 1989-2009. (Green 0–10,000 t; White 10,000–20,000 t; Pink >20,000 t; Black not fished)

Large vessel Shrimp Biomass 000 tonnes		year																				
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Max depth (m)	STRATUM																					
200	206				6	18	25				21	48	66			11	40	45		1	56	56
300	209							13	17	16	18	14		15	16	9				5		
	210	5	6	12	20	23		10					32		8			33	22	23	48	
	213				1	28	25	16		26	19	32	29	32	47	40	28	35	46	44	28	38
	214					10		21	36		22		33	18	9	18	24	21	23	26	20	26
	228	14	16	23	40	42	49	37	26	28	62	53	66	62	64	64	62	75	85	82	78	56
	620									37								21	53			
	621		0																			
	624	9	7	7	11	12	24						26				21	19	21			
	634		2	1		10	14											43	34	39	37	31
	635		2																		8	
	636																15				13	11
400	208	9	13	6	9	22	14	12	14	13	15	15	18	15	18	14						
	211	0			5	4	6	5	6	5	6	7	8	7	8	7	7	9	10	10	9	4
	216					0		3		3	2	2	3	1	2	3	4	3	2	3	3	4
	222			4	7	6	6	8	10	7	8	9	11	10	10	13	11	12	15	13	15	14
	229			1	10				9		15	13	17	14	14	21	19	25	20	22	25	10
	617	8	6	7	9	16	6	5	2	4	3	10	16	14	11	19	12	18	17	18	20	18
	623	0																16	14	16		
	625	2	0	5		12										13		21			25	
	626		5													16						
	628																	18				
	629		3															12				
	630	0	0														2	8	4	10	8	9
	633	9	8	20	27	28	43	29	39	44	18	23	37	35	32	49	63	66	60	68	66	26
	638	2				2							15			31		45	10		21	9
	639		1			20		18			10		3	12	14	6	42	26	36			10
500	217							1	1		1	1	1	2	2	2	2	2	1	1	1	2
	223				3	2	2	3	4	3	4	3	4	4	4	6	5	5	6	4	6	6
	227			0	10	6	12	12	12	11	12	14	14	13	14	17	20	20	23	17	19	9
	235	5	6	1	8	14	10	7	10	7	9	8	9	12	12	8						
	240					1	3	3	3	2	1	2	3	2	3	4	3	8	4	4		0
	622	6	7	9	12			3						13				24	25	19	30	
	627	2	5	1										19		23	13					
	631	6	6	10	18	21	15	15	5	24				21	40	39	33	38	33	37	43	27
	640					1						0										
	645	0				3	4	4	4						5	4						
750	212				11		10	8	17		12	8			15			7	21			
	218								1			2			1	3						
	224				3	3			5	4	4	5	7	6	6	7	7	6		5		5
	230				4	2	4	3	4	3	5	5	5	4	4	5	5			7		2
	641					3																
	646						5															
1000	231					1	8							4		7						
	236					2							6		9							
All		77	92	107	214	311	283	235	226	237	266	276	428	336	368	458	436	681	586	476	579	374

Table 12. SFA 6 percent contribution of large vessel commercial biomass, by depth range, within all strata.

Depth Range (m)	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<=200 m	0.00	0.00	0.00	2.80	5.79	8.83	0.00	0.00	0.00	7.89	17.39	15.42	0.00	0.00	2.40	9.17	6.61	0.00	0.21	9.67	14.97
201 - 300 m	36.36	35.87	40.19	33.64	40.19	39.58	41.28	34.96	45.15	45.49	35.87	43.46	37.80	39.13	28.60	34.40	36.27	48.46	46.01	40.07	43.32
301 - 400 m	38.96	39.13	40.19	31.31	35.37	26.50	34.04	35.40	32.07	28.95	28.62	29.91	32.14	29.62	41.92	36.70	40.97	32.08	33.61	33.16	27.81
401 - 500 m	24.68	26.09	19.63	23.83	15.43	16.25	20.43	17.26	19.83	10.15	10.14	7.24	25.60	21.74	22.49	17.43	14.24	15.70	17.23	17.10	11.76
501 - 750 m	0.00	0.00	0.00	8.41	2.57	6.71	4.68	11.95	2.95	7.89	7.25	2.80	2.98	7.07	3.28	2.75	1.91	3.58	2.52	0.00	1.87
751 - 100 m	0.00	0.00	0.00	0.00	0.96	2.83	0.00	0.00	0.00	0.00	0.00	1.40	1.19	2.45	1.53	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.00	101.09	100.00	100.00	100.32	100.71	100.43	99.56	100.00	100.38	99.28	100.23	99.70	100.00	100.22	100.46	100.00	99.83	99.58	100.00	99.73

Table 13. Stratified analysis of index strata commercial large vessel catch data from the observer dataset (January-June, single and double trawl; index strata), 1992-2009. (Green 0–10,000 t; White 10,000–20,000 t; Pink >20,000 t; Black not fished)

Index Strata Large vessel Shrimp Biomass 000 tonnes		year																	
		1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Max depth (m)	STRATUM																		
300	228	40	42	49	37	26	28	62	53	66	61	63	63	62	70	84	77	71	50
400	222	7	6	6	8	10	7	8	9	11	10	10	12	11	10	15	12	14	12
	617	9	16	6	4	2	4	3	10	15	14	11	15	11	17	16	17	19	15
	633	27	28	43	29	39	44	18	23	37	35	32	49	58	63	54	65	62	24
500	223	3	2	2	3	4	3	4	3	4	4	4	5	5	5	5	3	6	6
	227	10	6	12	12	12	11	12	14	14	13	14	16	19	20	21	14	18	9
All		96	99	118	93	93	98	107	112	147	138	133	161	164	186	195	188	190	115

Table 14. SFA 6 percent contribution of large vessel commercial biomass, by depth range, within the index strata.

Depth Range (m)	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
201 - 300 m	41.67	42.42	41.53	39.78	27.96	28.57	57.94	47.32	44.90	44.20	47.37	39.13	37.80	37.63	43.08	40.96	37.37	43.48
301 - 400 m	44.79	50.51	46.61	44.09	54.84	56.12	27.10	37.50	42.86	42.75	39.85	47.20	48.78	48.39	43.59	50.00	50.00	44.35
401 - 500 m	13.54	8.08	11.86	16.13	17.20	14.29	14.95	15.18	12.24	12.32	13.53	13.04	14.63	13.44	13.33	9.04	12.63	13.04
Total	100.00	101.01	100.00	100.00	100.00	98.98	100.00	100.00	100.00	99.28	100.75	99.38	101.22	99.46	100.00	100.00	100.00	100.87

Table 15. Stratified analysis of commercial small vessel catch data from the observer dataset (May-October, single trawl; all strata), 1998-2009. (Green 0–10,000 t; White 10,000–20,000 t; Pink >20,000 t; Black not fished)

Small vessel Shrimp Biomass 000 tonnes		year											
		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		.	.	.	.	.	.	.	.	.	.	.	.
Max depth (m)	STRATUM												
200	205	11	.	14	.	.	22	12	.	.	.	24	.
	206	14	13	10	14	9	12	13	.	16	16	16	15
	207	11	.	.	.	.	9	.	.	.	.	.	.
	618	.	.	12	13	.	4	.	.	.	.	9	.
	619	7	.	.	.	.	.	.	.	.	.	.	.
300	209	3	5	6	.	4	.	.	.	.	.	.	5
	210	6	6	7	6	6	.	.	15	12	10	.	.
	213	16	12	13	15	13	9	15	15	19	18	19	16
	214	11	15	12	13	.	8	12	6	13	13	17	10
	228	31	16	18	22	17	14	20	22	24	22	25	11
	620	13	13	15	17	14	18	45	24	26	20	21	18
	621	.	12	17	24	14	13	.	.	23	19	20	18
	624	8	8	7	13	9	8	13	11	13	13	11	3
	634	9	12	10	16	.	12	21	16	17	21	17	18
	635	5	5	7	8	6	8	.	.	.	13	13	3
	636	5	12	13	12	9	13	16	17	18	16	16	5
	637	4	9	8	5	7	10	11	10	11	13	11	9
366	345	.	.	.	.	7	.	.	.	14	15	8	8
	346	.	.	5	.	.	.	.	9	9	11	11	6
400	208	4	4	5	5	4	.	.	.	.	.	.	3
	211	2	2	2	2	4	1	3	2	3	4	1	1
	216	3	.	8	5	.	3	.	.	.	.	.	.
	222	3	3	3	4	3	3	4	5	6	.	4	3
	229	3	16	3	4	4	3	.	5	.	.	.	.
	617	5	4	4	28	3	4	3	6	7	5	6	5
	623	2	2	3	3	3	3	3	5	5	4	4	3
	625	2	5	6	7	6	6	7	9	9	9	7	5
	626	3	7	7	7	6	6	7	9	11	9	8	9
	628	5	4	6	4	7	5	6	6	6	9	7	7
	629	2	2	2	4	3	2	3	3	5	4	3	3
	630	1	.	3	.	1	2	4	3	3	3	4	3
	633	18	25	18	15	16	17	25	23	25	34	22	16
	638	9	13	17	15	13	19	22	23	24	28	19	17
	639	9	12	13	12	11	12	17	18	18	17	12	9
500	217	3	.	.	3	.	.	.	.	.	.	.	.
	223	2	1	1	2	1	1	1	.	2	.	.	.
	227	4	3	4	6	5	3	3	.	.	.	.	.
	235	2	2	3	4	2	3	.	4	.	.	3	.
	240	1	1	2	1	1	1	1	.	1	.	.	.
	622	4	4	5	4	4	4	4	9	7	5	6	5
	627	4	7	10	8	7	6	7	10	11	17	48	9
	631	8	.	9	7	9	11	17	14	14	20	14	10
	640	.	1	.	1	0	1	1	1	.	.	.	.
	645	6	.	1	.	.	.	.	.	.	.	.	2
	650	.	.	1	2	.	1	1	2	2	1	.	.
750	212	5	5	4	4	3	.	4	.	.	5	5	6
	218	.	.	.	.	.	3	.	.	.	.	.	.
	224	2	1	4	1	2	1	1	.	.	.	3	.
	230	3	1	.	1	1	1	2	.	.	.	.	.
	641	.	2	1	1	1	2	2	2	.	2	.	1
	646	.	3	.	.	.	.	5	.	.	.	6	.
	651	.	2	3	2	2	3	4	4	4	6	4	.
1000	231	2	1	.	.	.	.	2	.	.	.	.	.
	236	1	1	.	1	3	1	1	.	.	.	.	.
	642	.	.	.	3	4	3	4	.	.	.	2	.
	652	.	4	2	.	3	.	3	.	.	4	.	.
All		270	274	326	344	247	289	346	306	376	405	429	261

Table 16. SFA 6 percent contribution of small vessel commercial biomass, by depth range, within the all strata.

Depth Range (m)		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
101 - 200 m		15.93	4.74	11.04	7.85	3.64	16.26	7.23	0.00	4.26	3.95	11.42	5.75
201 - 300 m		41.11	45.62	40.80	43.90	40.08	39.10	44.22	44.44	46.81	43.95	39.63	44.44
301 - 400 m		26.30	36.13	32.21	33.43	36.84	29.76	30.06	41.18	38.56	37.53	27.04	37.55
401 - 500 m		12.59	6.93	11.04	11.05	11.74	10.73	10.12	13.07	9.84	10.62	16.55	9.96
501 - 750 m		3.70	5.11	3.68	2.62	3.64	3.46	5.20	1.96	1.06	3.21	4.20	2.68
751 - 1000 m		1.11	2.19	0.61	1.16	4.05	1.38	2.89	0.00	0.00	0.99	0.47	0.00
total		100.74	100.73	99.39	100.00	100.00	100.69	99.71	100.65	100.53	100.25	99.30	100.38

Table 17. Stratified analysis of index strata commercial small vessel catch data from the logbook dataset (May-October, single trawl; index strata), 1998-2009. (Green 0–10,000 t; White 10,000–20,000 t; Pink >20,000 t).

Small vessel Shrimp Biomass 000 tonnes		**yearf**											
		1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
		.	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**	**.**
Max depth (m)	**STRATUM**	**16**	**12**	**13**	**15**	**13**	**9**	**15**	**15**	**19**	**18**	**19**	**16**
300	**213**												
	228	**31**	**16**	**18**	**22**	**17**	**14**	**20**	**22**	**24**	**22**	**25**	**11**
	620	**13**	**13**	**15**	**17**	**14**	**18**	**45**	**24**	**26**	**20**	**21**	**18**
	624	**8**	**8**	**7**	**13**	**9**	**8**	**13**	**11**	**13**	**13**	**11**	**3**
	636	**5**	**12**	**13**	**12**	**9**	**13**	**16**	**17**	**18**	**16**	**16**	**5**
	637	**4**	**9**	**8**	**5**	**7**	**10**	**11**	**10**	**11**	**13**	**11**	**9**
400	**617**	**5**	**4**	**4**	**28**	**3**	**4**	**3**	**6**	**7**	**5**	**6**	**5**
	623	**2**	**2**	**3**	**3**	**3**	**3**	**3**	**5**	**5**	**4**	**4**	**3**
	625	**2**	**5**	**6**	**7**	**6**	**6**	**7**	**9**	**9**	**9**	**7**	**5**
	628	**5**	**4**	**6**	**4**	**7**	**5**	**6**	**6**	**6**	**9**	**7**	**7**
	633	**18**	**25**	**18**	**15**	**16**	**17**	**25**	**23**	**25**	**34**	**22**	**16**
	638	**9**	**13**	**17**	**15**	**13**	**19**	**22**	**23**	**24**	**28**	**19**	**17**
	639	**9**	**12**	**13**	**12**	**11**	**12**	**17**	**18**	**18**	**17**	**12**	**9**
500	**622**	**4**	**4**	**5**	**4**	**4**	**4**	**4**	**9**	**7**	**5**	**6**	**5**
All		**130**	**137**	**148**	**172**	**132**	**141**	**207**	**198**	**211**	**212**	**187**	**130**

Table 18. SFA 6 percent contribution of small vessel commercial biomass, by depth range, within the index strata.

Depth range (m)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
201 - 300 m	59.23	51.09	50.00	48.84	52.27	51.06	57.97	50.00	52.61	48.11	55.08	47.69
301 - 400 m	38.46	47.45	45.27	48.84	44.70	46.81	40.10	45.45	44.55	50.00	41.18	47.69
401 - 500 m	3.08	2.92	3.38	2.33	3.03	2.84	1.93	4.55	3.32	2.36	3.21	3.85
Total	100.77	101.46	98.65	100.00	100.00	100.71	100.00	100.00	100.47	100.47	99.47	99.23

Table 19. Hawke Channel + 3K (SFA 6) Northern shrimp biomass and abundance estimates using the original and new Delauney triangulation and parameter files used in Ogmap calculations. These estimates were calculated from 1996-2009 Canadian autumn multi species bottom trawl research surveys (standard tows = 15 min at 3.0 Nmi/hr).

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
2008	555,200	638,300	720,700	128,800	146,801	162,300	173
2009	315,300	404,900	543,400	79,680	102,255	133,200	218

Area compared each year = 171,048.5 sq. km.

A) **Original Indices** using the original Delauney triangulation and parameter files used by ogmap. These values did not account for the 1.0068 swept area correction factor.

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	406,848	500,279	596,630	96,381	115,669	139,744	238
1997	365,871	429,098	466,954	83,071	95,923	104,304	232
1998	404,834	461,618	512,461	93,904	105,828	118,098	234
1999	456,483	522,529	583,038	110,849	124,898	140,549	233
2000	504,306	576,594	638,714	122,628	137,610	151,020	241
2001	562,398	653,917	751,476	140,751	160,166	181,526	252
2002	536,524	605,993	658,347	132,596	146,898	159,276	253
2003	514,173	600,456	665,696	130,481	147,558	161,994	236
2004	593,005	656,736	744,025	129,575	144,117	163,605	214
2005	582,534	672,945	755,905	129,172	145,400	162,498	242
2006	774,934	894,743	1,023,916	181,828	208,164	238,008	234
2007	648,077	757,516	850,545	150,517	173,267	194,816	206
2008	546,491	634,989	719,057	127,562	146,174	161,088	173
2009	312,611	404,029	528,369	79,074	102,273	130,884	218

Area compared each year = 157,479 sq. km.

B) **Proposed Indices** using the new Delauney triangulation and parameter files used by ogmap. These values do account for the 1.0068 swept area correction factor.

Table 20. Biomass (000 t) of Northern Shrimp (Pandalus borealis) in Hawke Channel + 3K (SFA 6) over the period 1996-2009. The analysis was from areal expansion of multi-species research survey data collected during using a Campelen 1800 research survey trawl towed at 3 Nmi/hr for 15 min. (green<10,000 t; white 10,000–20,000 t; pink>20,000 t; black indicates not sampled).

Survey Fall SFA 6 Shrimp 000 Biomass tonnes		YEAR													
		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		.	.	.	.	.	.	.	.	.	.	.	.	.	.
Depth Range (m)	STRATUM														
101 - 200	205	1	0	4	2	6	4	7	3	5	8	.	12	3	4
	206	1	9	10	7	7	11	14	10	9	6	12	24	20	9
	207	1	1	3	2	8	6	4	2	5	3	4	13	8	4
	237	.	.	0	.	.	.	.	.	.	.	.	.	.	.
	618	0	1	0	1	1	2	2	2	5	2	5	11	7	1
	619	0	0	1	0	1	3	4	0	3	3	2	4	3	1
201 - 300	209	15	7	2	18	8	8	11	18	3	13	14	11	9	6
	210	35	14	14	28	13	20	19	13	26	16	23	10	10	17
	213	29	27	35	33	22	74	38	23	16	38	108	40	83	6
	214	7	28	13	29	18	21	15	34	20	21	35	21	28	85
	228	125	36	50	28	35	44	24	22	69	76	115	88	19	32
	620	13	16	19	44	34	18	27	14	19	24	35	51	21	21
	621	10	6	8	19	16	4	15	16	19	7	27	34	19	15
	624	19	15	15	19	21	17	14	13	22	27	36	29	15	14
	634	22	13	25	22	40	42	21	11	12	31	73	55	32	21
	635	5	8	7	8	11	4	4	3	0	8	.	20	16	8
	636	15	10	17	20	27	12	19	13	33	24	16	23	38	14
	637	5	7	10	14	.	13	7	16	22	33	17	39	22	8
301 - 400	208	13	11	13	8	12	13	11	10	11	32	12	8	6	2
	211	12	14	8	6	10	5	6	9	6	8	14	14	3	3
	216	.	.	.	.	.	.	.	3	.	.	1	.	.	.
	222	5	5	6	6	11	6	5	6	4	3	4	1	1	0
	229	19	22	14	13	17	23	18	31	20	13	31	3	18	0
	617	11	5	9	6	13	10	18	23	9	11	4	9	11	3
	623	3	7	12	13	6	9	10	14	16	9	10	12	15	9
	625	14	16	14	30	22	25	20	6	25	23	30	26	13	17
	626	3	12	6	17	16	34	16	30	18	15	22	23	26	24
	628	3	4	7	11	20	16	21	13	37	13	27	34	23	19
	629	4	2	5	3	5	8	7	4	7	6	9	4	11	7
	630	2	5	4	2	5	10	4	3	3	2	2	3	11	3
	633	49	49	51	44	71	118	51	68	65	93	131	41	50	25
	638	27	21	34	28	12	37	49	52	52	26	23	69	16	13
	639	41	35	33	29	52	24	26	26	57	29	10	6	39	10
401 - 500	223	1	0	0	0	.	0	0	1	0	0	0	0	0	0
	227	5	4	4	0	7	3	1	6	6	10	15	10	2	1
	235	2	3	8	4	2	4	2	4	5	1	2	2	0	1
	240	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	622	9	10	8	8	4	4	11	10	6	7	23	12	25	3
	627	8	12	9	12	11	28	46	47	18	24	10	7	26	17
	631	12	15	16	7	15	22	58	44	15	9	20	10	20	10
	640	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	645	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	650	1	0	0	0	.	0	0	0	0	0	0	0	0	0
501 - 750	212	1	7	1	1	0	3	2	5	3	2	1	1	5	2
	218	.	.	.	.	.	.	0	.	.	.	.	.	.	.
	224	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	230	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	641	0	0	0	0	.	0	0	0	0	0	0	0	0	0
	646	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	651	0	0	0	0	.	0	0	0	0	0	0	0	0	0
751 -1000	219	0	.	.	.	.	.	.	.	.	.	.	.	.	.
	231	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	236	0	0	0	0	0	0	0	0	0	0	0	0	.	0
	642	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	647	0	0	0	0	0	0	0	0	0	0	0	0	.	0
	652	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1001 -1250	225	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	232	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	643	0	0	0	0	0	0	0	0	0	0	0	0	.	0
	648	0	0	0	0	0	0	0	0	0	0	0	0	.	0
	653	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1251 -1500	221	.	.	.	.	.	.	.	.	0	.	.	.	.	.
	226	0	0	0	0	0	0	0	0	0	0	0	0	.	0
	233	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	644	0	0	0	0	0	0	0	0	0	0	0	0	.	0
	649	0	0	0	0	0	0	0	0	0	0	0	0	.	0
	654	0	0	0	0	0	0	0	0	0	0	0	0	.	0
All		549	457	492	544	580	707	627	627	670	678	921	780	676	437

Table 21. Biomass (000 t) of Northern Shrimp (*Pandalus borealis*) within Hawke Channel + 3K (SFA 6) index strata over the period 1996-2009. The analysis was from areal expansion of multi-species research survey data collected during using a Campelen 1800 research survey trawl towed at 3 Nmi/hr for 15 min. (green<10,000 t; white 10,000 – 20,000 t; pink>20,000 t).

Survey Fall SFA 6 Shrimp 000 index Biomass tonnes		YEAR													
		1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Depth Range (m)	STRATUM	1	9	10	7	7	11	14	10	9	6	12	24	20	9
101 - 200	206														
	207	1	1	3	2	8	6	4	2	5	3	4	13	8	4
	618	0	1	0	1	1	2	2	2	5	2	5	11	7	1
	619	0	0	1	0	1	3	4	0	3	3	2	4	3	1
201 - 300	209	15	7	2	18	8	8	11	18	3	13	14	11	9	6
	210	35	14	14	28	13	20	19	13	26	16	23	10	10	17
	213	29	27	35	33	22	74	38	23	16	38	108	40	83	6
	214	7	28	13	29	18	21	15	34	20	21	35	21	28	85
	228	125	36	50	28	35	44	24	22	69	76	115	88	19	32
	620	13	16	19	44	34	18	27	14	19	24	35	51	21	21
	621	10	6	8	19	16	4	15	16	19	7	27	34	19	15
	624	19	15	15	19	21	17	14	13	22	27	36	29	15	14
	634	22	13	25	22	40	42	21	11	12	31	73	55	32	21
	636	15	10	17	20	27	12	19	13	33	24	16	23	38	14
301 - 400	208	13	11	13	8	12	13	11	10	11	32	12	8	6	2
	211	12	14	8	6	10	5	6	9	6	8	14	14	3	3
	222	5	5	6	6	11	6	5	6	4	3	4	1	1	0
	229	19	22	14	13	17	23	18	31	20	13	31	3	18	0
	617	11	5	9	6	13	10	18	23	9	11	4	9	11	3
	623	3	7	12	13	6	9	10	14	16	9	10	12	15	9
	625	14	16	14	30	22	25	20	6	25	23	30	26	13	17
	626	3	12	6	17	16	34	16	30	18	15	22	23	26	24
	628	3	4	7	11	20	16	21	13	37	13	27	34	23	19
	629	4	2	5	3	5	8	7	4	7	6	9	4	11	7
	630	2	5	4	2	5	10	4	3	3	2	2	3	11	3
	633	49	49	51	44	71	118	51	68	65	93	131	41	50	25
	638	27	21	34	28	12	37	49	52	52	26	23	69	16	13
	639	41	35	33	29	52	24	26	26	57	29	10	6	39	10
401 - 500	227	5	4	4	0	7	3	1	6	6	10	15	10	2	1
	235	2	3	8	4	2	4	2	4	5	1	2	2	0	1
	240	0	0	0	1	0	0	0	0	0	0	0	0	0	0
	622	9	10	8	8	4	4	11	10	6	7	23	12	25	3
	627	8	12	9	12	11	28	46	47	18	24	10	7	26	17
	631	12	15	16	7	15	22	58	44	15	9	20	10	20	10
	640	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	645	0	0	0	0	0	0	0	0	0	0	0	0	0	0
501 - 750	212	1	7	1	1	0	3	2	5	3	2	1	1	5	2
	224	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	230	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	646	0	0	0	0	0	0	0	0	0	0	0	0	0	0
751 -1000	231	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	642	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	652	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1001 -1250	225	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	232	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	653	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1251 -1500	233	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All		537	442	471	519	563	685	609	602	643	628	903	709	635	417

Table 22. SFA 6 percent contribution of research survey total biomass, by depth range, within the index strata.

Depth Range (m)	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
101 - 200	0.37	2.49	2.97	1.93	3.02	3.21	3.94	2.33	3.42	2.23	2.55	7.33	5.98	3.60
201 - 300	54.00	38.91	42.04	50.10	41.56	37.96	33.33	29.40	37.17	44.11	53.38	51.06	43.15	55.40
301 - 400	38.36	47.06	45.86	41.62	48.31	49.34	43.02	49.00	51.32	45.06	36.43	35.68	38.27	32.37
401 - 500	6.70	9.95	9.55	6.17	6.93	8.91	19.38	18.44	7.78	8.12	7.75	5.78	11.50	7.67
501 - 750	0.19	1.58	0.21	0.19	0.00	0.44	0.33	0.83	0.47	0.32	0.11	0.14	0.79	0.48
Total	99.63	100.00	100.64	100.00	99.82	99.85	100.00	100.00	100.16	99.84	100.22	100.00	99.69	99.52

Table 23. Hawke Channel + 3K (SFA 6) Northern shrimp female spawning stock biomass and abundance estimates using the original and new Delauney triangulation and parameter files used in Ogmap calculations. These estimates were calculated from 1996-2009 Canadian autumn multi species bottom trawl research surveys (standard tows = 15 min at 3.0 Nmi/hr).

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
2008	283,400	337,700	404,900	39,710	47,438	56,180
2009	160,800	206,100	276,300	22,000	28,455	38,580

A) ***Original indices*** *using the original Delauney triangulation and parameter files used by ogmap. These values did not account for the 1.0068 swept area correction factor.*

Year	Biomass (tons)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	149,006	200,957	243,545	17,116	23,053	27,818
1997	145,583	183,439	211,227	17,659	22,166	25,291
1998	184,446	214,046	240,222	24,073	28,154	31,603
1999	223,006	260,459	297,610	30,456	35,137	40,040
2000	247,673	299,020	338,788	33,516	40,661	46,494
2001	290,764	353,085	424,870	42,698	51,562	62,361
2002	298,315	349,058	385,302	45,628	53,097	58,555
2003	263,580	323,183	366,475	39,577	48,289	54,780
2004	325,498	378,859	436,851	46,635	54,066	62,311
2005	325,599	395,471	450,946	43,665	53,699	60,720
2006	389,128	462,927	541,457	51,689	61,871	72,258
2007	353,286	430,105	493,231	46,887	57,303	65,845
2008	285,327	339,996	407,653	39,980	47,761	56,562
2009	159,477	204,984	276,165	21,908	28,432	38,601

B) ***Proposed indices*** *using the new Delauney triangulation and parameter files used by ogmap. These values do account for the 1.0068 swept area correction factor.*

Table 24. Hawke Channel + 3K (SFA 6) Northern shrimp fishable biomass and abundance estimates using the original definition (abundance of all males >17 mm carapace lf applied to a length weight curve to obtain weight per set added to weight of all females on a set by set basis prior to running OGmap), Delauney triangulation and parameter files compared with the new estimates using the new definition (abundances of all males and females > 17 mm carapace lf applied to length weight curves to determine weight per set then complete ogmap calculations) and new Delauney triangulation and parameter files used in Ogmap calculations. These estimates were calculated from 1996 - 2009 Canadian autumn multi species bottom trawl research surveys (standard tows = 15 min at 3.0 Nmi/hr).

Year	Biomass (tons)			Abundance (numbers x 10-6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
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
2008	456,300	531,700	616,200	80,890	93,532	107,400
2009	240,000	314,700	424,700	41,450	55,822	76,380

A) ***Original indices***

Year	Biomass (tons)			Abundance (numbers x 10-6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	240,625	315,128	378,960	44,571	56,979	68,281
1997	257,237	309,692	345,232	49,212	58,691	64,324
1998	313,014	359,025	398,290	59,150	68,008	75,812
1999	355,904	411,681	465,343	63,177	72,838	82,004
2000	359,226	416,513	472,391	66,006	75,555	84,773
2001	441,381	520,616	618,276	78,973	93,109	110,144
2002	425,574	491,016	540,048	77,030	87,816	95,686
2003	362,347	432,622	483,264	69,278	81,407	90,260
2004	399,599	454,671	523,133	72,973	81,871	94,669
2005	421,547	505,112	570,252	76,386	89,633	101,284
2006	555,250	669,824	791,445	98,435	118,311	139,442
2007	476,720	566,224	638,613	80,725	95,305	107,929
2008	434,031	509,944	585,555	75,319	89,322	102,694
2009	232,168	310,698	422,957	41,138	55,572	75,580

B) ***Proposed indices***

Table 25. 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)

Year	Male Ages				Female Ages			
	1	2	3	4	3	4	5	6
1996	9.66 (.018)	14.70 (.045)	17.45 (.049)	20.86 (.049)		20.30 (.058)	23.20 (.014)	26.01 (.044)
1997	9.72 (.033)	14.27 (.015)	17.53 (.021)	19.64 (.019)		20.56 (.065)	23.11 (.031)	25.35 (.107)
1998	10.04 (.014)	13.94 (.088)	16.57 (.030)	19.40 (.022)			22.01 (.018)	24.32 (.038)
1999	10.24 (.012)	14.94 (.009)	18.02 (.026)	20.14 (.013)			22.37 (.015)	24.55 (.044)
2000	9.84 (.015)	14.25 (.028)	17.66 (.018)	20.28 (.028)		19.26 (.127)	22.46 (.015)	24.33 (.047)
2001	9.53 (.043)	13.81 (.154)	16.55 (.082)	19.16 (.063)			22.15 (.027)	23.93 (.041)
2002	10.06 (.018)	14.32 (.026)	16.86 (.024)	19.13 (.020)			21.42 (.035)	23.34 (.106)
2003	10.35 (.017)	14.31 (.018)	17.18 (.043)	19.21 (.020)			21.82 (.014)	24.01 (.029)
2004	10.87 (.035)	14.90 (.024)	17.39 (.043)	19.56 (.030)		18.71 (.055)	21.86 (.016)	24.14 (.038)
2005	10.34 (.013)	14.72 (.124)	17.69 (.041)	20.04 (.039)		19.83 (.056)	22.33 (.013)	24.35 (.034)
2006	10.48 (.014)	14.41 (.011)	17.66 (0.43)	19.67 (.017)		19.69 (.083)	22.57 (.023)	24.35 (.054)
2007	10.12 (.029)	13.30 (.021)	16.18 (.020)	19.30 (.013)			22.39 (.036)	24.05 (.045)
2008	10.92 (.046)	14.27 (.043)	17.09 (.047)	19.51 (.036)			22.35 (.094)	23.69 (.113)
2009	10.49 (.141)	13.17 (.067)	16.23 (.082)	18.62 (.055)		19.64 (.176)	22.21 (.039)	24.28 (.080)

Table 25. (Cont'd)

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

Year	Male Ages				Female Ages			
	1	2	3	4	3	4	5	6
1996	.037 (.001)	.299 (.020)	.521 (.026)	.143 (.008)		.070 (.004)	.818 (.006)	.112 (.004)
1997	.025 (.006)	.233 (.002)	.420 (.005)	.322 (.005)		.118 (.008)	.793 (.014)	.089 (.013)
1998	.113 (.001)	.106 (.009)	.262 (.014)	.519 (.007)			.773 (.009)	.227 (.008)
1999	.103 (.001)	.384 (.002)	.210 (.003)	.303 (.004)			.844 (.080)	.156 (.080)
2000	.077 (.001)	.312 (.006)	.407 (.010)	.204 (006)		.010 (.001)	.851 (.010)	.139 (.010)
2001	.022 (.001)	.296 (.033)	.283 (.053)	.399 (.023)			.760 (.015)	.240 (.015)
2002	.073 (.001)	.186 (.003)	.444 (.004)	.297 (.005)			.562 (.034)	.438 (.034)
2003	.090 (.001)	.285 (.003)	.247 (.006)	.378 (.006)			.780 (.007)	.220 (.007)
2004	.035 (.001)	.354 (.006)	.353 (.006)	.258 (.007)		.043 (.002)	.780 (.007)	.177 (.007)
2005	.152 (.002)	.184 (.016)	.421 (.033)	.243 (.020)		.045 (.003)	.799 (.007)	.156 (.007)
2006	.099 (.001)	.367 (.002)	.184 (.005)	.350 (.005)		.031 (.003)	.800 (.015)	.169 (.014)
2007	.059 (.001)	.270 (.003)	.369 (.003)	.302 (.002)			.736 (.021)	.264 (.021)
2008	.050 (.002)	.233 (.005)	.396 (.006)	.321 (.008)			.773 (.069)	.227 (.069)
2009	.026 (.004)	.240 (.005)	.348 (.011)	.386 (.015)+		.039 (.010)	.762 (.018)	.200 (.017)

Table 25. (Cont'd)

Distributional Sigmas (Standard Error and constraints)

Year	Male Ages				Female Ages			
	1	2	3	4	3	4	5	6
1996	.905 (.014)	1.032 (.019)	1.45 (.068)	1.02 (.021)	1.132 (.011) Sigmas Eq.			
1997	1.136 (.007) Sigmas Eq.				1.230 (.024) Sigmas Eq.			
1998	.938 (.011)	1.05 (.058)	.995 (.043)	1.14 (.011)			1.210 (.018) COV = .055	1.34 (.008) COV=.055
1999	1.048 (.004) Sigmas Eq.						1.148 (.009) COV = .051	1.260 (.009) COV=.051
2000	.864 (.011)	1.300 (.022)	1.078 (.026)	0.871 (.014)		.923 (.008) COV = .048	1.076 (.008) COV = .048	1.166 (.008) COV = .048
2001	.821 (.026)	1.389 (.068)	1.235 (.131)	1.184 (.021)	1.268 (.012) Sigmas Eq.			
2002	1.179 (.008) Sigmas Eq.						.996 (.015)	1.32 (.037)
2003	1.192 (.007) Sigmas Eq.					1.15 (.013)	.715 (.079)	.835 (.077)
2004	1.247 (.011) Sigmas Eq.					1.074 (.0093) COV = .057	1.255 (.0093) COV = .057	1.386(.0093) COV = .057
2005	.941 (.009)	1.355 (.076)	1.131 (.058)	1.071 (.026)		.952 (.009) COV=.048	1.072 (.009) COV=.048	1.169 (.009) COV=.048
2006	1.215 (.006) Sigmas Eq.					1.095 (.013) COV = .056	1.256 (.013) COV = .056	1.354 (.013) COV = .056
2007	1.260 (.006) Sigmas Eq.				1.330 (.014) Sigmas Eq.			
2008	1.401 (.014) Sigmas Eq.				1.423 (.027) Sigmas Eq.			
2009	1.485 (.021) Sigmas Eq.					1.200 (.024) COV=.0611)	1.358 (.024) COV=.0611)	1.484 (.024) COV=.0611)

Table 25. (Cont'd)

Population at Age Estimates (000,000's)

Year	Male Ages						Female Ages				Total
	0	1	2	3	4	5	3	4	5	6	
1996	31	3,408	27,674	48,237	13,247	12	68	1,609	18,790	2,588	115,665
1997	10	1,849	17,091	30,876	23,724	55	0	2,557	17,250	2,184	95,677
1998	9	8,753	8,275	20,332	40,317	41	3	129	21,643	6,377	105,840
1999	1	9,249	34,461	18,830	27,219	2	33	197	29,300	5,612	124,903
2000	0	7,353	29,946	38,979	19,596	58	29	472	34,446	5,704	136,582
2001	12	2,383	32,113	30,698	43,368	32	37	166	39,024	12,343	160,180
2002	9	6,849	17,392	41,642	27,915	0	12	257	29,562	23,272	146,909
2003	16	8,966	28,188	24,686	37,419	4	77	48	37,539	10,611	147,556
2004	41	3,198	31,796	31,710	23,275	27	114	2,338	42,076	9,549	144,122
2005	12	13,958	16,863	38,532	22,328	3	134	2,652	42,401	8,507	145,391
2006	164	14,297	52,740	26,430	50,660	165	44	1,971	48,746	10,325	205,542
2007	25	5,112	27,107	42,517	41,197	22	29	236	41,883	15,164	173,292
2008	455	4,897	22,775	38,736	31,535	0	17	138	36,573	11,037	146,165
2009	15	1,879	17,639	25,550	28,340	51	41	1,115	21,444	5,667	101,740

Table 26. Hawke Channel + 3K (SFA 6) Northern shrimp recruitment indices using the original definition (abundance of all males and unidentified Pandalus 11.5-16 mm carapace lf), Delauney triangulation and parameter files compared with the new estimates using the new definitions (abundances of all males + females with 11.5–16 mm carapace lf) and new Delauney triangulation and parameter files used in Ogmap calculations. These estimates were calculated from 1996-2009 Canadian autumn multi species bottom trawl research surveys (standard tows = 15 min at 3.0 Nmi/hr).

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
2008	32,370	36,615	40,650
2009	26,750	33,114	38,820

A) Original *(this table approximates abundances of age 2 males + unidentified Pandalus)*

Year	lower 95% CL	recruitment index ($X10^6$)	upper 95% CL
1996	32,741	38,983	49,404
1997	19,472	22,290	24,898
1998	15,122	18,426	22,109
1999	29,248	34,648	42,416
2000	29,157	34,109	39,648
2001	38,450	44,999	51,911
2002	29,499	33,820	38,722
2003	31,020	35,905	42,799
2004	31,734	37,163	43,937
2005	18,928	22,425	26,086
2006	49,857	57,706	68,382
2007	43,061	50,226	57,297
2008	30,909	36,404	40,755
2009	25,855	32,637	39,366

B) Proposed *(this table approximates abundances of age 2 males + females)*

Table 27. Original formulation of 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) compared with the proposed formulation (abundance removed/ previous year's abundance from the fishable portion of the resource). Each index is expressed as a percent.

Year	lower CL of total biomass (t)	total biomass (t)	fishable biomass (t)
1996	406,848	500,279	315,128
1997	365,871	429,098	309,692
1998	404,834	461,618	359,025
1999	456,483	522,529	411,681
2000	504,306	576,594	416,513
2001	562,398	653,917	520,616
2002	536,524	605,993	491,016
2003	514,173	600,456	432,622
2004	593,005	656,736	454,671
2005	582,534	672,945	505,112
2006	774,934	894,743	669,824
2007	648,077	757,516	566,224
2008	546,491	634,989	509,944
2009	312,611	404,029	310,698

Year	Catch (t)	Catch/ lower C.L.	Catch/ total biomass	Catch/ fishable biomass
1997	21,018	5.17	4.20	6.67
1998	46,337	12.66	10.80	14.96
1999	51,202	12.65	11.09	14.26
2000	63,224	13.85	12.10	15.36
2001	52,590	10.43	9.12	12.63
2002	60,384	10.74	9.23	11.60
2003	71,227	13.28	11.75	14.51
2004	77,776	15.13	12.95	17.98
2005	75,197	12.68	11.45	16.54
2006	75,673	12.99	11.25	14.98
2007	80,725	10.42	9.02	12.05
2008	74,506	11.50	9.84	13.16
2009	45,117	8.26	7.11	8.85
2010*	85,725	27.42	21.22	27.59

* assumes that the 90,560 t TAC will be assigned to this fishery in 2010-11

A) Original *formulation.*

Table 27 (Cont'd)

Year	Large vessel removals ($X10^6$)	Small vessel removals ($X10^6$)	Total removals ($X10^6$)	Abundance from the fishable portion of the resource ($X10^6$)	Exploitation Rate (%)
1990	885		885		
1991	906		906		
1992	952		952		
1993	1,246		1,246		
1994	1,756		1,756		
1995	1,765		1,765		
1996	1,720		1,720	56,979	
1997	2,239	unknown	unknown	58,691	
1998	2,624	4,076	6,700	68,008	11.42
1999	2,856	unknown	unknown	72,838	
2000	3,330	8,716	12,046	75,555	16.54
2001	3,377	6,179	9,556	93,109	12.65
2002	3,619	7,592	11,211	87,816	12.04
2003	5,288	8,064	13,352	81,407	15.20
2004	4,550	11,833	16,383	81,871	20.12
2005	4,625	9,619	14,244	89,633	17.40
2006	4,300	10,772	15,072	118,311	16.81
2007	4,701	11,097	15,798	95,305	13.35
2008	3,130	11,248	14,378	89,322	15.09
2009	fishery ongoing	5,933	unknown	55,572	

B) ***Proposed*** *formulation.*

Table 28. 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 0.75, 0.25 and 0.29 respectively. This analysis is based upon data from the multispecies survey dataset.

Year	Age 3+ male and total female abundance (millions; yr=t)	Age 4+ male and total female abundance (millions; yr=t)	Survival rate ($S = n_{t+1}/n_t$)	Annual mortality rate (A=1-S)	Instantaneous mortality rate (Z=-ln(S))
1996	84,551	36,314			
1997	76,646	45,770			
1998	88,842	68,510	0.72	0.28	0.33
1999	81,193	62,363	0.83	0.17	0.19
2000	99,284	60,305	0.76	0.24	0.28
2001	125,668	94,970	0.75	0.25	0.29
2002	122,660	81,018	0.74	0.26	0.30
2003	110,384	85,698	0.68	0.32	0.38
2004	109,089	77,379	0.77	0.23	0.26
2005	114,557	76,025	0.77	0.23	0.26
2006	138,341	111,911	0.73	0.27	0.32
2007	141,048	98,531	0.68	0.32	0.39
2008	118,036	79,300			
2009	82,208	56,658			

Table 29. 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 toaccount for vagaries within the observer dataset. The survival, S, in the blue box is the sum of the multiparous females (shaded green) divided by the sum of the primiparous females from the previous year (shaded yellow). Median survival, annual mortality, and instantaneous mortality rates were 0.36, 0.64 and 1.02 respectively. This analysis is based upon data from the Observer dataset.

Year	Abundance primiparous females (raw count; yr=t)	abundance multiparous females (raw count; yr=t)	Survival rate ($S = n_{t+1}/n_t$	Annual mortality rate (A=1-S)	Instantaneous mortality rate (Z=-ln(S))
1999	12,310	10,642			
2000	64,627	13,521			
2001	18,860	7,121	0.36	0.64	1.02
2002	25,003	11,821	0.27	0.73	1.31
2003	34,297	11,222	0.40	0.60	0.91
2004	33,464	8,288	0.40	0.60	0.91
2005	39,371	13,459	0.37	0.63	0.99
2006	49,571	19,987	0.30	0.70	1.20
2007	54,758	16,720	0.28	0.72	1.28
2008	19,215	3,344			
2009	20,687	5,407			

Table 30. **ORIGINAL MODEL** of large vessel (>500 t) Northern Shrimp fishery data for Hopedale and Cartwright Channels (SFA 5), 1977–2009. (observer data, single trawl, no windows, history> 3 yrs.)

YEAR	TAC[1] (t)	FLEET[2] CATCH (t)	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE RELATIVE TO 2009	EFFORT[3] (HR)	STANDARDIZED CPUE RELATIVE TO 2009	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1977		2,686						
1978	5,300	3,630						
1979	4,000	3,727						
1980	4,800	4,108	444	0.20	9,251	0.55	929	4,423
1981	4,800	3,449	473	0.21	7,298	0.58	981	3,515
1982	4,800	1,983	405	0.18	4,894	0.53	896	2,214
1983	4,800	1,000						
1984	4,200	1,002	368	0.17	2,725	0.46	773	1,296
1985	3,570	1,689	339	0.15	4,980	0.38	635	2,659
1986	4,400	4,826						
1987	4,800	5,956						
1988	4,800	7,838						
1989	6,000	5,985	888	0.40	6,737	0.74	1,241	4,823
1990	6,000	5,360	579	0.26	9,253	0.62	1,054	5,085
1991	6,375	6,118	537	0.24	11,385	0.49	831	7,365
1992	6,375	6,315	560	0.25	11,277	0.44	737	8,573
1993	6,375	5,719	612	0.28	9,351	0.47	791	7,230
1994	7,650	7,499	735	0.33	10,207	0.54	907	8,266
1995	7,650	7,616	1,224	0.55	6,223	0.70	1,175	6,481
1996	7,650	7,383	1,540	0.70	4,795	0.90	1,516	4,871
1997	15,300	15,103	1,147	0.52	13,162	0.99	1,665	9,071
1998	14,929	14,827	1,590	0.72	9,324	0.99	1,675	8,852
1999	15,136	14,945	1,495	0.68	9,996	1.07	1,805	8,278
2000	14,050	14,368	1,710	0.77	8,404	1.14	1,917	7,493
2001	14,694	15,001	1,853	0.84	8,096	1.23	2,080	7,213
2002	14,118	15,128	2,043	0.92	7,406	1.21	2,038	7,423
2003	28,072 [4]	29,882	2,143	0.97	13,946	1.16	1,954	15,295
2004	16,780	21,048	2,007	0.91	10,489	1.03	1,746	12,057
2005	21,276	21,756	2,008	0.91	10,834	1.07	1,810	12,017
2006	22,043	22,501	2,081	0.94	10,814	1.08	1,825	12,328
2007	16,780	23,747	2,297	1.04	10,340	1.13	1,913	12,416
2008	16,780	20,409	2,014	0.91	10,135	1.01	1,700	12,003
2009	16,780	24,883	2,215	1.00	11,236	1.00	1,687	14,746

[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, INDUSTRY REQUESTED A 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 31. **Original** multiplicative year, month, area and vessel CPUE model for large vessels (>500 t) fishing shrimp in Hopedale and Cartwright Channels (SFA 5), 1980–2009, 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	26	1980 1981 1982 1984 1985 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
month	12	1 2 3 4 5 6 7 8 9 10 11 12
CFV	22	
area	4	51 52 53 54

Number of Observations Read	1863
Number of Observations Used	1858

Dependent Variable: lncpue

Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	60	40090.11703	668.16862	98.47	<.0001
Error	1797	12193.90927	6.78570		
Corrected Total	1857	52284.02631			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.766776	35.39094	2.604938	7.360466

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	25	28832.55444	1153.30218	169.96	<.0001
month	11	6442.58046	585.68913	86.31	<.0001
CFV	21	4153.95234	197.80725	29.15	<.0001
area	3	661.02980	220.34327	32.47	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	25	5879.796279	235.191851	34.66	<.0001
month	11	4384.191697	398.562882	58.74	<.0001
CFV	21	3905.386106	185.970767	27.41	<.0001
area	3	661.029803	220.343268	32.47	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		7.032048225	B	0.07785137	90.33	<.0001
year	1980	-0.597192608	B	0.09475339	-6.30	<.0001
year	1981	-0.542227932	B	0.10684351	-5.07	<.0001
year	1982	-0.633274437	B	0.12255069	-5.17	<.0001
year	1984	-0.780200676	B	0.15004823	-5.20	<.0001
year	1985	-0.977127882	B	0.12629145	-7.74	<.0001
year	1989	-0.307273601	B	0.10343655	-2.97	0.0030
year	1990	-0.470590565	B	0.10770414	-4.37	<.0001
year	1991	-0.708675447	B	0.08360190	-8.48	<.0001
year	1992	-0.828879262	B	0.08682303	-9.55	<.0001
year	1993	-0.757668122	B	0.06826541	-11.10	<.0001
year	1994	-0.620547801	B	0.05818982	-10.66	<.0001
year	1995	-0.361772884	B	0.05987981	-6.04	<.0001
year	1996	-0.107427060	B	0.06617399	-1.62	0.1047
year	1997	-0.013392444	B	0.05728927	-0.23	0.8152
year	1998	-0.007390649	B	0.05852248	-0.13	0.8995
year	1999	0.067583579	B	0.05890531	1.15	0.2514
year	2000	0.127758117	B	0.05783433	2.21	0.0273
year	2001	0.209060995	B	0.05863495	3.57	0.0004
year	2002	0.188736989	B	0.05915804	3.19	0.0014
year	2003	0.146509032	B	0.05948854	2.46	0.0139
year	2004	0.033949592	B	0.05308236	0.64	0.5225
year	2005	0.070343136	B	0.05733116	1.23	0.2200

Table 31 (Cont'd)

Parameter		Estimate	Standard Error	t Value	Pr > |t|
year	2006	0.078503491 B	0.05418396	1.45	0.1476
year	2007	0.125298459 B	0.05295410	2.37	0.0181
year	2008	0.007627352 B	0.05507719	0.14	0.8899
year	2009	0.000000000 B	.	.	.
month	1	0.361725574 B	0.03647309	9.92	<.0001
month	2	0.626483931 B	0.04257441	14.72	<.0001
month	3	0.420579162 B	0.04375560	9.61	<.0001
month	4	0.289000543 B	0.04157310	6.95	<.0001
month	5	0.049253208 B	0.03990441	1.23	0.2173
month	6	-0.076863788 B	0.04199142	-1.83	0.0673
month	7	-0.021612215 B	0.04773299	-0.45	0.6508
month	8	-0.083271236 B	0.05180724	-1.61	0.1082
month	9	-0.350090974 B	0.04661224	-7.51	<.0001
month	10	-0.248151937 B	0.04782436	-5.19	<.0001
month	11	-0.106301866 B	0.04751748	-2.24	0.0254
month	12	0.000000000 B	.	.	.
CFV	101019	0.253738852 B	0.05494550	4.62	<.0001
CFV	101597	0.479636133 B	0.06967197	6.88	<.0001
CFV	102968	0.461716332 B	0.05766570	8.01	<.0001
CFV	104076	0.299930734 B	0.06146615	4.88	<.0001
CFV	105795	0.370096244 B	0.08987499	4.12	<.0001
CFV	125081	0.397122304 B	0.09804259	4.05	<.0001
CFV	131652	0.295545740 B	0.06125067	4.83	<.0001
CFV	134608	0.245966285 B	0.06802063	3.62	0.0003
CFV	134752	0.554718054 B	0.05896804	9.41	<.0001
CFV	134993	0.156189529 B	0.07559441	2.07	0.0390
CFV	138355	0.383445895 B	0.06767936	5.67	<.0001
CFV	138493	0.365736551 B	0.09527543	3.84	0.0001
CFV	138560	0.485618873 B	0.08116763	5.98	<.0001
CFV	138775	0.384415691 B	0.08078650	4.76	<.0001
CFV	154641	-0.128163839 B	0.06752997	-1.90	0.0579
CFV	158909	0.735845031 B	0.07475504	9.84	<.0001
CFV	176085	0.571674245 B	0.07899401	7.24	<.0001
Parameter		Estimate	Error	t Value	Pr > |t|
CFV		0.645393250 B	0.07495740	8.61	<.0001
CFV		0.002228919 B	0.05942138	0.04	0.9701
CFV		-0.004186872 B	0.06209670	-0.07	0.9463
CFV		-0.147500986 B	0.06256067	-2.36	0.0185
CFV		0.000000000 B	.	.	.
area		-0.073155103 B	0.02668780	-2.74	0.0062
area	52	0.198532235 B	0.02609133	7.61	<.0001
area	53	-0.054674835 B	0.08874936	-0.62	0.5379
area	54	0.000000000 B	.	.	.

Table 31 (Cont'd)

year	lncpue LSMEAN	95% Confidence Limits	
1980	6.833768	6.674481	6.993055
1981	6.888733	6.698255	7.079210
1982	6.797686	6.574759	7.020614
1984	6.650760	6.370447	6.931072
1985	6.453833	6.222095	6.685571
1989	7.123687	6.938914	7.308460
1990	6.960370	6.767105	7.153635
1991	6.722285	6.582692	6.861879
1992	6.602081	6.457276	6.746887
1993	6.673292	6.570321	6.776264
1994	6.810413	6.733597	6.887228
1995	7.069188	6.979662	7.158713
1996	7.323534	7.218099	7.428968
1997	7.417568	7.338033	7.497104
1998	7.423570	7.338068	7.509072
1999	7.498544	7.412816	7.584272
2000	7.558719	7.474548	7.642889
2001	7.640022	7.553348	7.726695
2002	7.619698	7.530359	7.709036
2003	7.577470	7.485456	7.669484
2004	7.464910	7.386901	7.542919
2005	7.501304	7.413422	7.589185
2006	7.509464	7.427408	7.591520
2007	7.556259	7.472821	7.639697
2008	7.438588	7.345977	7.531198
2009	7.430961	7.335935	7.525986

Table 32. **PROPOSED** model of large vessel (>500 t) Northern Shrimp fishery data for Hopedale and Cartwright Channels (SFA 5), 1977–2009. (observer data, single + double trawl, standardized footrope length, speed and effort, no windows, history> 3 yrs.)

YEAR	TAC [1] (t)	FLEET [2] CATCH (t)	UNSTANDARDIZED CPUE (KG/HR)	UNSTANDARDIZED CPUE RELATIVE TO 2009	EFFORT [3] (HR)	STANDARDIZED CPUE RELATIVE TO 2009	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1977		2,686						
1978	5,300	3,630						
1979	4,000	3,727						
1980	4,800	4,108	635	0.25	6,470	0.40	851	4,826
1981	4,800	3,449	628	0.25	5,491	0.40	864	3,991
1982	4,800	1,983	501	0.20	3,956	0.31	656	3,021
1983	4,800	1,000						
1984	4,200	1,002	554	0.22	1,807	0.33	706	1,420
1985	3,570	1,689	448	0.18	3,766	0.31	676	2,497
1986	4,400	4,826						
1987	4,800	5,956						
1988	4,800	7,838						
1989	6,000	5,985	1,189	0.47	5,034	0.64	1,376	4,350
1990	6,000	5,360	795	0.31	6,740	0.47	1,012	5,295
1991	6,375	6,118	810	0.32	7,553	0.47	1,002	6,107
1992	6,375	6,315	819	0.32	7,712	0.44	945	6,682
1993	6,375	5,719	994	0.39	5,755	0.51	1,086	5,269
1994	7,650	7,499	985	0.39	7,613	0.53	1,135	6,608
1995	7,650	7,616	1,234	0.49	6,173	0.61	1,313	5,802
1996	7,650	7,383	1,473	0.58	5,012	0.71	1,532	4,821
1997	15,300	15,103	1,196	0.47	12,624	0.69	1,483	10,185
1998	14,929	14,827	1,499	0.59	9,892	0.75	1,620	9,154
1999	15,136	14,945	1,417	0.56	10,544	0.78	1,684	8,876
2000	14,050	14,368	1,742	0.69	8,247	0.82	1,764	8,146
2001	14,694	15,001	1,739	0.69	8,624	0.84	1,810	8,287
2002	14,118	15,128	1,958	0.77	7,726	0.84	1,808	8,365
2003	28,072 [4]	29,882	2,055	0.81	14,542	0.89	1,913	15,619
2004	16,780	21,048	2,253	0.89	9,341	0.94	2,017	10,433
2005	21,276	21,756	2,231	0.88	9,750	0.96	2,052	10,604
2006	22,043	22,501	2,494	0.98	9,022	1.02	2,198	10,236
2007	16,780	23,747	2,647	1.04	8,971	1.07	2,303	10,310
2008	16,780	20,409	2,538	1.00	8,043	1.03	2,212	9,228
2009	16,780	24,883	2,537	1.00	9,809	1.00	2,148	11,585

[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 + DOUBLE TRAWL, NO WINDOW**

[4] **DURING 2003, INDUSTRY REQUESTED A 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 33. **PROPOSED** Multiplicative year, month, vessel, gear, area CPUE model for large vessels (>500 t) fishing for shrimp in Hopedale + Cartwright Channels (SFA 5), 1980 - 2009, weighted by effort (Single + double trawls, year, month area, observer data, no windows, history > 3 years). This model differs from that presented in Table 31 by being restricted to classes that have a minimum of 10 hours of fishing activity and area 53 (south eastern corner of Cartwright Channel) was dropped as it . As well there was an attempt to standardize tow data by time, footrope length and tow speed.

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                                    The GLM Procedure
                                 Class Level Information
Class       Levels  Values
year            26  1980 1981 1982 1984 1985 1989 1990 1991 1992 1993 1994 1995 1996 1997
1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
month           12  1 2 3 4 5 6 7 8 9 10 11 12
CFV             20
area             3  51 52 54
gear             2  2 10
                             Number of Observations Read        1596
                             Number of Observations Used        1517
Dependent Variable: lncpue
Weight: effort
                                                   Sum of
      Source                      DF          Squares     Mean Square    F Value    Pr > F
      Model                       58      25420.14423       438.27835     124.57    <.0001
      Error                     1458       5129.56427         3.51822
      Corrected Total           1516      30549.70850
                       R-Square     Coeff Var      Root MSE    lncpue Mean
                       0.832091      25.44685      1.875692       7.371017

      Source                      DF        Type I SS     Mean Square    F Value    Pr > F
      year                        25      18376.67138       735.06686     208.93    <.0001
      month                       11        745.11057        67.73732      19.25    <.0001
      CFV                         19       6151.51263       323.76382      92.02    <.0001
      area                         2         57.32760        28.66380       8.15    0.0003
      gear                         1         89.52205        89.52205      25.45    <.0001

      Source                      DF      Type III SS     Mean Square    F Value    Pr > F
      year                        25      3722.749517      148.909981      42.33    <.0001
      month                       11       520.647626       47.331602      13.45    <.0001
      CFV                         19      5600.981577      294.788504      83.79    <.0001
      area                         2        59.908075       29.954037       8.51    0.0002
      gear                         1        89.522052       89.522052      25.45    <.0001
                                                           Standard
           Parameter               Estimate                   Error    t Value    Pr > |t|
           Intercept            7.427737003 B       0.06116699     121.43      <.0001
           year      1980      -0.858575716 B       0.07114851     -12.07      <.0001
           year      1981      -0.910934307 B       0.07781801     -11.71      <.0001
           year      1982      -1.182848640 B       0.08865328     -13.34      <.0001
           year      1984      -1.109986331 B       0.10826849     -10.25      <.0001
           year      1985      -1.164423612 B       0.09198062     -12.66      <.0001
           year      1989      -0.446258293 B       0.07537437      -5.92      <.0001
           year      1990      -0.751416631 B       0.07823317      -9.60      <.0001
           year      1991      -0.764501138 B       0.06115424     -12.50      <.0001
           year      1992      -0.835773006 B       0.06506514     -12.85      <.0001
           year      1993      -0.695827651 B       0.05055982     -13.76      <.0001
           year      1994      -0.641454886 B       0.04299213     -14.92      <.0001
           year      1995      -0.492034583 B       0.04443132     -11.07      <.0001
           year      1996      -0.330947177 B       0.04896830      -6.76      <.0001
           year      1997      -0.368066204 B       0.04192467      -8.78      <.0001
```

Table 33. (Cont'd)

Parameter		Estimate		Standard Error	t Value	Pr > |t|
year	1998	-0.278065210	B	0.04346334	-6.40	<.0001
year	1999	-0.238387310	B	0.04284623	-5.56	<.0001
year	2000	-0.195092459	B	0.04274152	-4.56	<.0001
year	2001	-0.170252154	B	0.04332502	-3.93	<.0001
year	2002	-0.170473010	B	0.04355691	-3.91	<.0001
year	2003	-0.113840552	B	0.04241670	-2.68	0.0074
year	2004	-0.061617334	B	0.03843859	-1.60	0.1091
year	2005	-0.045727320	B	0.04056024	-1.13	0.2598
year	2006	0.024587264	B	0.04009769	0.61	0.5399
year	2007	0.070482362	B	0.04018870	1.75	0.0797
year	2008	0.029876430	B	0.04322491	0.69	0.4896
year	2009	0.000000000	B	.	.	.
month	1	0.091968364	B	0.02600266	3.54	0.0004
month	2	0.176453563	B	0.03070496	5.75	<.0001
month	3	0.127659303	B	0.03160441	4.04	<.0001
month	4	0.043178597	B	0.02996322	1.44	0.1498
month	5	-0.000658908	B	0.02824010	-0.02	0.9814
month	6	-0.018798923	B	0.02959678	-0.64	0.5254
month	7	0.001307545	B	0.03367862	0.04	0.9690
month	8	-0.078721006	B	0.03666184	-2.15	0.0319
month	9	-0.195762536	B	0.03127201	-6.26	<.0001
month	10	-0.066930147	B	0.03190467	-2.10	0.0361
month	11	-0.029882297	B	0.03357373	-0.89	0.3736
month	12	0.000000000	B	.	.	.
CFV		0.280612565	B	0.03980918	7.05	<.0001
CFV		0.421355557	B	0.05066272	8.32	<.0001
CFV		0.427270862	B	0.04192562	10.19	<.0001
CFV		0.342923028	B	0.04324437	7.93	<.0001
CFV		0.383677270	B	0.06596559	5.82	<.0001
CFV		0.476853253	B	0.06893939	6.92	<.0001
CFV		0.420923743	B	0.04441428	9.48	<.0001
CFV		0.141230185	B	0.05017418	2.81	0.0049
CFV		0.552948042	B	0.04215285	13.12	<.0001
CFV		-0.044251013	B	0.05581099	-0.79	0.4280
CFV		0.368260752	B	0.04878950	7.55	<.0001
CFV		0.293427949	B	0.06084303	4.82	<.0001
CFV		-0.360984876	B	0.04922112	-7.33	<.0001
CFV		0.584260170	B	0.05203534	11.23	<.0001
CFV		0.556526443	B	0.05273045	10.55	<.0001
CFV		0.624753824	B	0.05140156	12.15	<.0001
CFV		-0.188557454	B	0.04315561	-4.37	<.0001
CFV		-0.169794497	B	0.04502725	-3.77	0.0002
CFV		0.018593271	B	0.04533404	0.41	0.6818
CFV		0.000000000	B	.	.	.
area	51	0.050807906	B	0.01891162	2.69	0.0073
area	52	0.074122602	B	0.01870912	3.96	<.0001
area	54	0.000000000	B	.	.	.
gear	2	-0.118308270	B	0.02345371	-5.04	<.0001
gear	10	0.000000000	B	.	.	.

Table 33. (Cont'd)

year	lncpue LSMEAN	95% Confidence Limits	
1980	6.812303	6.690629	6.933978
1981	6.759945	6.623680	6.896209
1982	6.488030	6.328817	6.647244
1984	6.560893	6.360265	6.761520
1985	6.506455	6.340060	6.672851
1989	7.224621	7.093261	7.355980
1990	6.919462	6.781425	7.057500
1991	6.906378	6.807399	7.005357
1992	6.835106	6.725456	6.944756
1993	6.975051	6.901284	7.048818
1994	7.029424	6.975659	7.083189
1995	7.178844	7.119739	7.237949
1996	7.339932	7.268721	7.411143
1997	7.302813	7.252034	7.353591
1998	7.392814	7.334388	7.451240
1999	7.432492	7.378623	7.486360
2000	7.475786	7.420200	7.531373
2001	7.500627	7.442514	7.558739
2002	7.500406	7.441588	7.559224
2003	7.557038	7.501526	7.612551
2004	7.609262	7.564083	7.654441
2005	7.625152	7.574067	7.676237
2006	7.695466	7.644833	7.746099
2007	7.741361	7.690245	7.792478
2008	7.700755	7.637585	7.763926
2009	7.670879	7.602710	7.739048

Table 34. SFA 5 stratified analysis of commercial large vessel catch data from the observer dataset (single + double trawl, all strata), 1980–2009. (Green 0–10,000 t; White 10,000–20,000 t; Pink > 20,000 t: Black not fished).

Large vessel Shrimp Biomass 000 tonnes		year																									
Max depth (m)	STRATUM	1980	1981	1982	1984	1985	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
200	201																						15.6				
	954	8.38	3.69	3.73	3.8	4.98	5.78		10.43	11.53	13.6	11.53	7.48		14.69		25.65	17.02	35.03	21.54	32.86	19.13	25.35	49.19	68.02	27.24	
	956																					28.02					
300	214											8.99	7.28	8.8	5.55	7.64	6.07	2.36	10.89	7.15	11.23	16.42	14.67	7.23	13.59	10.52	12.35
	215									25.84		13.99	12.97	5.4	21.97	22.39	27.75	30.9	30.89	33.6	35.25	33.43	37.58	39.76	39.06	43.5	37.69
	943											3.84						0.57					15.39				
	950	2.86																									13.13
	953	2.44	2.19	1.47		1.93	2.77	4.31	2.96	3.38	2.43	3.31	4.38	1.05	4.71	6.87	5.74	5.85	6.57	6.54	6.28	6.85	8.15	9.74	7.87	8.03	8.61
	955			3.23					3.35	4.97	4.85	5.7	5.63	5.74	6.96	8.43	9.6	8.76	8.67	11.51	10.82	12.55	12.43	11.82	15.08	12.77	17.76
400	203			2.29	0.71	0.54	4.13	4.84	5.6	5.78	2.97	4	5.91	6.7	6.42	7.93	7.79	8.93	8.8	9.7	7.87	9.74	11.17	11.79	14.84	12.98	14.24
	216											3.15	3.88	2.84	3.77	4.01	3.79	4.13	4.93	5.58	6.44	6.84	6.03	6.33	6.56	6.54	5.95
	932											0.08	0.82	1.14	0.66	1.13	1.04	0.66	1.05	1.23	1.62	1.42	1.71	1.7	2.19	1.42	
	944			3.66			21.46		5.75	8.76	18.22	10.16	11.18	9.32	4.76	14.78	14.37	21.43	23.84	21.27	23.54	26.11	26.57	28.66	31.87	33.2	32.64
	949	1.09																						8.54			
	952	1.41	1.62	1.19	0.16	1.27	1.71	1.76	1.99	2.05	2.26	2.78	3.21	3.47	3.26	4.02	3.67	4.43	4.19	4.74	4.23	5.1	5.87	6.59	7.58	5.8	5.25
	959														0.18											4.2	
500	204						6.4	2.76	2.1	2.75	5.19	3.28	3.94	5.31	4.57	6.09	7.73	7.96	6.89	8.25	7.99	6.61	7.98	7.1	10.43	11.32	
	217								0.01			2.82	3.55	4.03	2.9	4.21	4.24	4.07	4.52	5.02	6.53	5.98	5.87	6.49	6.51	6.4	6.55
	933													0.16			1.62			1.47	1.18		0.74	1.28	1.31		
	942											0.7	0.87	1.67	0		0.49	1.26	1.31	1.22	1.28	1.69	1.52	2.34	2.17	2.65	1.97
	945	3.07	0.35				7.59			5.87	9.89	6.29	11.27	4.24	3.2	8.23	1.26	7.01				8.38			10.13		
	948	1.66	1.2		1.52						1.24	2.19										2.37					
	951	2.45	1.92	1.68	2.1	1.42	1.7	2.45	1.86	2.46	2.76	2.81	3.34	2.94	4.23	3.84	3.79	5.69	4.23	5.39	4.46	7.74	9.24	9.76	6.88		
	960																						3.25		4.45		
750	218											1.98	3.74	5.23	2.87	4.51	6.31	6.37	7.21	7.04	8.05	8.09	8.68	9.46	7.68	9.13	7.32
	239						0.63	0.59			2.18	2.35	2.21	1.49	2.26	2.42			3.05	4.62	4.06	3.56	2.17	3.89		4.72	
	934														0.26		1.94							3.82			
	941											2.21	0.58	2.7	0.47		0.71	2.92	2.54	2.42	2.34	2.85	2.44	4.27	4.06	5.29	3.48
	946	3.57									15.78					26.55											
	947	1.7	2.03	2	1.72	1.28	2.06	0.99	1.3	1.71	1.98	3.11	1.88	3.79	3.2			5.32	4.28	7.12		7.37	5.68	6.76			
	961																						7.61		7.56		
1000	219												5.65						6	3.37	5.28	7.32	4.71	9.07			
	940																				2.39			2.61			
All		28.63	13.01	19.26	10.01	11.42	54.25	17.7	35.34	75.09	83.34	95.26	99.75	76.02	96.91	133.1	133.6	145.6	174.9	168.8	183.7	227.6	240.4	248.2	267.8	205.7	166.9

Table 35. SFA 5 percent contribution of large vessel commercial biomass, by depth range within all strata.

Depth Range (m)	1980	1981	1982	1984	1985	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<= 200 m	29.27	28.36	19.37	37.96	43.61	10.65	0.00	29.51	15.35	16.32	12.10	7.50	0.00	15.16	0.00	19.20	11.69	20.03	12.76	17.89	20.72	17.03	19.82	25.40	13.24	0.00
201 - 300 m	18.51	16.83	24.40	0.00	16.90	5.11	24.35	17.86	45.53	8.74	37.61	30.34	27.61	40.44	34.06	36.80	33.27	32.60	34.83	34.61	30.43	36.70	27.62	28.23	36.37	53.65
301 - 400 m	8.73	12.45	37.07	8.69	15.85	50.32	37.29	37.75	22.09	28.14	21.17	25.06	30.87	19.66	23.94	22.95	27.18	24.48	25.19	23.79	21.62	21.36	25.63	23.54	31.18	34.80
401 - 500 m	25.08	26.67	8.72	36.16	12.43	28.92	29.44	11.23	14.76	22.89	18.99	23.03	24.14	15.38	16.81	14.32	17.85	9.69	12.65	11.67	14.40	11.90	10.87	15.64	9.90	5.10
501 - 750 m	18.41	15.60	10.38	17.18	11.21	4.96	8.93	3.68	2.28	23.93	10.13	8.43	17.38	9.35	25.15	6.71	10.03	9.77	12.56	7.87	9.61	11.06	11.36	7.21	9.30	6.47
751 - 1000 m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.66	0.00	0.00	0.00	0.00	0.00	3.43	2.00	4.18	3.22	1.96	4.71	0.00	0.00	0.00
Total	100.00	99.92	99.95	100.00	100.00	99.96	100.00	100.03	100.01	100.01	100.01	100.02	100.00	99.98	99.96	99.97	100.03	99.99	99.99	100.00	99.99	100.00	100.00	100.01	100.00	100.02

Table 36. Stratified analysis of SFA 5 index strata commercial large vessel catch data from the observer dataset (single + double trawl, index strata), 1994–2009. (Green 0–10,000 t; White 10,000–20,000 t; Pink > 20,000 t).

Index Strata Large vessel Shrimp Biomass 000 tonnes		year															
		1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Max depth (m)	STRATUM																
300	214	8.99	7.28	8.8	5.55	7.64	6.07	2.36	10.89	7.15	11.23	16.42	14.67	7.23	13.59	10.52	12.35
	215	13.99	12.97	5.4	21.97	22.39	27.75	30.9	30.89	33.6	35.25	33.43	37.58	39.76	39.06	43.5	37.69
	953	3.31	4.38	1.05	4.71	6.87	5.74	5.85	6.57	6.54	6.28	6.85	8.15	9.74	7.87	8.03	8.61
	955	5.7	5.63	5.74	6.96	8.43	9.6	8.76	8.67	11.51	10.82	12.55	12.43	11.82	15.08	12.77	17.76
400	203	5.46	8.05	9.13	8.76	10.81	10.61	12.17	12	13.22	10.72	13.27	15.14	16.07	20.23	17.7	19.41
	216	3.15	3.88	2.84	3.77	4.01	3.79	4.13	4.93	5.58	6.44	6.84	6.03	6.33	6.56	6.54	5.95
	944	10.16	11.18	9.32	4.76	14.78	14.37	21.43	23.84	21.27	23.54	26.11	26.57	28.66	31.87	33.2	32.64
	952	2.78	3.21	3.47	3.26	4.02	3.67	4.43	4.19	4.74	4.23	5.1	5.87	6.59	7.58	5.8	5.25
500	217	2.82	3.55	4.03	2.9	4.21	4.24	4.07	4.52	5.02	6.53	5.98	5.87	6.49	6.51	6.4	6.55
750	218	1.98	3.74	5.23	2.87	4.51	6.31	6.37	7.21	7.04	8.05	8.09	8.68	9.46	7.68	9.13	7.32
All		58.32	63.87	55	65.51	87.67	92.16	100.5	113.7	115.7	123.1	134.6	141	142.1	156	153.6	153.5

Table 37. SFA 5 percent contribution of large vessel commercial biomass, by depth range within index strata.

Depth Range (m)	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
201 - 300 m	54.85	47.38	38.16	59.82	51.71	53.34	47.63	50.15	50.82	51.65	51.45	51.65	48.24	48.46	48.71	49.78
301 - 400 m	36.95	41.21	45.02	31.37	38.35	35.20	41.95	39.54	38.73	36.50	38.13	38.02	40.57	42.46	41.17	41.21
401 - 500 m	4.84	5.56	7.33	4.43	4.80	4.60	4.05	3.98	4.34	5.30	4.44	4.16	4.57	4.17	4.17	4.27
501 - 750 m	3.40	5.86	9.51	4.38	5.14	6.85	6.34	6.34	6.08	6.54	6.01	6.16	6.66	4.92	5.94	4.77
Total	100.03	100.00	100.02	100.00	100.00	99.99	99.97	100.01	99.97	99.99	100.03	99.99	100.04	100.02	99.99	100.02

Table 38. Hopedale + Cartwright Channels (SFA 5) Northern Shrimp biomass and abundance estimates using the original and new Delauney triangulation and parameter files used in Ogmap calculations. These estimates were calculated from 1996–2009 Canadian autumn multi species bottom trawl research surveys (standard tows = 15 min at 3.0 Nmi/hr.)

Original Version

SFA 5

Year	Biomass (t)			Abundance (numbers x 10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	62,490	151,300	310,700	13,060	38,942	90,800
1997	85,780	129,200	174,800	17,950	28,636	40,430
1998	60,750	86,200	117,700	12,350	17,354	23,960
1999	72,970	108,100	153,900	14,190	21,471	30,150
2000						
2001	178,500	247,800	330,600	44,270	61,522	80,970
2002						
2003						
2004	129,600	183,000	237,200	26,790	39,075	52,170
2005						
2006	146,000	181,100	217,300	32,680	39,692	46,450
2007						
2008	95,590	157,000	227,200	22,900	33,846	46,600

Area compared each year = 60,578.6 sq. km.

Hopedale Channel

Year	Biomass (t)			Abundance (numbers x 10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	25,960	64,300	127,400	6,142	14,523	32,050
1997	41,990	80,000	115,800	9,156	17,962	27,990
1998	23,220	44,100	68,520	4,626	9,100	14,100
1999	27,200	51,500	85,950	4,939	10,816	18,230
2000						
2001	96,370	154,100	219,600	24,140	38,430	56,010
2002						
2003						
2004	52,600	93,100	137,700	11,350	20,490	31,410
2005						
2006	73,170	104,500	132,700	15,050	20,730	25,990
2007						
2008	36,820	91,700	150,500	7,949	18,089	28,590

Area compared each year = 34,284.2 sq. km.

Cartwright Channel

Year	Biomass (t)			Abundance (numbers x 10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	27,780	80,400	198,500	5,942	22,224	60,250
1997	34,840	48,900	75,040	7,192	10,374	16,410
1998	32,140	43,300	58,510	6,574	8,585	11,750
1999	41,210	56,900	77,710	8,205	11,021	14,780
2000	44,800	73,900	121,300	10,970	17,153	26,720
2001	70,060	89,500	123,500	17,380	21,847	28,800
2002	45,410	58,300	76,760	12,480	16,135	20,270
2003	65,850	95,300	134,100	16,100	21,327	28,690
2004	64,090	85,600	108,400	13,290	17,735	22,940
2005	93,750	141,300	192,400	21,540	29,248	36,450
2006	62,600	79,700	105,100	16,050	19,633	24,930
2007	70,510	85,600	103,700	19,940	23,757	27,820
2008	46,860	67,900	105,300	12,370	16,623	23,220
2009	21,700	56,100	157,900	7,465	15,926	39,210

Area compared each year = 25,204.6 sq. km.

Proposed Version

SFA 5

Year	Biomass (t)			Abundance (numbers x 10^6)			No. Sets
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	
1996	63,146	152,228	330,834	13,672	39,225	94,317	111
1997	88,679	128,367	177,197	18,837	28,428	40,373	111
1998	62,240	85,981	121,118	12,706	17,350	24,878	120
1999	73,003	105,513	148,100	14,307	20,941	29,852	117
2000							
2001	189,580	249,284	329,224	46,283	62,087	83,272	90
2002							
2003							
2004	129,575	186,459	239,115	27,778	40,249	53,381	119
2005							
2006	155,249	188,372	236,799	34,735	41,868	50,803	118
2007							
2008	102,694	158,873	233,376	24,415	34,792	48,558	98

Area compared each year = 59,872 sq. km.

Hopedale Channel

Year	Biomass (tons)			Abundance (numbers x 10^6)			No. Sets
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	
1996	28,533	69,066	135,616	6,487	15,863	35,520	77
1997	48,961	86,685	124,843	10,481	19,673	28,825	71
1998	24,918	43,796	70,486	5,046	9,070	14,689	83
1999	25,613	53,763	87,269	5,177	10,845	17,790	81
2000							
2001	108,533	165,216	228,745	27,264	41,325	58,515	57
2002							
2003							
2004	56,914	105,110	154,846	12,072	23,586	35,369	86
2005							
2006	78,198	109,943	133,804	15,837	22,493	27,113	81
2007							
2008	43,413	89,807	146,691	9,518	18,296	28,140	69

Area compared each year = 34,766 sq. km.

Year	Biomass (tons)			Abundance (numbers x 10^6)			No. Sets
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	
1996	27,969	80,947	199,850	5,982	22,375	60,660	34
1997	35,077	49,233	75,550	7,241	10,445	16,522	40
1998	32,359	43,594	58,908	6,619	8,643	11,830	37
1999	41,490	57,287	78,238	8,261	11,096	14,881	36
2000	45,105	74,403	122,125	11,045	17,270	26,902	35
2001	70,536	90,109	124,340	17,498	21,996	28,996	33
2002	45,719	58,696	77,282	12,565	16,245	20,408	39
2003	66,298	95,948	135,012	16,209	21,472	28,885	32
2004	64,526	86,182	109,137	13,380	17,855	23,096	33
2005	94,388	142,261	193,708	21,686	29,447	36,698	35
2006	63,026	80,242	105,815	16,159	19,767	25,100	37
2007	70,989	86,182	104,405	20,076	23,919	28,009	38
2008	47,179	68,362	106,016	12,454	16,736	23,378	27
2009	21,848	56,481	158,974	7,516	16,034	39,477	34

Area compared each year = 24,095.8 sq. km.

Table 39. Biomass (t) of Northern Shrimp (Pandalus borealis) in Hopedale + Cartwright Channels (SFA 5) over the period 1996 – 2008. The analysis was from areal expansion of multi species research survey data collected using a Campelen 1800 research shrimp trawl towed at 3 Nmi/hr for 15 min. (green < 10,000 t; white 10,000–20,000 t; pink>20,000 t; black indicates not sampled).

Survey Fall SFA 5 Shrimp 000 Biomass tonnes		Year							
		1996	1997	1998	1999	2001	2004	2006	2008
		.	.	.	.	.	.	.	.
Depth Range (m)	STRATUM								
<=200	930	0	.	0	1	2	12	6	3
	954	0	.	13	2	12	26	17	2
	956	0	.	7	0	0	13	8	1
101 - 200	201	1	0	1	2	2	2	4	2
	205	0	0	.	.	3	.	3	.
	206	.	.	.	0	.	.	.	.
	237	0	0	.	0	0	0	0	1
	238	0	0	0	0	0	0	0	1
201 - 300	202	4	2	2	4	12	13	3	5
	214	.	11	5	.	.	.	18	.
	215	91	7	15	15	21	31	20	32
	234	1	1	0	0	1	1	3	3
	931	0	1	1	1	.	4	6	0
	943	0	0	0	0	.	1	1	0
	950	5	1	.	0	1	23	7	.
	953	19	5	1	13	17	17	8	7
	955	18	10	2	2	31	9	13	.
301 - 400	203	6	3	7	7	11	3	8	6
	216	.	2	3	7	.	4	.	.
	932	0	0	0	0	.	1	1	0
	944	1	14	3	12	.	5	19	4
	949	6	17	.	.	15	0	.	.
	952	1	2	2	2	10	0	3	.
	959	0	.	.	.	0	0	0	0
401 - 500	204	4	6	2	0	2	5	4	4
	217	.	0	1	0	.	.	.	0
	933	0	0	0	0	.	0	0	0
	942	0	0	0	0	0	0	0	0
	945	0	0	1	0	1	1	2	1
	948	1	2	2	.	11	.	1	0
	951	1	2	0	0	0	0	1	0
	960	.	.	.	.	.	.	.	0
501 - 750	218	.	0	0	0	.	0	0	.
	239	1	1	1	1	2	1	1	3
	934	0	0	0	0	.	0	0	0
	941	0	0	0	0	0	0	0	.
	946	1	1	1	1	2	3	0	.
	947	0	1	0	0	5	0	0	0
	961	0	.	.	.	.	.	0	.
751 -1000	219	.	.	0	0	.	0	.	.
	935	.	0	0	0	.	0	0	0
	940	0	0	0	0	.	0	0	0
	962	.	.	0	.	.	.	0	.
1001 -1250	220	0	.	.	.	0	0	.	.
	936	.	0	0	.	0	0	0	0
	939	0	0	.	0	.	0	.	0
	963	0	0	.	.	.	0	.	0
1251 -1500	221	0	0	0	.	.	.	0	.
	937	.	0	0	.	0	0	0	0
	938	0	0	0	0	0	0	0	0
	964	.	0	0	0	.	.	0	.
All		162	88	70	71	162	175	158	77

Table 40. SFA 5 percent contribution of research survey total biomass, by depth range, within all strata.

Depth Range (m)	1996	1997	1998	1999	2001	2004	2006	2008
<= 200 m	0.62	0.00	30.00	7.04	11.73	30.29	24.05	12.99
201 - 300 m	85.19	43.18	37.14	49.30	51.23	56.57	50.00	61.04
301 - 400 m	8.64	43.18	21.43	39.44	22.22	7.43	19.62	12.99
401 - 500 m	3.70	11.36	8.57	0.00	8.64	3.43	5.06	6.49
501 - 750 m	1.23	3.41	2.86	2.82	5.56	2.29	0.63	3.90
751- 1250 m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1251 - 1500 m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	99.38	101.14	100.00	98.59	99.38	100.00	99.37	97.40

Table 41. Biomass (000 t) of Northern Shrimp within Hopedale and Cartwright Channels (SFA 5) index strata over the period 1996–2008. (green<10,000 t; white 10,000–20,000 t; pink>20,000 t).

Survey Fall SFA 5 Shrimp Biomass 000 tonnes		YEAR							
		1996	1997	1998	1999	2001	2004	2006	2008
		.	.	.	.	.	.	.	.
Depth Range (m)	STRATUM	1	0	1	2	2	2	4	2
101 - 200	201								
	238	0	0	0	0	0	0	0	1
201 - 300	202	4	2	2	4	12	13	3	5
	215	91	7	15	15	21	31	20	32
	234	1	1	0	0	1	1	3	3
	953	19	5	1	13	17	17	8	7
301 - 400	203	6	3	7	7	11	3	8	6
401 - 500	204	4	6	2	0	2	5	4	4
	942	0	0	0	0	0	0	0	0
	945	0	0	1	0	1	1	2	1
	951	1	2	0	0	0	0	1	0
501 - 750	239	1	1	1	1	2	1	1	3
	947	0	1	0	0	5	0	0	0
1251 -1500	938	0	0	0	0	0	0	0	0
All		127	26	30	44	75	75	53	66

Table 42. SFA 5 percent contribution of research survey total biomass, by depth range, within index strata.

Depth Range (m)	1996	1997	1998	1999	2001	2004	2006	2008
101 - 200 m	0.79	0.00	3.33	4.55	2.67	2.67	7.55	4.55
201 - 300 m	90.55	57.69	60.00	72.73	68.00	82.67	64.15	71.21
301 - 400 m	4.72	11.54	23.33	15.91	14.67	4.00	15.09	9.09
401 - 500 m	3.94	30.77	10.00	0.00	4.00	8.00	13.21	7.58
501 - 750 m	0.79	7.69	3.33	2.27	9.33	1.33	1.89	4.55
1251 - 1500 m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	100.79	107.69	100.00	95.45	98.67	98.67	101.89	96.97

Table 43. Hopedale + Cartwright Channels (SFA 5) Northern Shrimp female spawning stock biomass (SSB) and abundance estimates using the original and new Delauney triangulation and parameter files used in Ogmap calculations. These estimates were calculated from 1996–2009 Canadian autumn multi species bottom trawl research surveys (standard tows = 15 min at 3.0 Nmi/hr.)

Original Values

SFA 5

Year	Biomass (t X10^3)			Abundance (10^9)		
	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						
2008	46,280	83,000	124,100	6,187	11,123	16,506

Cartwright Channel

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
2008	18,220	33,600	61,990	2,527	4,654	8,650
2009	4,949	21,300	71,840	679	3,019	10,330

Proposed Values

SFA 5

Year	Biomass (t X10^3)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	21,868	33,224	47,753	2,512	3,939	5,724
1997	28,553	39,668	50,290	3,516	4,854	6,147
1998	26,851	37,956	50,239	3,310	4,670	6,268
1999	33,506	50,139	69,016	4,225	6,240	8,601
2000						
2001	67,174	96,451	129,273	9,167	12,769	16,944
2002						
2003						
2004	61,928	86,484	110,547	8,768	12,030	15,303
2005						
2006	60,851	81,651	106,721	7,918	10,611	13,984
2007						
2008	45,457	82,155	126,051	6,045	11,003	16,803

Cartwright Channel

Year	Biomass (t)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
1996	9,703	15,203	22,542	1,119	1,748	2,680
1997	11,608	16,512	22,331	1,418	2,001	2,702
1998	12,947	20,438	27,768	1,581	2,456	3,359
1999	17,196	28,291	39,446	2,178	3,545	4,995
2000	15,183	33,023	60,720	1,946	4,199	7,731
2001	26,720	37,755	57,146	3,522	4,925	7,363
2002	17,468	22,754	34,533	2,684	3,446	5,118
2003	26,882	52,555	81,500	4,086	7,469	11,518
2004	28,895	45,105	59,945	4,179	6,237	8,230
2005	35,248	73,396	112,762	4,677	9,790	15,092
2006	22,784	31,916	51,105	3,006	4,201	6,776
2007	26,569	35,641	48,175	3,725	4,929	6,666
2008	18,032	35,741	61,797	2,479	4,948	8,475
2009	5,460	19,230	70,345	737	2,729	10,098

Table 44. Hopedale + Cartwright Channels (SFA 5) Northern Shrimp fishable biomass and abundance estimates using the original and new definitions of fishable biomass, Delauney triangulation and parameter files used in Ogmap calculations. These estimates were calculated from 1996–2009 Canadian autumn multi species bottom trawl research surveys (standard tows = 15 min at 3.0 Nmi/hr.)

Original Values

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						
2008	68,030	127,700	190,900	12,000	21,801	32,310

Cartwright Channel

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
2008	34,420	50,700	90,030	6,042	8,973	15,170
2009	10,090	34,900	106,600	2,005	6,679	20,310

Proposed Values

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	46,403	86,283	145,080	8,645	18,227	33,104
1997	70,164	101,787	137,428	14,075	21,191	29,509
1998	50,511	70,677	100,781	9,539	13,485	20,045
1999	62,935	90,813	128,669	10,823	16,186	23,630
2000						
2001	137,428	183,540	246,867	26,700	36,004	49,414
2002						
2003						
2004	102,492	150,617	200,555	19,592	29,454	39,467
2005						
2006	125,548	155,349	196,024	23,418	29,112	37,040
2007						
2008	73,063	128,367	198,440	13,189	21,951	33,828

Cartwright Channel

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	17,005	34,936	71,130	3,081	7,709	18,163
1997	24,717	32,520	51,337	4,641	6,332	10,491
1998	24,143	32,117	44,672	4,525	5,903	8,484
1999	32,771	44,601	62,935	5,790	7,509	11,145
2000	27,697	50,139	91,397	5,291	8,920	15,495
2001	48,236	63,026	93,693	8,900	11,405	17,186
2002	30,758	39,668	56,995	5,916	7,599	10,954
2003	39,547	68,362	108,030	8,224	12,362	18,807
2004	42,638	61,113	80,544	8,195	11,170	14,699
2005	62,301	100,680	135,616	12,917	18,907	24,163
2006	45,085	55,978	83,071	8,499	10,573	15,756
2007	43,534	55,676	71,735	7,887	9,994	12,645
2008	34,221	55,877	93,300	6,264	9,376	15,233
2009	10,974	34,433	125,548	2,073	6,444	22,905

Table 45. Modal analysis using Mix 3.01 (MacDonald and Pitcher, 1993) of Pandalus borealis in Cartwright Channel, from autumn multi species bottom trawl surveys.

Mean Carapace Length (Standard Error)

	Age				
Year	1	2	3	4	5
1996		15.91 (.072)	17.36 (.029)	19.46 (.129)	21.37 (.086)
1997		14.34 (.31)	17.35 (.19)	19.05 (.18)	20.61 (.60)
1998	10.02 (.071)	14.54 (.67)	16.88 (.094)	18.51(.067)	
1999	10.72 (.070)	14.84 (.060)	17.09 (.094)	19.12 (.080)	21.12 (.047)
2000	9.90 (.141)	14.07 (.125)	16.91 (.055)	19.69 (.124)	21.70 (.488)
2001	10.38 (.159)	14.42 (.301)	16.85 (.055)	19.28 (.071)	21.78 (.194)
2002		13.24 (.082)	15.93 (.045)	18.75 (.038)	
2003		12.71 (.082)	15.13 (.077)	17.47 (.04)	19.63 (.045)
2004		14.30 (.163)	16.62 (.081)	18.79 (.136)	20.30 (.411)
2005	10.41 (.029)	14.40 (.064)	17.51 (.074)	19.20 (.246)	20.42 (.152)
2006	9.87 (.084)	13.84 (.041)	17.00 (.151)	19.12 (.060)	22.72 (.152)
2007	10.81 (.202)	13.11 (.079)	16.04 (.031)	19.71 (.027)	
2008	10.82 (.379)	13.05 (.221)	15.42 (.086)	17.79 (.086)	20.27 (.063)
2009	10.85 (.093)	13.87 (.098)	16.03 (.063)	18.18 (.064)	20.76 (.107)

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

	Age					
Year	1	2	3	4	5	Total
1996		.122 (.018)	.755 (.021)	.088 (.009)	.035 (.005)	1.000
1997		.030 (.007)	.534 (.123)	.323 (.190)	.113 (.087)	1.000
1998	.016 (.002)	.030 (.029)	.084 (.072)	.538 (.105)	.332 (.141)	1.000
1999	.032 (.002)	.137 (.007)	.208 (.012)	.317 (.012)	.305 (.013)	0.999
2000	.005 (.001)	.091 (.003)	.638 (.009)	.170 (.010)	.096 (.126)	1.000
2001	.010 (.002)	.151 (.031)	.410 (.051)	.412 (.032)	.016 (.006)	0.999
2002		.104 (.008)	.514 (.009)	.381 (.010)		0.999
2003		.052 (.004)	.185 (.008)	.526 (.009)	.237 (.010)	1.000
2004		.041 (.009)	.458 (.025)	.460 (.024)	.041 (.038)	1.000
2005	.089 (.002)	.065 (.003)	.435 (.033)	.267 (.031)	.144 (.046)	1.000
2006	.036 (.002)	.344 (.008)	.198 (.017)	.404 (.018)	.018 (.002)	1.000
2007	.025 (.006)	.219 (.006)	.517 (.007)	.239 (.004)		1.000
2008	.010 (.005)	.083 (.010)	.373 (.011)	.339 (.012)	.195 (.009)	1.000
2009	.031 (.002)	.142 (.012)	.476 (.012)	.311 (.013)	.040 (.004)	1.000

Distributional Sigmas (Standard Error and constraints)

	Age				
Year	1	2	3	4	5
1996		.902 (.021 Eq)	.902 (.021 Eq)	.902 (.021 Eq)	.902 (.021 Eq)
1997		1.032 (.176)	.856 (.094)	.771 (.219)	.878 (.176)
1998	.641 (.056)	.843 (.272)	.538 (.189)	1.52 (.181)	.978 (.107)
1999	.897 (.020 Eq)	.897 (.020 Eq)	.897 (.020 Eq)	.897 (.020 Eq)	.897 (.020 Eq)
2000	.951 (.015 Eq)	.951 (.015 Eq)	.951 (.015 Eq)	.951 (.015 Eq)	.951 (.015 Eq)
2001	.778 (.094)	1.34 (.174)	.892 (.068)	.980 (.067)	.594 (.091)
2002		1.21 (.020 Eq)	1.21 (.020 Eq)	1.21 (.020 Eq)	
2003		1.01 (.200 Eq)	1.01 (.200 Eq)	1.01 (.200 Eq)	1.01 (.200 Eq)
2004		1.100 (.049 Eq)	1.100 (.049 Eq)	1.100 (.049 Eq)	1.100 (.049 Eq)
2005	1.014 (.018 Eq)	1.014 (.018 Eq)	1.014 (.018 Eq)	1.014 (.018 Eq)	1.014 (.018 Eq)
2006	1.246 (.023 Eq)	1.246 (.023 Eq)	1.246 (.023 Eq)	1.246 (.023 Eq)	1.246 (.023 Eq)
2007	1.219 (.014 Eq)	1.219 (.014 Eq)	1.219 (.014 Eq)	1.219 (.014 Eq)	
2008	1.102 (.030 Eq)	1.102 (.030 Eq)	1.102 (.030 Eq)	1.102 (.030 Eq)	1.102 (.030 Eq)
2009	1.047 (.028 Eq)	1.047 (.028 Eq)	1.047 (.028 Eq)	1.047 (.028 Eq)	1.047 (.028 Eq)

Table 45. (Cont'd)

Population at Age Estimates (10^6)

	Male Ages						Female	Total
Year	0	1	2	3	4	5		
1996	0	19	2,509	15,546	1,816	728	1,748	22,365
1997	3	16	263	3,909	1,803	840	2,003	8,837
1998	0	90	171	475	3,049	1,878	2,457	8,120
1999	0	207	878	1,337	2,037	1,960	3,545	9,965
2000	0	59	1,306	7,730	3,194	308	4,201	16,779
2001	0	151	2,351	6,391	6,425	255	4924	20,505
2002	0	272	1,202	5,935	4,403	0	3,448	15,259
2003	0	664	2,352	6,698	3,025	0	7,465	20,204
2004	1	42	429	4,821	4,833	437	6,314	16,878
2005	0	1,583	1,164	7,748	4,752	2,568	9,722	27,537
2006	0	528	5,081	2,917	5,957	284	4,200	18,967
2007	17	495	4,211	9,937	4,596	7	4,924	24,188
2008	16	143	919	4,157	3,777	2,184	4,945	16,141
2009	37	403	1,751	5,860	3,832	487	2,746	15,117

Table 46. SFA 5 and Cartwright Channel Northern Shrimp recruitment indices using the original definition (abundance of all males and unidentified Pandalus 11.5-16 mm carapace lf), Delauney triangulation and parameter files compared with estimates using the new definitions (abundances of all males + females with 11.5–16 mm carapace lf) and new Delauney triangulation and parameter files used in Ogmap calculations. These estimates were calculated from 1996 - 2009 Canadian autumn multi species bottom trawl research surveys (standard tows = 15 min at 3.0 Nmi/hr).

Original Values

SFA 5

Year	Lower 95% CL	Recruitment index ($X10^6$)	Upper 95% CL
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			
2008	8,482	10,975	14,020

Cartwright Channel

Year	Lower 95% CL	Recruitment index ($X10^6$)	Upper 95% CL
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
2008	4,056	5,155	6,138
2009	3,843	5,973	10,010

Proposed Values

SFA 5

Year	Lower 95% CL	Recruitment index ($X10^6$)	Upper 95% CL
1996	1,955	10,714	31,523
1997	1,751	2,988	4,581
1998	1,299	1,796	2,541
1999	1,660	2,469	3,473
2000			
2001	10,632	15,867	21,475
2002			
2003			
2004	3,218	4,774	7,121
2005			
2006	6,637	8,360	10,541
2007			
2008	6,464	8,021	10,199

Cartwright Channel

Year	Lower 95% CL	Recruitment index ($X10^6$)	Upper 95% CL
1996	1,085	7,657	23,146
1997	652	888	1,566
1998	668	944	1,387
1999	949	1,519	2,207
2000	2,294	3,863	5,533
2001	3,996	5,864	8,136
2002	3,504	5,280	7,051
2003	2,502	3,822	5,800
2004	1,817	2,667	4,155
2005	1,943	2,611	3,419
2006	4,671	6,026	7,742
2007	7,552	10,343	12,182
2008	3,958	4,820	5,936
2009	3,643	5,925	10,068

Table 47. SFA 5 exploitation rate indices over the period 1996–2009. This table presents the original formulation of indices in which catch is divided by the previous year's lower 95% confidence interval below the total biomass index, the total biomass index and the fishable biomass index. There was no attempt to determine exploitation in terms of count because length frequency data from the small vessel fleet was not sufficient to be confident that it was representative of fleet activities.

Year	lower C.L. of total biomass (t)	total biomass (t)	fishable biomass (t)
1996	63,146	152,228	86,283
1997	88,679	128,367	101,787
1998	62,240	85,981	70,677
1999	73,003	105,513	90,813
2001	189,580	249,284	183,540
2004	129,575	186,459	150,617
2006	155,249	188,372	155,349
2008	102,694	158,873	128,367

Year	Catch (t)	Catch/ lower C.L.	Catch/ total biomass	Catch/ fishable biomass
1997	15,103	23.92	9.92	17.50
1998	15,170	17.11	11.82	14.90
1999	15,109	24.28	17.57	21.38
2000	14,694	20.13	13.93	16.18
2001	15,116			
2002	15,339	8.09	6.15	8.36
2003	30,437			
2004	22,690			
2005	22,898	17.67	12.28	15.20
2006	22,612			
2007	23,768	15.31	12.62	15.30
2008	20,503			
2009	24,883	24.23	15.66	19.38

Table 48. Survival, annual mortality and instantaneous mortality rate indices for Northern Shrimp (Pandalus borealis) within Cartwright Channel. 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 0.67, 0.33 and 0.39 respectively. This analysis is based upon data from the multispecies survey dataset.

Year	Age 3+ male and total female abundance (millions; yr=t)	Age 4+ male and total female abundance (millions; yr=t)	Survival rate ($S = n_{t+1}/n_t$	Annual mortality rate (A=1-S)	Instantaneous mortality rate (Z=-ln(S))
1996	19,838	4,292			
1997	8,555	4,646			
1998	7,859	7,384	0.60	0.40	0.50
1999	8,879	7,542	0.84	0.16	0.17
2000	15,433	7,703	0.69	0.31	0.37
2001	17,995	11,604	0.67	0.33	0.40
2002	13,786	7,851	0.64	0.36	0.44
2003	17,188	10,490	0.72	0.28	0.33
2004	16,405	11,584	0.69	0.31	0.38
2005	24,790	17,042	0.68	0.32	0.39
2006	13,358	10,441	0.65	0.35	0.43
2007	19,464	9,527	0.52	0.48	0.65
2008	15,063	10,906			
2009	12,925	7,065			

Table 49. Survival, annual mortality and instantaneous mortality rate indices for Northern Shrimp (Pandalus borealis) within Hopedale + Cartwright Channels (SFA 5). Indices were calculated by combining 4 years of data in order to account for vagaries within the observer dataset. The survival, S, in the blue box is the sum of the multiparous females (shaded green) divided by the sum of the primiparous females from the previous year (shaded yellow). Median survival, annual mortality, and instantaneous mortality rates were 0.38, 0.62 and 0.98 respectively. This analysis is based upon data from the Observer dataset.

Year	Abundance primiparous females (raw count; yr=t)	abundance multiparous females (raw count; yr=t)	Survival rate ($S = n_{t+1}/n_t$	Annual mortality rate (A=1-S)	Instantaneous mortality rate (Z=-ln(S))
1990	36,882	10,192			
1991	51,312	8,503			
1992	35,416	13,112	0.19	0.81	1.69
1993	16,092	4,042	0.16	0.84	1.81
1994	3,662	242			
1995	875	98			
1996					
1997	14,034	2,890			
1998	1,708	522			
1999	6,907	6,454	0.49	0.51	0.71
2000	1,407	510	0.57	0.43	0.57
2001	11,172	4,369	0.39	0.61	0.95
2002	3,160	675	0.56	0.44	0.58
2003	5,190	3,243	0.38	0.62	0.98
2004	15,918	3,477	0.35	0.65	1.04
2005	24,058	5,957	0.39	0.61	0.95
2006	14,249	4,406	0.37	0.63	1.00
2007	25,385	9,053	0.37	0.63	0.99
2008	19,769	9,828			
2009	25,968	7,731			

Table 50. **ORIGINAL MODEL** NORTHERN SHRIMP LARGE VESSEL (>500 t) FISHERY DATA FOR DIV. 2G (SFA 4), 1979 - 2009.

(Single trawl, observer dataset, no windows, all months, history>3 yrs)

YEAR	TAC [1]	FLEET [2] CATCH	UNSTANDARDIZED CPUE	CPUE Relative to 2009	EFFORT [3]	CPUE Relative to 2009	STANDARDIZED MODELLED CPUE	EFFORT
	(t)	(t)	(KG/HR)		(HR)			(HRS)
1978	500	3						
1979	500	0						
1980	500	2						
1981	500	5						
1982	500	30						
1983	500	0						
1984	500	0						
1985	500	2						
1986	500	7						
1987	500	1,083						
1988	500	3,842						
1989	2,580	2,945	439	0.10	6,712	0.17	522	5,639
1990	2,580	2,561	719	0.17	3,562	0.18	551	4,646
1991	2,635	2,706	2,010	0.48	1,346	0.73	2,256	1,200
1992	2,635	2,723	2,093	0.50	1,301	0.64	1,979	1,376
1993	2,735	3,982	2,210	0.53	1,802	0.60	1,867	2,133
1994	4,000	5,104	3,740	0.89	1,365	1.03	3,194	1,598
1995	5,200	5,160	1,261	0.30	4,092	0.36	1,124	4,592
1996	5,200	5,216	1,297	0.31	4,022	0.36	1,118	4,667
1997	5,200	8,184	3,062	0.73	2,673	0.83	2,589	3,161
1998	8,008	7,975	2,145	0.51	3,717	0.63	1,954	4,082
1999	8,214	7,464	2,330	0.56	3,204	0.68	2,120	3,521
2000	8,227	8,130	2,586	0.62	3,144	0.72	2,234	3,640
2001	8,307	8,452	4,179	1.00	2,022	1.09	3,382	2,499
2002	8,008	13,020	2,755	0.66	4,726	0.67	2,076	6,272
2003	12,685 [4]	9,644	3,498	0.83	2,757	0.83	2,576	3,743
2004	10,243	10,247	2,364	0.56	4,335	0.58	1,811	5,658
2005	10,330	10,084	2,420	0.58	4,167	0.57	1,761	5,726
2006	10,169	10,009	2,931	0.70	3,414	0.69	2,132	4,694
2007	9,882	10,735	2,896	0.69	3,707	0.72	2,233	4,807
2008	10,782	10,664	2,916	0.69	3,657	0.71	2,220	4,803
2009	10,782	10,664	4,197	1.00	2,541	1.00	3,109	3,430
2010								

[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 51. **Original** multiplicative year, month, area and vessel CPUE model for large vessels (>500 t) fishing shrimp in NAFO Division 2G (SFA 4), 1989–2009, weighted by effort. (Original model formulation, single trawl no windows, observer data, all months, history>3 yrs.)

```
                                     The GLM Procedure
                                  Class Level Information
Class        Levels  Values
year             21  1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003
              2004 2005 2006 2007 2008 2009
month            12  1 2 3 4 5 6 8 9 10 11 12 99 Standardized against July
CFV              21
                                              Number of Observations Read         789
                                              Number of Observations Used         789
Dependent Variable: lncpue
Weight: effort                                      Sum of
            Source                        DF          Squares     Mean Square    F Value    Pr > F
            Model                         51       8285.99820       162.47055      24.47    <.0001
            Error                        737       4892.51089         6.63841
            Corrected Total              788      13178.50910

                   R-Square     Coeff Var      Root MSE    lncpue Mean
                   0.628751      33.36469      2.576512       7.722271

           Source                     DF       Type I SS     Mean Square    F Value    Pr > F
           year                       20     6252.792461      312.639623      47.10    <.0001
          month                      11      488.499882       44.409080       6.69    <.0001
          CFV                        20     1544.705858       77.235293      11.63    <.0001

          Source                     DF     Type III SS     Mean Square    F Value    Pr > F
          year                       20     3673.732373      183.686619      27.67    <.0001
          month                      11      441.021972       40.092907       6.04    <.0001
          CFV                        20     1544.705858       77.235293      11.63    <.0001
                                                          Standard
          Parameter               Estimate                   Error    t Value    Pr > |t|
         Intercept             7.594847262 B      0.13481988      56.33      <.0001
         year      1989       -1.783955555 B      0.20925845      -8.53      <.0001
         year      1990       -1.729938571 B      0.15450510     -11.20      <.0001
         year      1991       -0.320830532 B      0.18798751      -1.71      0.0883
         year      1992       -0.451651954 B      0.16423021      -2.75      0.0061
         year      1993       -0.509938521 B      0.19539758      -2.61      0.0092
         year      1994        0.026853211 B      0.13092228       0.21      0.8375
         year      1995       -1.017668678 B      0.09366973     -10.86      <.0001
         year      1996       -1.022975606 B      0.09351561     -10.94      <.0001
         year      1997       -0.182888541 B      0.11207981      -1.63      0.1032
         year      1998       -0.464506781 B      0.08876122      -5.23      <.0001
         year      1999       -0.382991396 B      0.09018465      -4.25      <.0001
         year      2000       -0.330674430 B      0.09167343      -3.61      0.0003
         year      2001        0.084108346 B      0.09890410       0.85      0.3954
         year      2002       -0.403834398 B      0.08837137      -4.57      <.0001
         year      2003       -0.187885000 B      0.08891419      -2.11      0.0349
         year      2004       -0.540445393 B      0.08298240      -6.51      <.0001
         year      2005       -0.568382622 B      0.08329109      -6.82      <.0001
         year      2006       -0.377026557 B      0.08277295      -4.55      <.0001
         year      2007       -0.330924560 B      0.08071743      -4.10      <.0001
         year      2008       -0.336580236 B      0.08209815      -4.10      <.0001
         year      2009        0.000000000 B       .                 .          .
```

Table 51 (Cont'd)

Parameter		Estimate		Standard Error	t Value	Pr > |t|
month	1	0.261474426	B	0.06205713	4.21	<.0001
month	2	0.256425795	B	0.34064157	0.75	0.4518
month	3	-1.433978376	B	1.49069027	-0.96	0.3364
month	4	-0.274410218	B	0.14200250	-1.93	0.0537
month	5	0.030589566	B	0.07541167	0.41	0.6851
month	6	-0.074834611	B	0.06554779	-1.14	0.2540
month	8	0.005545482	B	0.05466067	0.10	0.9192
month	9	-0.075021250	B	0.06753212	-1.11	0.2670
month	10	-0.102273874	B	0.04874311	-2.10	0.0362
month	11	-0.044445826	B	0.04491135	-0.99	0.3227
month	12	0.161444033	B	0.05321544	3.03	0.0025
month	99	0.000000000	B	.	.	.
CFV		0.504585440	B	0.11239608	4.49	<.0001
CFV		0.891157312	B	0.13283521	6.71	<.0001
CFV		0.727436790	B	0.11533089	6.31	<.0001
CFV		0.621137147	B	0.11582002	5.36	<.0001
CFV		0.563724373	B	0.12532151	4.50	<.0001
CFV		0.641493981	B	0.12902634	4.97	<.0001
CFV		0.572929755	B	0.11420926	5.02	<.0001
CFV		0.531203832	B	0.13035285	4.08	<.0001
CFV		0.733909327	B	0.11271568	6.51	<.0001
CFV		0.557176761	B	0.13345482	4.18	<.0001
CFV		0.548792368	B	0.12758112	4.30	<.0001
CFV		0.657909540	B	0.12534550	5.25	<.0001
CFV		0.600453780	B	0.14610197	4.11	<.0001
CFV		0.226700433	B	0.12509142	1.81	0.0704
CFV		0.915558945	B	0.13077130	7.00	<.0001
CFV		0.762866387	B	0.12626307	6.04	<.0001
CFV		0.930134458	B	0.12473013	7.46	<.0001
CFV		0.261728682	B	0.12076405	2.17	0.0305
CFV		0.345547532	B	0.12026839	2.87	0.0042
CFV		0.053377075	B	0.12831096	0.42	0.6775
CFV		0.000000000	B	.	.	

year	lncpue LSMEAN	95% Confidence Limits	
1989	6.258093	5.799180	6.717005
1990	6.312110	5.942398	6.681822
1991	7.721218	7.305178	8.137258
1992	7.590397	7.211100	7.969693
1993	7.532110	7.097175	7.967045
1994	8.068902	7.739468	8.398335
1995	7.024380	6.750968	7.297792
1996	7.019073	6.744814	7.293332
1997	7.859160	7.561896	8.156424
1998	7.577542	7.309762	7.845321
1999	7.659057	7.392812	7.925302
2000	7.711374	7.439207	7.983541
2001	8.126157	7.841979	8.410334
2002	7.638214	7.368968	7.907460
2003	7.854163	7.584644	8.123683
2004	7.501603	7.238255	7.764951
2005	7.473666	7.207277	7.740054
2006	7.665022	7.396416	7.933628
2007	7.711124	7.443556	7.978692
2008	7.705468	7.436402	7.974534
2009	8.042048	7.753664	8.330432

Table 52. PROPOSED MODEL NORTHERN SHRIMP LARGE VESSEL (>500 t) FISHERY DATA FOR DIV. 2G (SFA 4), 1979 - 2009.

(Single trawl, observer dataset, no windows, July - December, history>3 yrs)

YEAR	TAC [1] (t)	FLEET [2] CATCH (t)	UNSTANDARDIZED CPUE (KG/HR)	CPUE Relative to 2009	EFFORT [3] (HR)	CPUE Relative to 2009	STANDARDIZED MODELLED CPUE	EFFORT (HRS)
1978	500	3						
1979	500	0						
1980	500	2						
1981	500	5						
1982	500	30						
1983	500	0						
1984	500	0						
1985	500	2						
1986	500	7						
1987	500	1,083						
1988	500	3,842						
1989	2,580	2,945	679	0.16	4,336	0.26	869	3,388
1990	2,580	2,561	843	0.20	3,039	0.28	934	2,741
1991	2,635	2,706	3,918	0.95	691	1.25	4,104	659
1992	2,635	2,723	1,810	0.44	1,505	0.56	1,832	1,486
1993	2,735	3,982	1,515	0.37	2,628	0.44	1,451	2,745
1994	4,000	5,104	1,590	0.38	3,210	0.48	1,585	3,220
1995	5,200	5,160	1,309	0.32	3,943	0.40	1,299	3,972
1996	5,200	5,216	1,253	0.30	4,162	0.38	1,253	4,163
1997	5,200	8,184	2,048	0.50	3,996	0.60	1,974	4,146
1998	8,008	7,975	1,954	0.47	4,081	0.63	2,060	3,871
1999	8,214	7,464	2,027	0.49	3,682	0.65	2,130	3,505
2000	8,227	8,130	2,256	0.55	3,604	0.66	2,177	3,734
2001	8,307	8,452	2,596	0.63	3,256	0.75	2,476	3,414
2002	8,008 [4]	13,020	2,424	0.59	5,370	0.67	2,188	5,950
2003	12,685	9,644	2,658	0.64	3,628	0.71	2,319	4,158
2004	10,243	10,247	2,957	0.72	3,465	0.75	2,452	4,179
2005	10,330	10,084	3,070	0.74	3,285	0.74	2,430	4,149
2006	10,169	10,009	3,230	0.78	3,098	0.82	2,698	3,710
2007	9,882	10,735	3,365	0.81	3,190	0.88	2,878	3,730
2008	10,782	10,664	3,629	0.88	2,939	0.92	3,013	3,540
2009	10,782	10,664	4,133	1.00	2,580	1.00	3,286	3,245
2010								

[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 53. **Proposed** multiplicative year, month, area and vessel CPUE model for arge vessels (>500 t) fishing shrimp in NAFO Division 2G (SFA 4), 1989–2009, weighted by effort. (Original model formulation, single trawl no windows, observer data, July–December data, history>3 yrs.)

The GLM Procedure

Class Level Information

Class	Levels	Values
year	21	1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
month	6	8 9 10 11 12 99 Standardized to July
CFV	21	

Number of Observations Read	595
Number of Observations Used	595

Dependent Variable: lncpue
Weight: effort

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	45	7469.639935	165.991999	59.31	<.0001
Error	549	1536.389591	2.798524		
Corrected Total	594	9006.029526			

R-Square	Coeff Var	Root MSE	lncpue Mean
0.829404	21.65786	1.672879	7.724119

Source	DF	Type I SS	Mean Square	F Value	Pr > F
year	20	5359.456220	267.972811	95.76	<.0001
month	5	152.696316	30.539263	10.91	<.0001
CFV	20	1957.487399	97.874370	34.97	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
year	20	1934.158067	96.707903	34.56	<.0001
month	5	98.394488	19.678898	7.03	<.0001
CFV	20	1957.487399	97.874370	34.97	<.0001

Parameter		Estimate		Standard Error	t Value	Pr > |t|
Intercept		7.779048777	B	0.09544217	81.51	<.0001
year	1989	-1.329833498	B	0.15009833	-8.86	<.0001
year	1990	-1.257911498	B	0.10484727	-12.00	<.0001
year	1991	0.222047837	B	0.26910867	0.83	0.4097
year	1992	-0.584341994	B	0.15566241	-3.75	0.0002
year	1993	-0.817781660	B	0.12936698	-6.32	<.0001
year	1994	-0.729105056	B	0.09086933	-8.02	<.0001
year	1995	-0.928125152	B	0.06499043	-14.28	<.0001
year	1996	-0.964261051	B	0.06561211	-14.70	<.0001
year	1997	-0.509748544	B	0.08874036	-5.74	<.0001
year	1998	-0.466976038	B	0.06274621	-7.44	<.0001
year	1999	-0.433830356	B	0.06480680	-6.69	<.0001
year	2000	-0.411676521	B	0.06414369	-6.42	<.0001
year	2001	-0.283238844	B	0.07046158	-4.02	<.0001
year	2002	-0.406798271	B	0.06421364	-6.34	<.0001
year	2003	-0.348623879	B	0.06387912	-5.46	<.0001
year	2004	-0.292905848	B	0.06267923	-4.67	<.0001
year	2005	-0.301806716	B	0.05963515	-5.06	<.0001
year	2006	-0.197262795	B	0.05925039	-3.33	0.0009
year	2007	-0.132569276	B	0.05748503	-2.31	0.0215
year	2008	-0.087010886	B	0.05814885	-1.50	0.1351
year	2009	0.000000000	B	.	.	.

Table 53. (Cont'd)

Parameter		Estimate	Standard Error	t Value	Pr > |t|
month	8	-0.030794980 B	0.03774161	-0.82	0.4149
month	9	-0.064919277 B	0.04699464	-1.38	0.1677
month	10	-0.044079533 B	0.03352827	-1.31	0.1892
month	11	0.015414552 B	0.03093377	0.50	0.6185
month	12	0.132698565 B	0.03642277	3.64	0.0003
month	99	0.000000000 B	.	.	.
CFV		0.245907253 B	0.08012337	3.07	0.0023
CFV		0.561642512 B	0.09359518	6.00	<.0001
CFV		0.399697924 B	0.08196189	4.88	<.0001
CFV		0.359356106 B	0.08309647	4.32	<.0001
CFV		0.320464472 B	0.09572360	3.35	0.0009
CFV		0.551194422 B	0.09035494	6.10	<.0001
CFV		0.457162253 B	0.08042250	5.68	<.0001
CFV		0.227449401 B	0.09039147	2.52	0.0121
CFV		0.652227069 B	0.07936753	8.22	<.0001
CFV		0.159585131 B	0.09999330	1.60	0.1111
CFV		0.400026234 B	0.09028503	4.43	<.0001
CFV		0.474371531 B	0.08866381	5.35	<.0001
CFV		0.358649432 B	0.11020406	3.25	0.0012
CFV		-0.384209939 B	0.08600513	-4.47	<.0001
CFV		0.620627821 B	0.10334954	6.01	<.0001
CFV		0.551548111 B	0.08962904	6.15	<.0001
CFV		0.696555484 B	0.08781374	7.93	<.0001
CFV		-0.052905384 B	0.08462000	-0.63	0.5321
CFV		-0.076232651 B	0.08544875	-0.89	0.3727
CFV		0.136697868 B	0.09045258	1.51	0.1313
CFV		0.000000000 B	.	.	.

year	lncpue LSMEAN	95% Confidence Limits	
1989	6.767736	6.492406	7.043066
1990	6.839658	6.658654	7.020662
1991	8.319617	7.802774	8.836461
1992	7.513227	7.225340	7.801114
1993	7.279788	7.047738	7.511837
1994	7.368464	7.222313	7.514616
1995	7.169444	7.098137	7.240752
1996	7.133308	7.057127	7.209490
1997	7.587821	7.447249	7.728393
1998	7.630593	7.564169	7.697018
1999	7.663739	7.591490	7.735988
2000	7.685893	7.616354	7.755432
2001	7.814331	7.719293	7.909368
2002	7.690771	7.615479	7.766063
2003	7.748946	7.673181	7.824710
2004	7.804664	7.727847	7.881480
2005	7.795763	7.730525	7.861000
2006	7.900307	7.830357	7.970256
2007	7.965000	7.898230	8.031770
2008	8.010558	7.938299	8.082818
2009	8.097569	7.997338	8.197801

Table 54. Stratified analysis of NAFO Division 2G (SFA 4) large vessel catch data from the observer dataset (single + double trawl, all strata; July–December data), 1989–2009. (Green = 0–10,000 t; White = 10,000–20,000 t; Pink > 20,000 t; Black not fished.)

Large vessel Shrimp Biomass 000 tonnes		year																				
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Max depth (m)	STRATUM	17.09																				
200	925																					
	930															77.03						
	931															4.81				7.71		
300	901	1.25																		47.99	38.32	76.96
	908	0	3.91			7.87			24.75		25.34	18.19	34.05	35.82	28.69	23.66	30.3	22.11	28.96	28.75	36.95	64.28
	911	1.99	3.68								18.56	13	24.39			24.68		25.91	9	10.51	23.94	
	924	5.49	1.53			32.28	40.63		12.14	36.22	26.23	42.44	35.59	43.46	27.36	44.52	37.25	25.23	36.89	29.61	26.65	50.75
	926										7.91		34.55		11.85			8.18	12.68	18.48	15.61	24.23
400	902	0	0.67			0.34			2.08		2.32	5.06	6.13	3.59	5.4	3.22	3.24	3.9	6.06	8.17	12.64	9.63
	912	0	0.05										0.17									
	923		0.01		8.24	9.48	9.59	6.76	5.06	10.74	7.57	8.88	10.57	13.21	10.68	13.18	8.25	8.8	10.36	9.71	7.46	17.03
	927			11.2	6.95	11.64	0.72	8.63	10.83	31.66	12.95	7.38	15.04		8.39	1.78	20.12	5.96	20.42	17.54	11.36	39.74
500	903												3.1			0.9	0.37	3.67	1.72	6.38	8.35	
	922		11.24	3.08	0.6	8.16	6.41	3.53	6.16	7.82	6.51	6.93	7.24	9.96	9.22	10.56	4.46	7.84	4.66			
	928		2.33	10.58	0.77	20.58	7.49	7.14	10.83	0.15			6.44		0.55							
750	904																				11.28	
	921		2.18						1.32													
	929							6.65	0.57													
1000	905																	3.97				
All		25.82	25.59	24.86	16.56	90.35	64.84	32.72	73.75	86.6	107.4	101.9	177.3	106	102.1	204.4	104	115.6	130.7	184.9	192.6	282.6

Table 55. SFA 4 percent contribution of large vessel commercial biomass, by depth range within all strata.

Depth range (m)	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
<=200 m	66.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.04	0.00	0.00	0.00	4.17	0.00	0.00
201 - 300 m	33.81	35.64	0.00	0.00	44.44	62.66	0.00	50.02	41.82	72.66	72.26	72.52	74.79	66.50	45.43	64.95	70.44	66.97	73.20	73.45	76.51
301 - 400 m	0.00	2.85	45.05	91.73	23.75	15.90	47.04	24.37	48.96	21.27	20.92	18.00	15.85	23.97	8.89	30.39	16.14	28.19	19.16	16.33	23.50
401 - 500 m	0.00	53.03	54.95	8.27	31.81	21.44	32.61	23.04	9.20	6.06	6.80	9.46	9.40	9.57	5.61	4.64	9.96	4.88	3.45	4.34	0.00
501 - 750 m	0.00	8.52	0.00	0.00	0.00	0.00	20.32	2.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.86	0.00
751 - 1000 m	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.43	0.00	0.00	0.00	0.00
Total	100.00	100.04	100.00	100.00	100.00	100.00	99.97	99.99	99.99	99.99	99.98	99.98	100.04	100.04	99.97	99.99	99.97	100.04	99.97	99.98	100.01

Table 56. NAFO Division 2G (SFA 4) Northern shrimp biomass and abundance estimates using the original and new Delauney triangulation files used in Ogmap calculations. These estimates were calculated from 2005–2009 NSRF–DFO joint northern shrimp bottom trawl survey. (standard tows = 15 mins at 3.0 Nmi./hr).

Year	Biomass (t)			Abundance (numbers X 10^6)			Survey Sets
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	
2005	34,840	72,600	120,100	6,565	14,305	24,120	78
2006	58,230	116,800	175,600	10,640	21,785	34,060	77
2007	89,110	135,600	209,400	15,930	23,860	36,530	77
2008	98,400	152,600	260,400	19,800	30,363	50,810	69
2009	114,900	208,300	430,300	23,320	42,060	85,850	75

area compared each year 51,858 sq km

*A) **Original indices** using the original Delauney triangulation file.*

Year	Biomass (t)			Abundance (numbers X 10^6)			Survey Sets
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.	
2005	33,406	70,979	116,185	6,278	13,997	23,509	78
2006	53,723	107,426	160,484	9,609	20,335	32,016	76
2007	86,575	133,502	204,783	15,475	23,496	35,802	77
2008	92,293	148,100	247,572	19,049	29,609	49,263	69
2009	112,560	205,186	415,708	22,129	41,594	84,380	75

area compared each year 43,570 sq km

*B) **Proposed indices** using new Delauney triangulation file. These values account for the 1.0068 swept area correction factor.*

Table 57. Biomass (000 t) of Northern shrimp (Pandalus borealis) in SFA 4. The analysis was from areal expansion of multi-species research survey data collected using a Campelen 1800 research shrimp trawl towed at 3 Nmi/hr for 15 min.). (Green <10,000 t; White 10,000–20,000 t; Pink > 20,000 t; Black not surveyed).

Survey Summer SFA 4 Shrimp 000 Biomass tonnes		YEAR				
		2005	2006	2007	2008	2009
		.	.	.	.	.
Depth Range (m)	STRATUM	5.69	0.04	0.1	0.07	0.08
<=200	909					
	910	0.04	0.16	0.03	0.69	0.04
	925	0.02	0.26	0.78	1.25	0.13
	930	.	0.05	0.77	1.88	0.39
201 - 300	901	12.74	7.69	45.92	47.47	58.21
	908	28.79	26.84	27.53	37.83	80.35
	911	18.2	2.96	7.04	7.7	3.98
	924	3.33	16.93	43.87	42.26	29.19
	926	2.71	22.55	1.55	1.17	7.11
	931	.	0.02	4.87	0.07	0.04
301 - 400	902	0.09	0.09	0.19	1.52	1.29
	912	0	0.02	0	0	0.01
	923	6.21	22.98	1.3	1.6	3.8
	927	0.26	.	.	3.79	0.01
401 - 500	903	0	0	0	0.02	0.1
	913	0	0	0	0	0
	922	.	0.27	.	.	.
501 - 750	904	0	0	0	0	0
	914	0	0	0	.	0.01
	921	0	0.01	.	.	0.03
All		78.07	100.9	133.9	147.3	184.8

Table 58. SFA 4 percent contribution of research survey total biomass, by depth range. The analysis made use of areal expansion calculations.

Depth range (m)	2005	2006	2007	2008	2009
<= 200 m	7.37	0.51	1.25	2.64	0.35
201 - 300 m	84.24	76.30	97.67	92.67	96.80
301 - 400 m	8.40	22.88	1.11	4.69	2.77
401 - 500 m	0.00	0.27	0.00	0.01	0.05
501 - 750 m	0.00	0.01	0.00	0.00	0.02
Total	100.01	99.97	100.04	100.01	99.98

Table 59. NAFO Division 2G (SFA 4) Northern shrimp female spawning stock biomass and abundance estimates using the original and new Delauney triangulation files used in Ogmap calculations. These estimates were calculated from 2005–2009 NSRF–DFO joint northern shrimp bottom trawl survey. (standard tows = 15 mins at 3.0 Nmi./hr).

Year	Biomass (t)			Abundance (10^6)		
	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	34,260	66,400	99,420	3,767	6,832	9,849
2007	56,250	76,200	115,700	7,170	10,016	15,320
2008	53,990	90,300	160,200	7,350	12,494	22,310
2009	67,740	133,000	279,500	9,784	19,525	41,710

A) Original Indices

Year	Biomass (t)			Abundance (10^6)		
	Lower C.I.	Estimate	Upper C.I.	Lower C.I.	Estimate	Upper C.I.
2005	17,186	34,533	52,807	2,379	4,691	7,097
2006	30,597	53,360	72,832	3,805	6,647	9,158
2007	54,297	80,846	121,219	7,179	10,444	15,656
2008	53,058	88,296	157,262	7,177	11,876	20,921
2009	66,831	130,985	272,339	9,670	19,306	40,493

B) Proposed Indices

Table 60. NAFO Division 2G (SFA 4) Northern shrimp fishable biomass and abundance estimates using the original and new Delauney triangulation files used in Ogmap calculations. These estimates were calculated from 2005–2009 NSRF – DFO joint northern shrimp bottom trawl survey. (standard tows = 15 mins at 3.0 Nmi./hr).

year	Fishable biomass (000 t)			Fishable abundance (10^6)		
	Lower 95% C.I.	Estimate	Upper 95% C.I.	Lower 95% C.I.	Estimate	Upper 95% C.I.
2005	31,060	66,200	110,600	5,286	11,826	20,390
2006	52,000	103,100	147,600	7,887	17,226	25,870
2007	81,140	126,700	199,100	13,290	20,755	32,950
2008	82,860	131,800	226,200	13,710	21,776	37,070
2009	98,720	180,900	380,500	17,220	32,012	67,830

A) Original Indices

year	Fishable biomass (000 t)			Fishable abundance (10^6)		
	Lower 95% C.I.	Estimate	Upper 95% C.I.	Lower 95% C.I.	Estimate	Upper 95% C.I.
2005	29,399	62,321	102,694	5,219	11,831	20,237
2006	45,618	92,424	135,717	7,774	16,537	25,432
2007	72,560	113,970	176,593	12,776	20,296	31,845
2008	74,463	119,004	194,715	13,229	21,204	35,147
2009	94,307	179,512	370,603	17,337	32,896	67,959

B) Proposed Indices

Table 61. SFA 4 (NAFO Division 2G) Northern Shrimp recruitment indices using the original definition (abundance of all males and unidentified Pandalus 11.5-16 mm carapace lf), Delauney triangulation and parameter files compared with estimates using the new definitions (abundances of all males + females with 11.5–16 mm carapace lf) and new Delauney triangulation and parameter files used in Ogmap calculations. These estimates were calculated from 2005-2009 Northern Shrimp Research Foundation – DFO Northern Shrimp bottom trawl research surveys (standard tows = 15 min at 3.0 Nmi/hr).

year	Recruitment index ($X10^6$)		
	Lower 95% C.I.	Estimate	Upper 95% C.I.
2005	481	1,048	1,792
2006	1,009	2,425	4,410
2007	1,465	2,199	3,348
2008	2,934	4,830	7,327
2009	2,273	4,397	8,940

A) Original Indices

year	Recruitment index ($X10^6$)		
	Lower 95% C.I.	Estimate	Upper 95% C.I.
2005	468	1,011	1,726
2006	974	2,360	4,344
2007	1,427	2,134	3,293
2008	2,787	4,691	7,201
2009	2,239	4,336	8,736

B) Proposed Indices

Table 62. Original formulation of SFA 6 exploitation rate indices (total catch/ lower 95% confidence interval of within year biomass estimate; total catch/ within year total biomass and total catch/within year's fishable biomass) compared with the proposed formulation (abundance removed/ within year's abundance from the fishable portion of the resource). Each index is expressed as a percent.

Year	lower CL of total biomass (t)	total biomass (t)	fishable biomass (t)
2005	33,406	70,979	62,321
2006	53,723	107,426	92,424
2007	86,575	133,502	113,970
2008	92,293	148,100	119,004
2009	112,560	205,186	179,512

Year	Catch (t)	Catch/ lower C.L.	Catch/ total biomass	Catch/ fishable biomass
2005	10,247	30.67	14.44	16.44
2006	10,084	18.77	9.39	10.91
2007	10,009	11.56	7.50	8.78
2008	10,735	11.63	7.25	9.02
2009	10,664	9.47	5.20	5.94

A) ***Original*** *formulation.*

Year	Large vessel removals ($X10^6$)	Abundance from the fishable portion of the resource ($X10^6$)	Exploitation Rate (%)
1990	350		
1991	239		
1992	318		
1993	255		
1994	255		
1995	472		
1996	528		
1997	558		
1998	930		
1999	909		
2000	868		
2001	991		
2002	1,020		
2003	1,587		
2004	1,241		
2005	1,380	11,831	11.67
2006	1,376	16,537	8.32
2007	1,478	20,296	7.28
2008	1,612	21,204	7.60
2009	1,618	32,896	4.92

B) ***Proposed*** *formulation.*

Table 63. Survival, annual mortality and instantaneous mortality rate indices for Northern Shrimp (Pandalus borealis) withinNAFO Division 2G (SFA 4).Indices were calculated by combining 4 years of data in order to account for vagaries within the observer dataset. The survival, S, in the blue box is the sum of the multiparous females (shaded green) divided by the sum of the primiparous females from the previous year (shaded yellow). Median survival, annual mortality, and instantaneous mortality rates were 0.64, 0.36 and 0.45 respectively (please note that the values in red were not reasonable and therefore were not included in the median calculations). This analysis is based upon data from the Observer dataset.

Year	Abundance primiparous females (raw count; yr=t)	abundance multiparous females (raw count; yr=t)	Survival rate ($S = n_{t+1}/n_t$	Annual mortality rate (A=1-S)	Instantaneous mortality rate (Z=-ln(S))
1990	38,091	23,874			
1991	13,419	19,394			
1992	15,738	13,315	0.56	0.44	0.58
1993	6,325	6,041	0.66	0.34	0.41
1994	2,522	2,483	0.48	0.52	0.74
1995	4,145	3,328	0.92	0.08	0.08
1996	3,974	1,906	1.18	-0.18	-0.16
1997	13,091	7,891	1.17	-0.17	-0.16
1998	17,265	14,783	0.88	0.12	0.12
1999	15,539	20,405	0.86	0.14	0.15
2000	1,651	1,046	0.58	0.42	0.55
2001	13,828	4,548	0.42	0.58	0.86
2002	5,864	1,851	0.70	0.30	0.36
2003	9,221	8,172	0.61	0.39	0.49
2004	7,281	6,737	0.92	0.08	0.09
2005	7,676	5,321	0.56	0.44	0.58
2006	19,736	7,266	0.48	0.52	0.74
2007	10,517	5,354	0.44	0.56	0.82
2008	6,233	3,728			
2009	9,099	3,102			

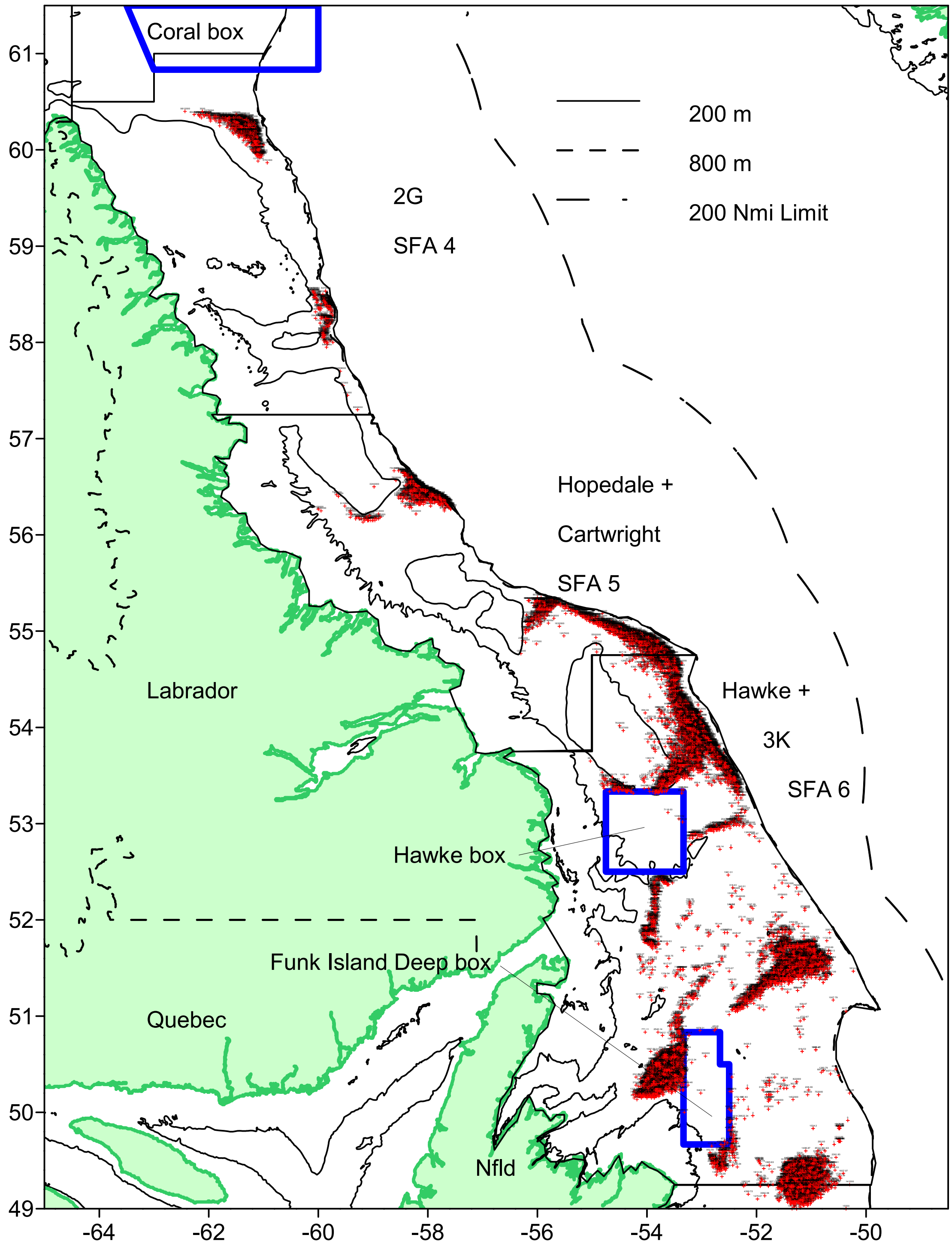


Figure 1. Map of northern shrimp fishing areas (SFAs) including the coral, Hawke Channel and Funk Island Deep closed areas. The coral area is a voluntary closure established by the large vessel fleet. The Hawke Channel closure is a mandatory closure for both large and small vessels. The Funk Island Deep closed area is a mandatory closure for smallvessels but is a voluntary closure for large vessels. The red crosses indicate large and small vessel fishing positions during the 2009/10 management year.

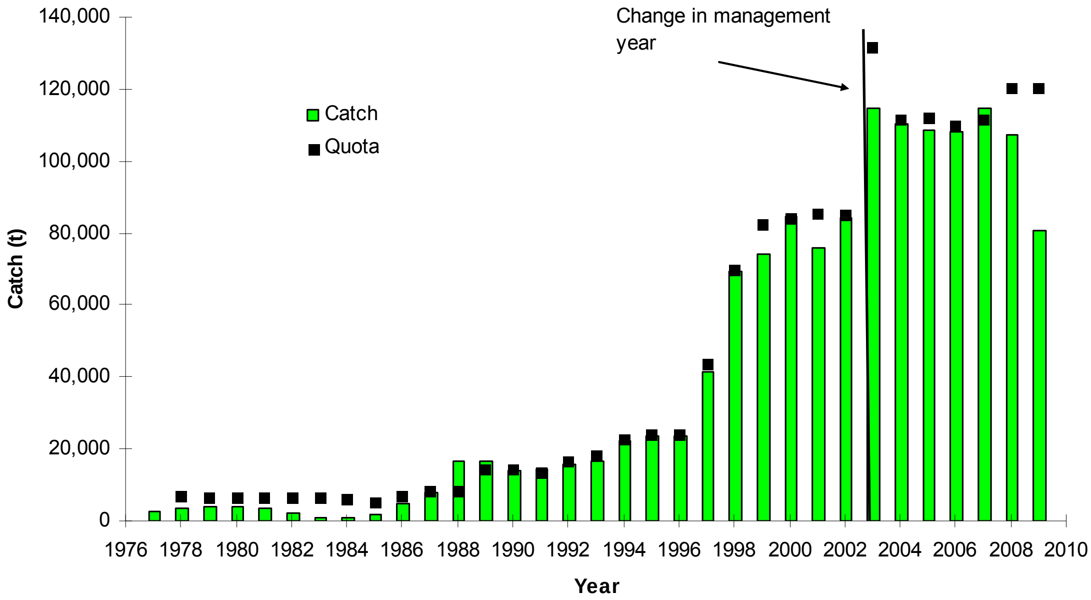


Figure 2.Historic northern shrimp catches (SFA's 4-6) and TAC's for the period 1977–2009. In 2003, the management year changed from Jan. 1–Dec. 31 to Apr. 1–Mar. 31. Catches for the 2009/10 management year are preliminary.

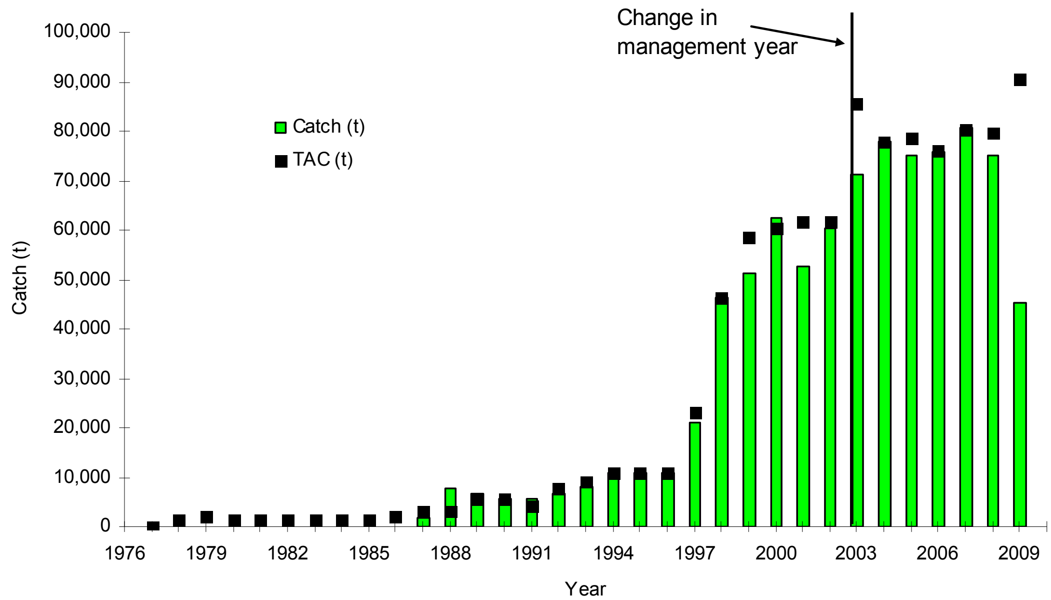


Figure 3. History of combined SFA 6 large and small vessel quotas and catches, 1977–2009. In 2003, the management year changed from Jan. 1–Dec. 31 to Apr. 1–Mar. 31. Catches for the 2009/10 management year are preliminary.

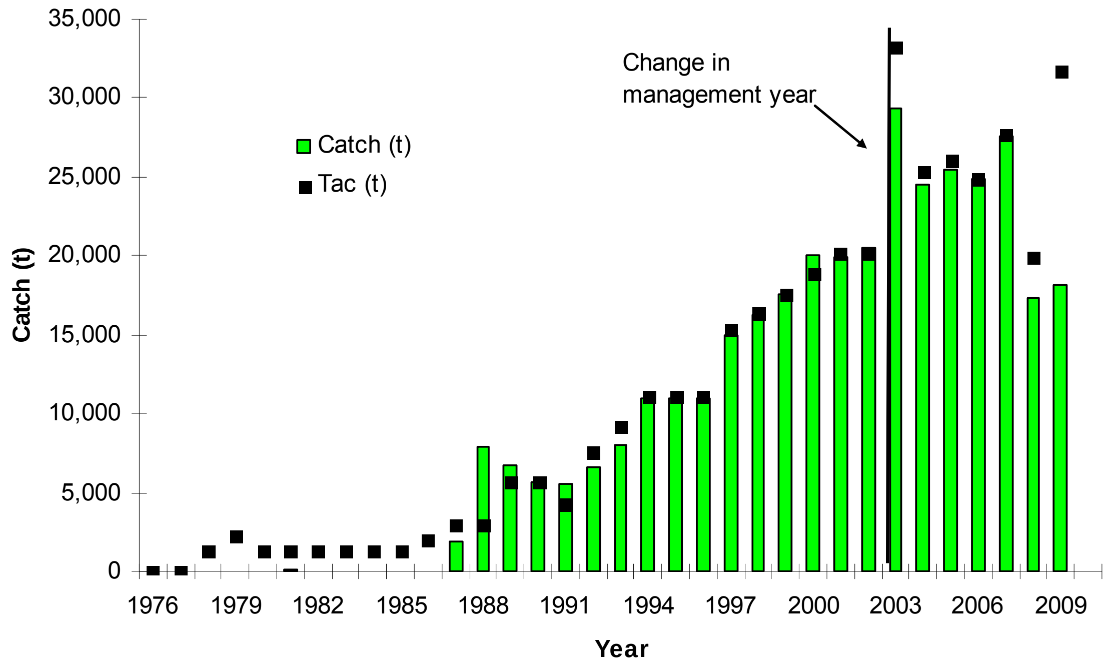


Figure 4.History of SFA 6 large vessel (>500 t) quotas and catches, 1977–2009. In 2003, the management year changed from Jan. 1–Dec. 31 to Apr. 1–Mar. 31. Catches for the 2009/10 management year are preliminary.

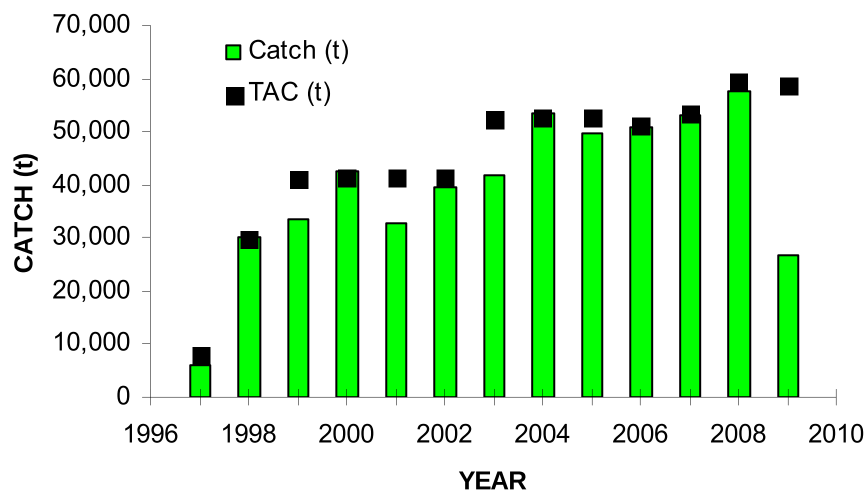


Figure 5. History of SFA 6 small vessel (<= 500 t; <=100’ LOA) quotas and catches, 1977–2009.

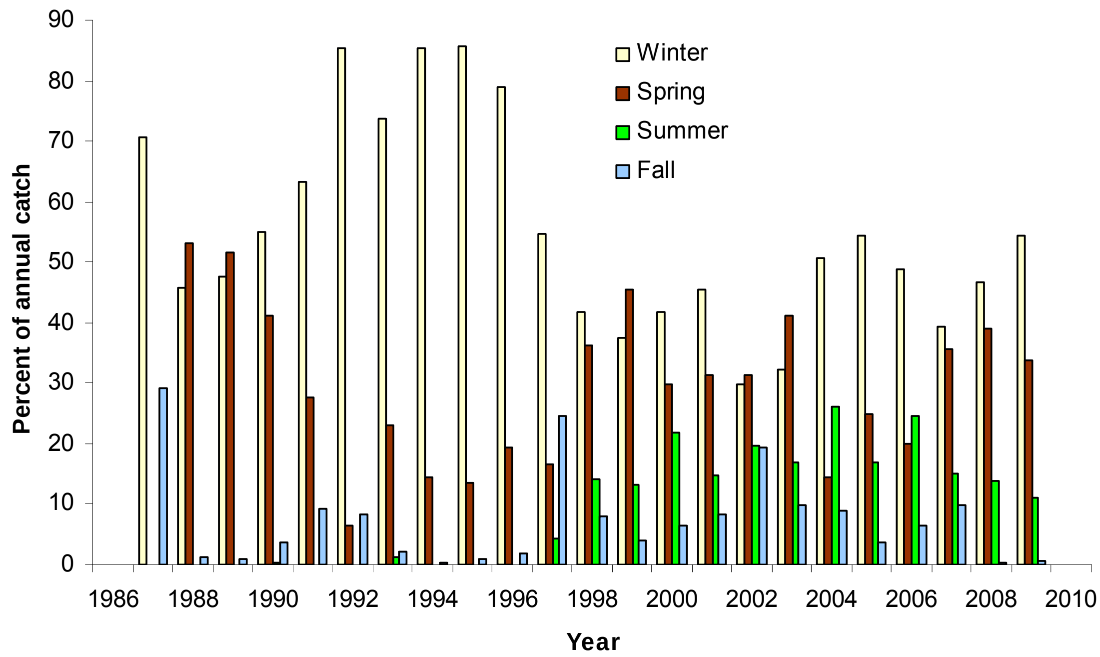


Figure 6. Seasonality of the large vessel (>500 t) shrimp fishery within Hawke Channel + 3K (SFA 6) as determined from percent annual catch by season.

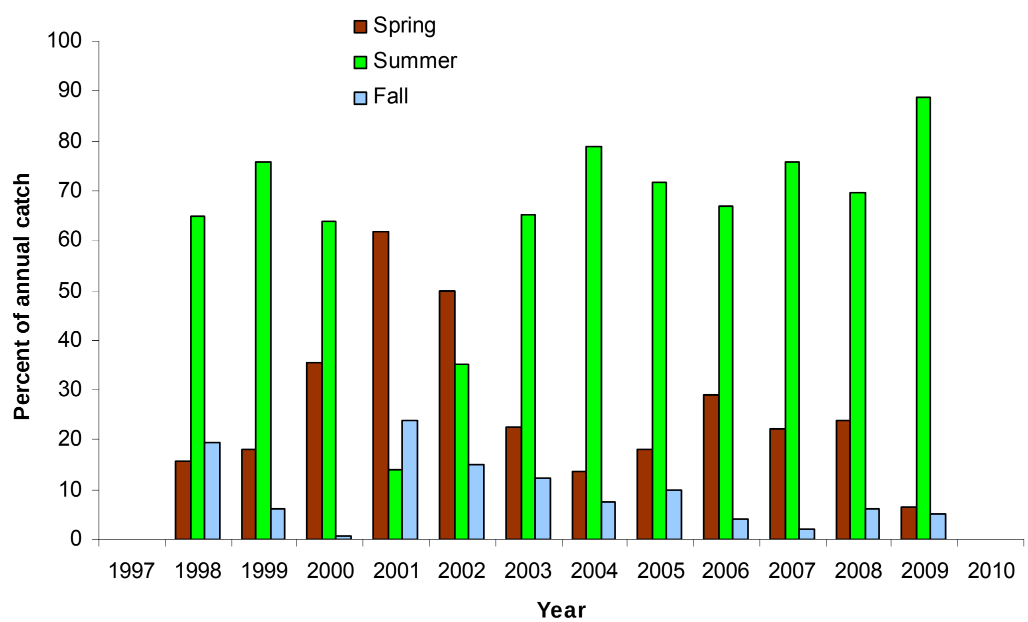


Figure 7. Seasonality of the small vessel (<=500 t; <= 100 ‘ LOA) shrimp fishery within Hawke Channel + 3K (SFA 6) as determined from percent annual catch by season.

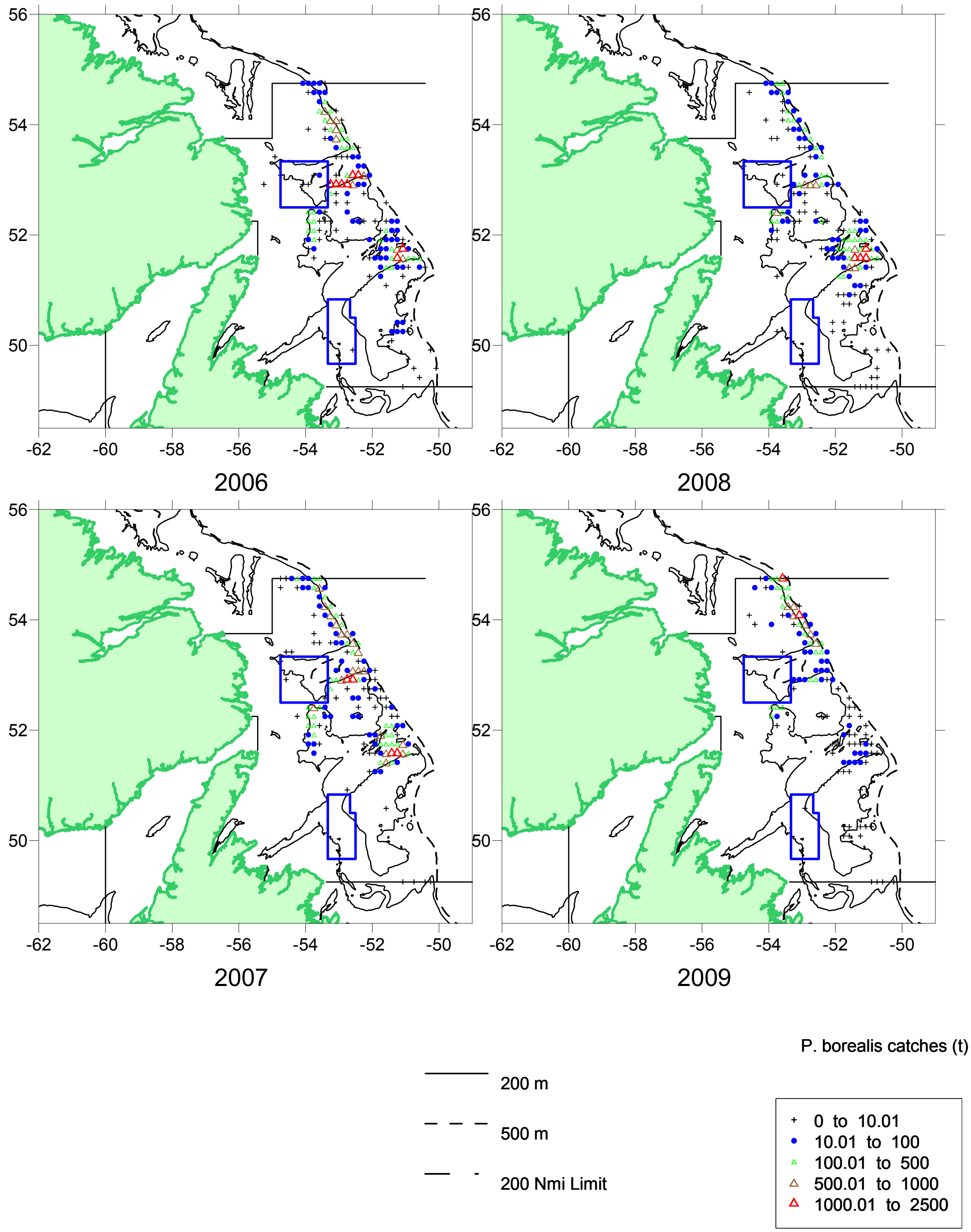


Figure 8. Distribution of large vessel (>500 t) shrimp catches in Hawke+3K (SFA 6). (Observer data aggregated into 10 min X 10 min cells). Please note that the blue boxes indicate the Hawke Channel and Funk Island Deep closed areas. The Hawke Channel closed area is a mandatory closure for trawlers while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

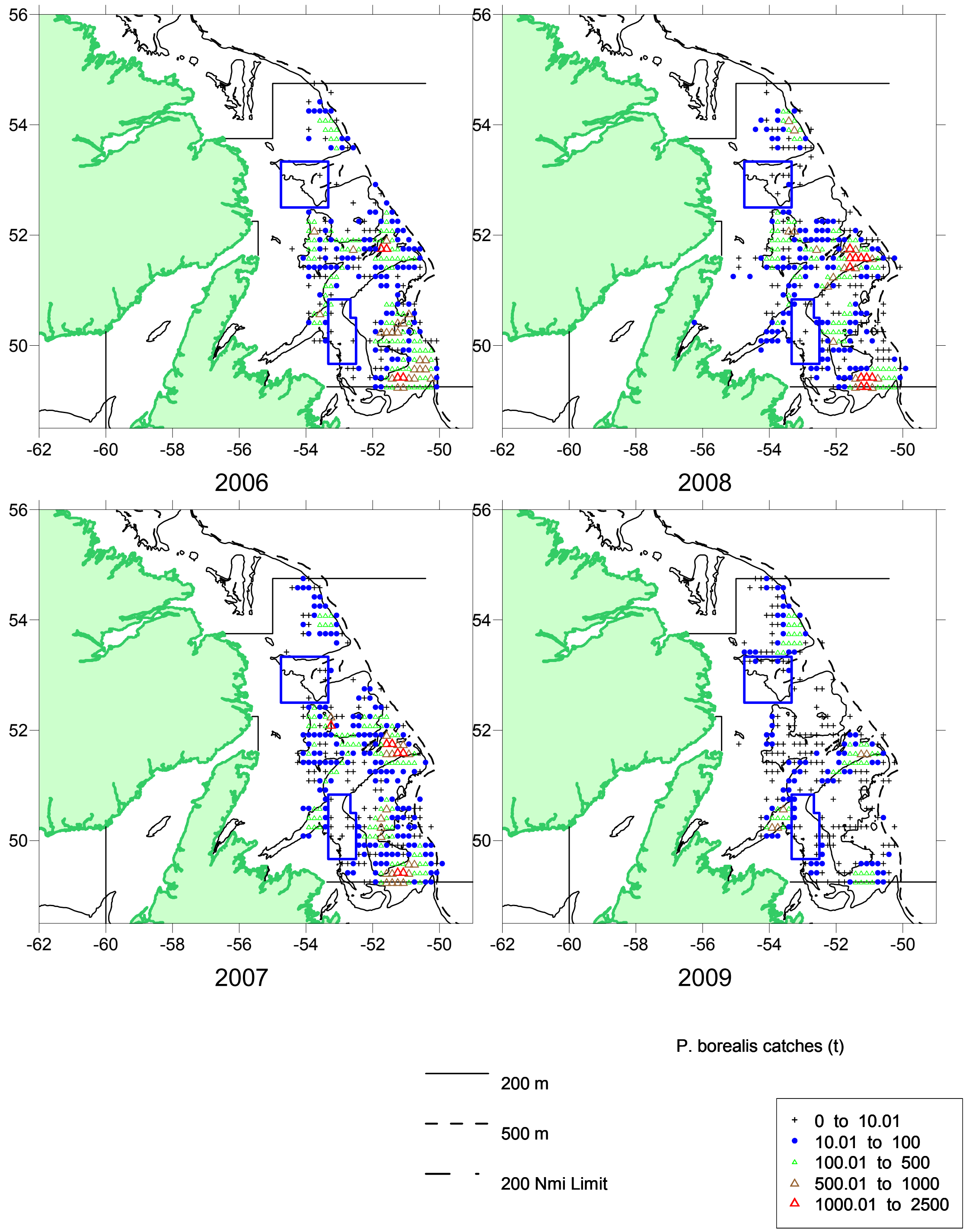


Figure 9. Distribution of small vessel (<=500 t; <= 100' LOA) catches inHawke+3K (SFA 6). (Observer data aggregated into 10 min X 10 min cells). Please note that the blue boxes indicate the Hawke Channel and Funk Island Deep closed areas. The Hawke Channel closed area is a mandatory closure for trawlers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

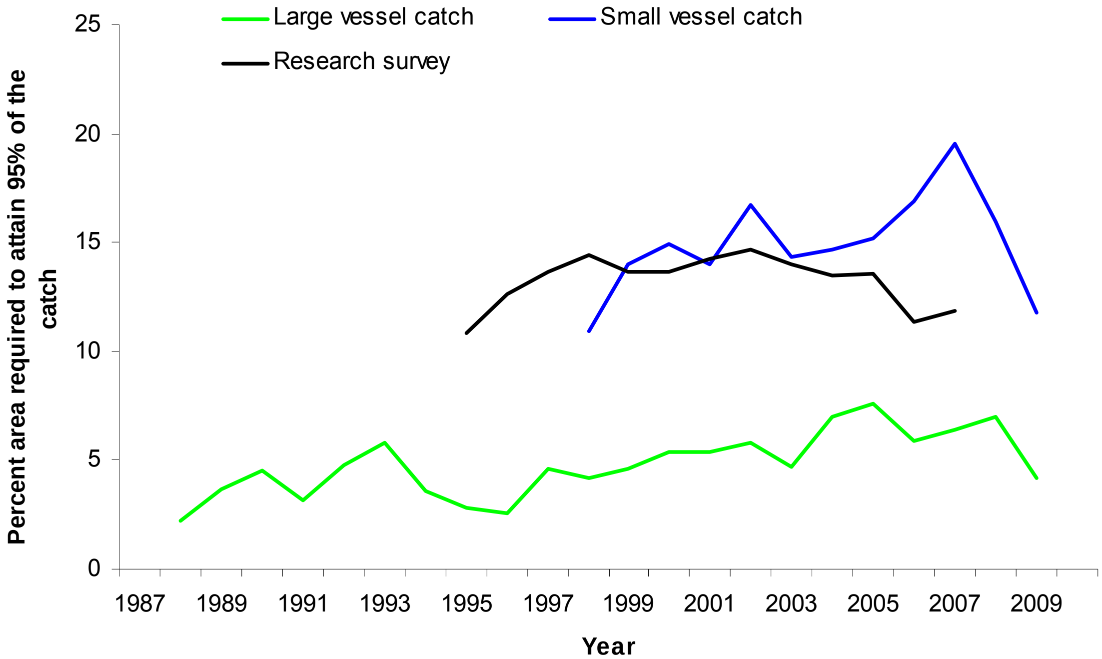
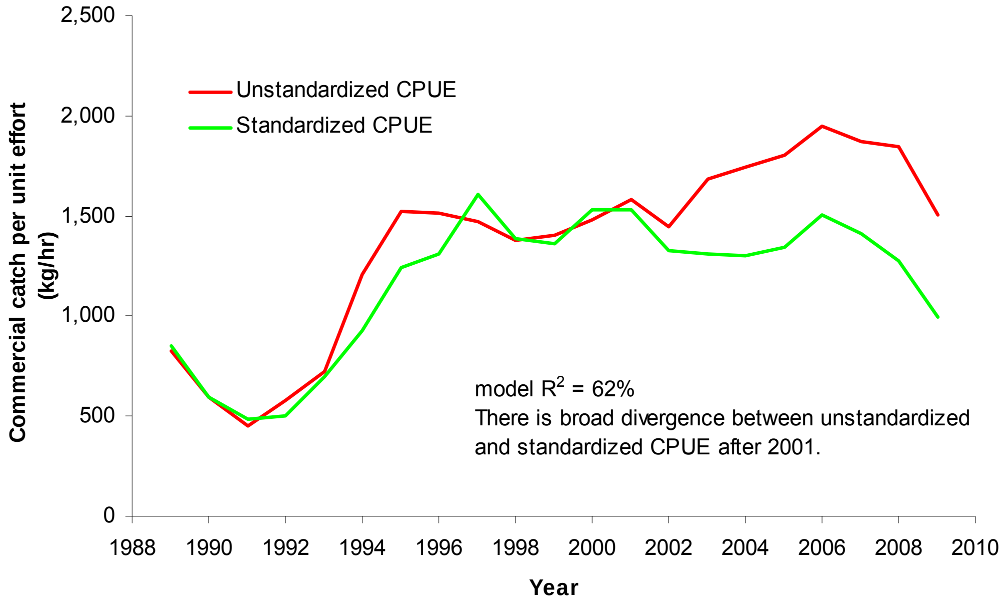
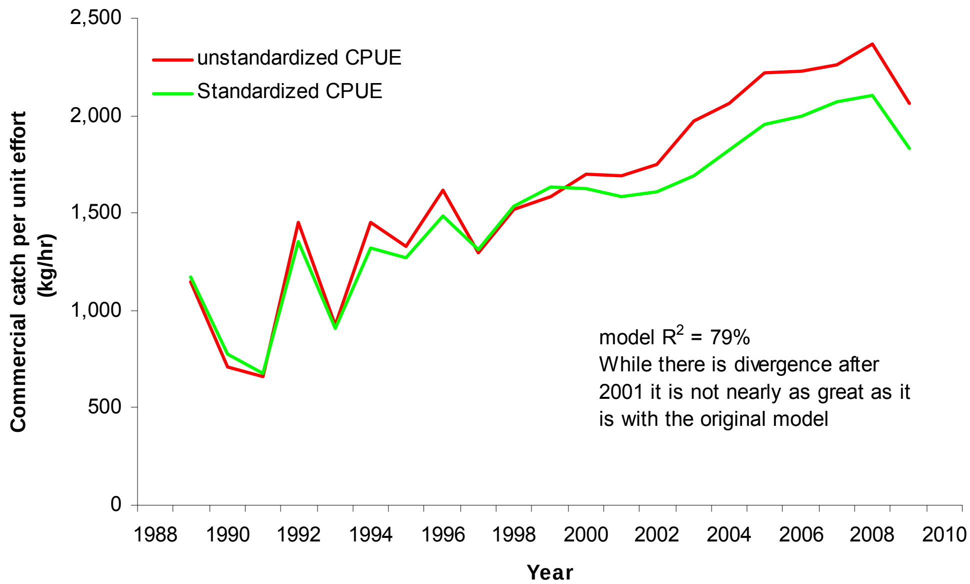


Figure 10. The percent total area within SFA 6 necessary to obtain 95% of the research survey and fishery catches.



*A) **Original** model formulation.*



*B) **Proposed** model formulation.*

Figure 11.A comparison of large vessel commercial catch rates (kg/hr) developed using the original model formulation (Observer data; history>3 yrs; all months; year, month, area, gear) and the proposed model formulation (Observer data; history>3 yrs; January–June data only, year, month, year, area; note that Funk Island Deep data have been removed).

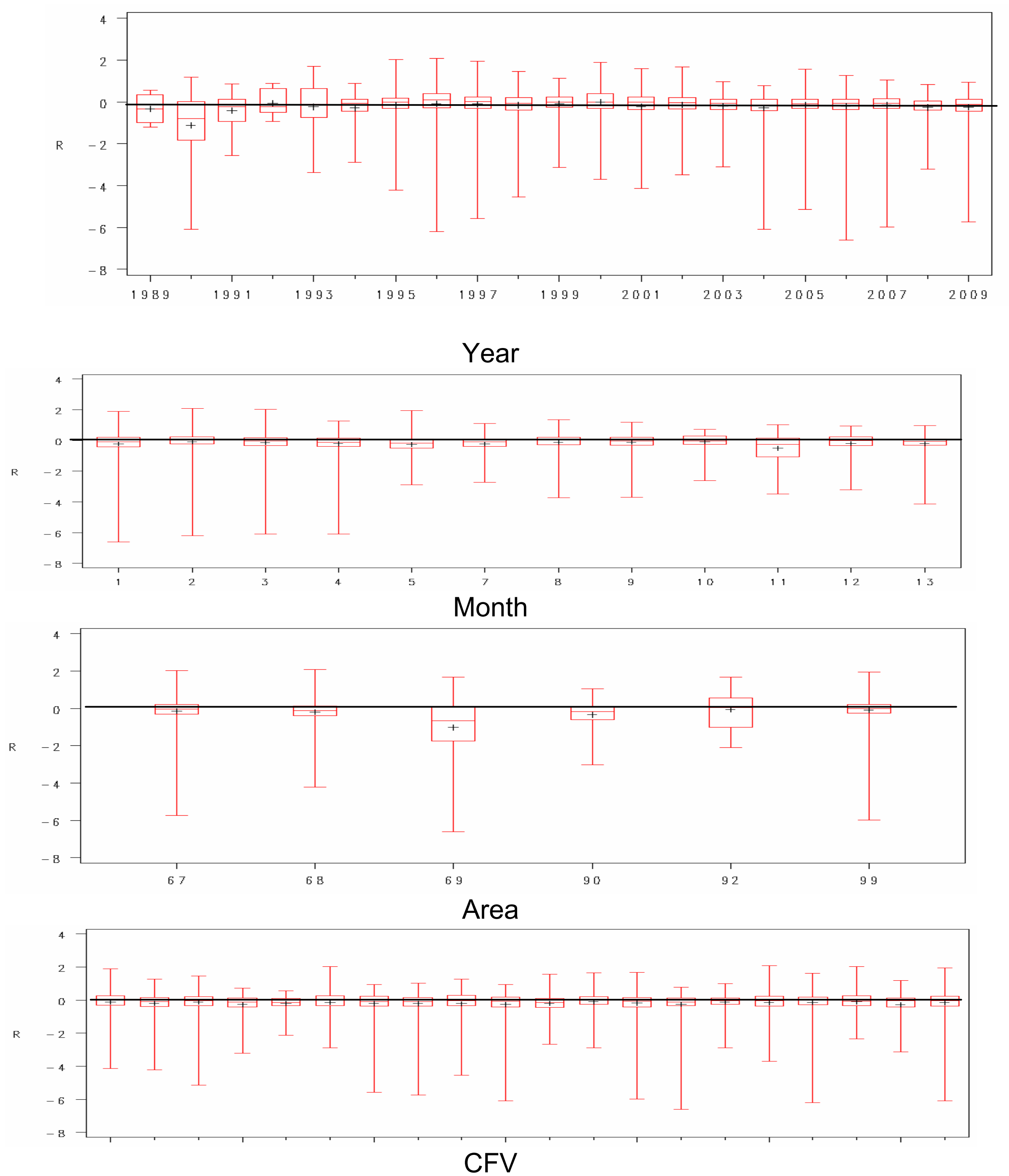
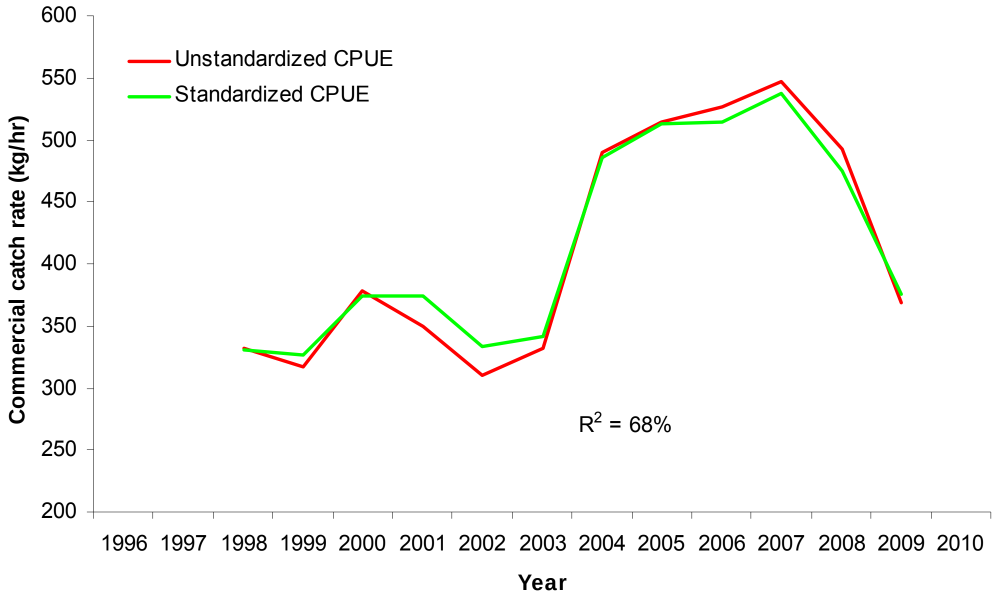
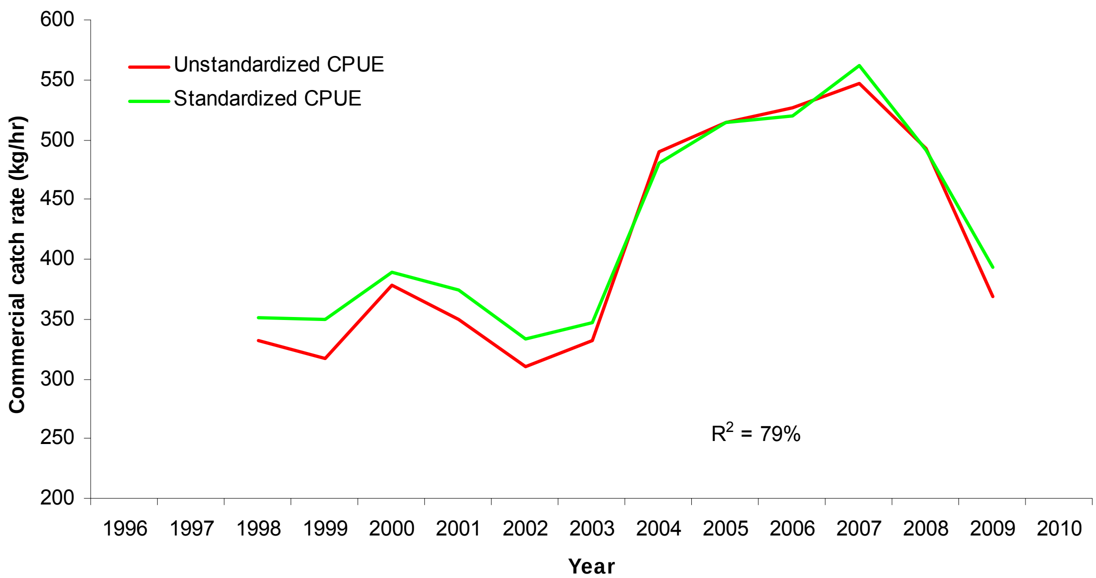


Figure 12. The distribution of residuals around estimated values for parameters used in the original large vessel (>500 t) shrimp catch rate model for Hawke Channel + 3K (SFA 6), 1989–2009.



A) ***Original*** *model formulation.*



B) ***Proposed*** *model formulation.*

Figure 13. A comparison of large vessel commercial catch rates (kg/hr) developed using the original model formulation (Observer data; (Single + double trawls, year, month area, observer data, no windows, history > 3 years; Funk Island Deep removed from analysis history>3 yrs; April - October; year, month, area) and the proposed model formulation (Raw Logbook data; history>3 yrs; April - October, year, month, year* month interaction, area).

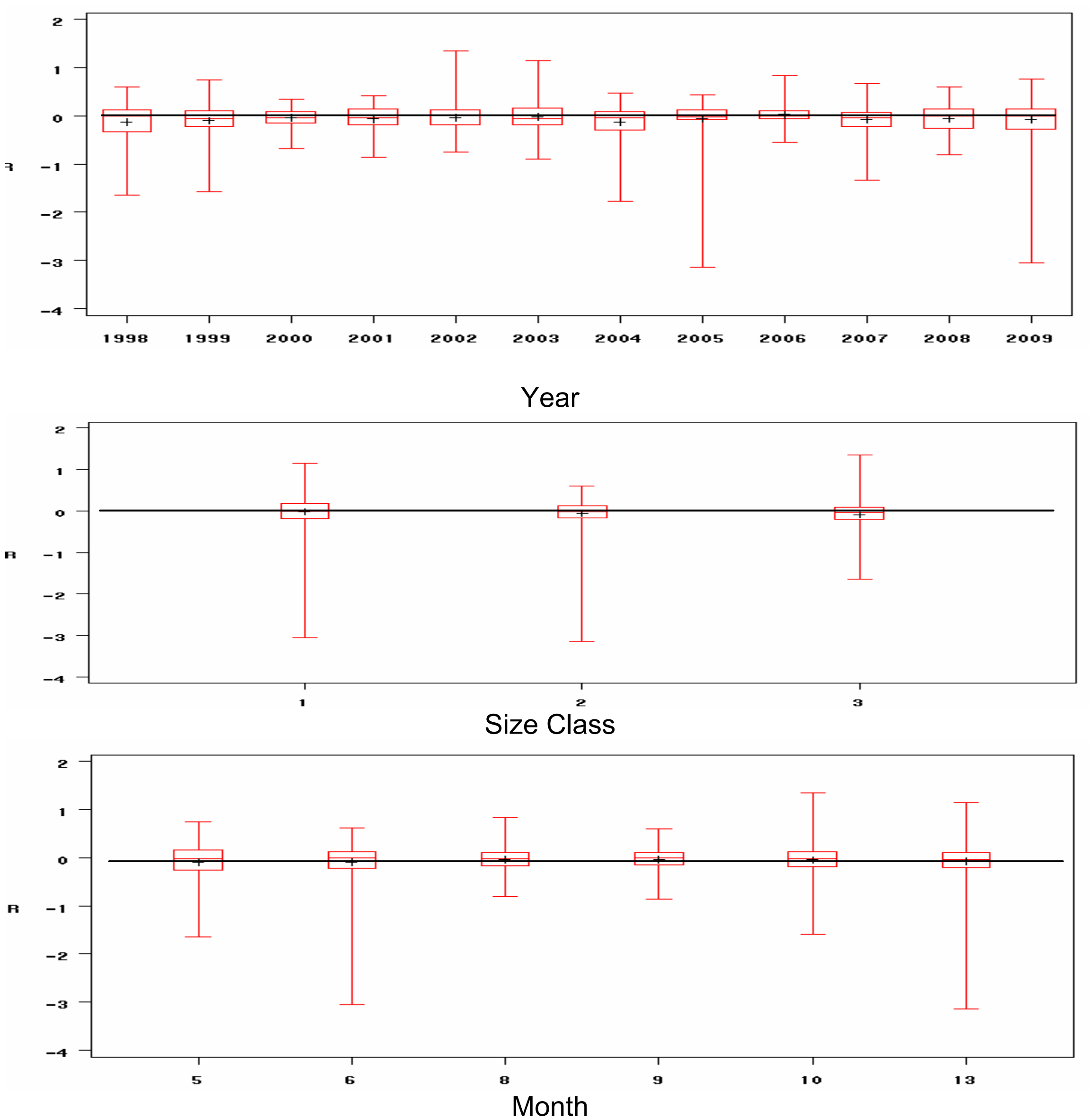


Figure 14. The distribution of residuals around estimated values for parameters used in the original small vessel (<=500 t; LOA<100’) shrimp catch rate model for Hawke Channel + 3K (SFA 6), 1998–2009.

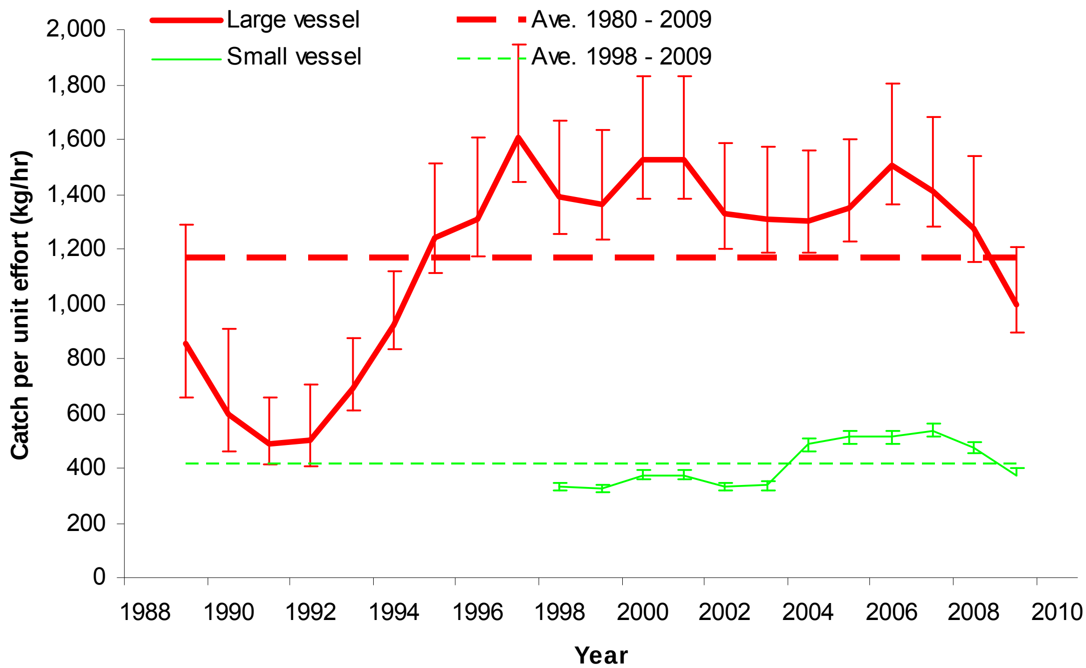


Figure 15. Original SFA 6 large and small vessel standardized CPUE (error bars indicate 95% confidence intervals.

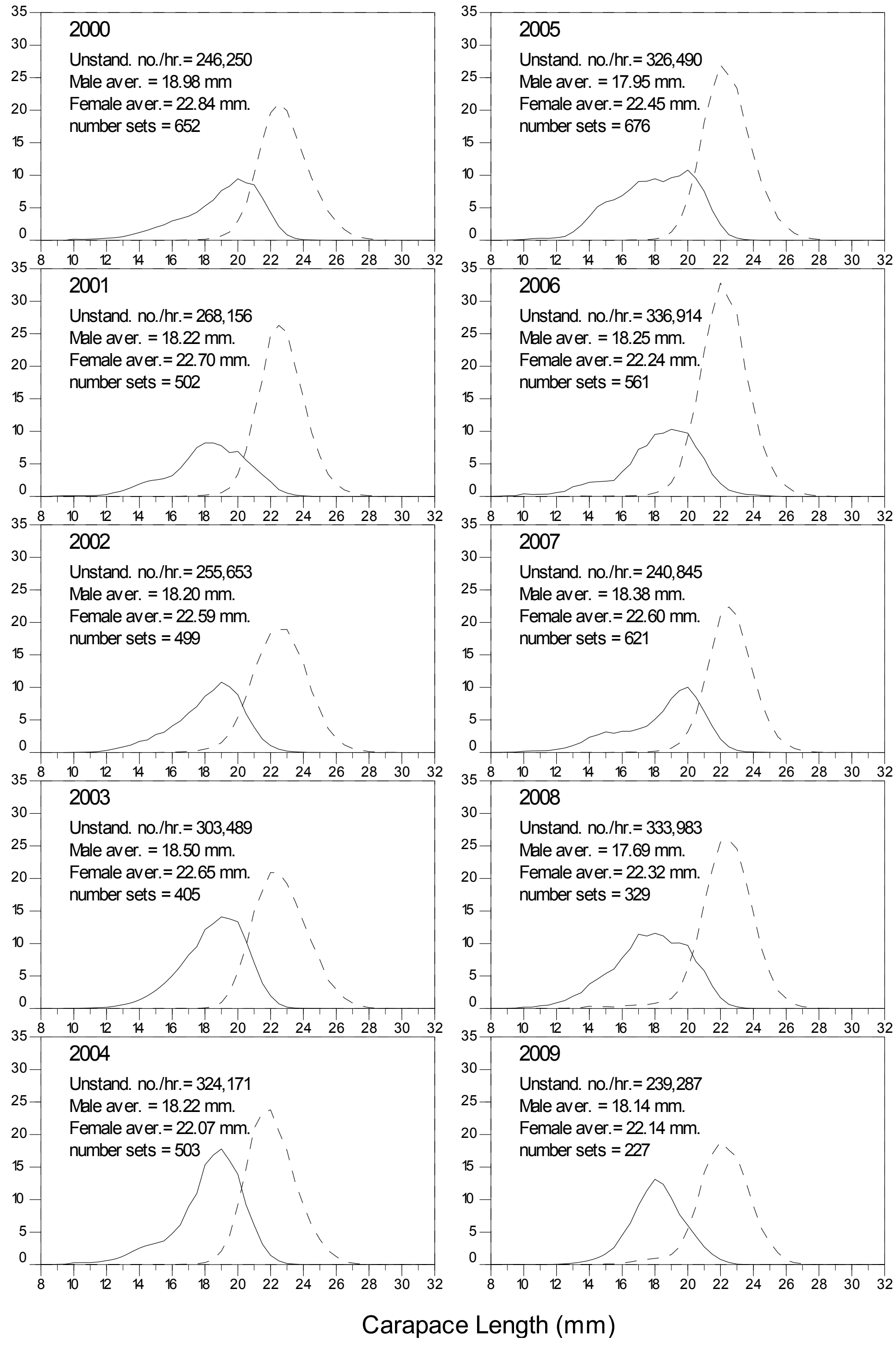


Figure 16. Observed northern shrimp length frequencies (000's per hr.) from the Canadian small vessel (<500 t) fleet fishing shrimp in Hawke Channel + 3K (SFA 6) over the period 2000–09. Solid lines = males; dotted lines = females. The number per hour was based upon raw unstandardized effort since this figure represents an entire year's catch at length, whereas the proposed model is for the first half of the year.

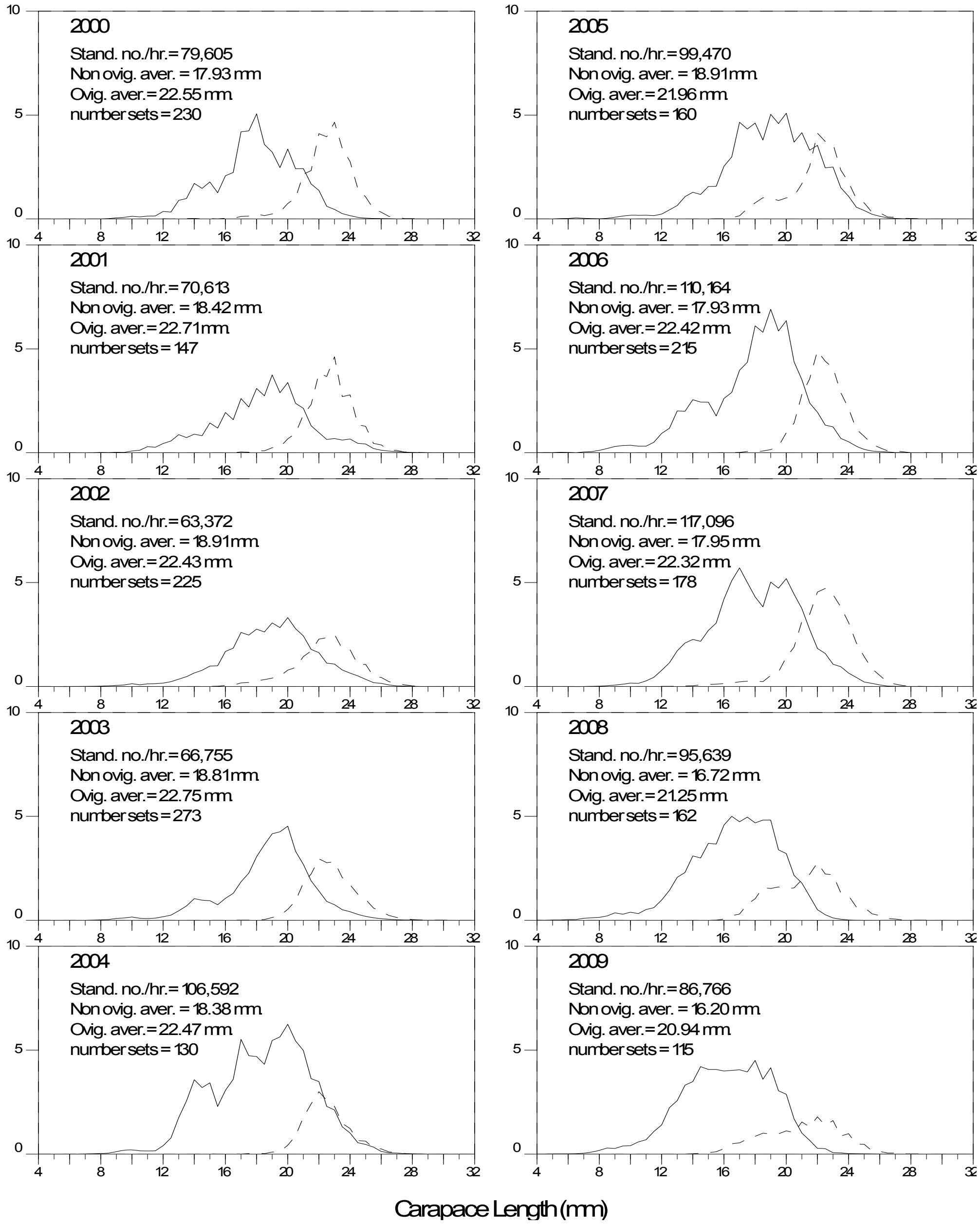


Figure 17. Observed northern shrimp length frequencies (000's per hr.) from the Canadian small vessel (<500 t) fleet fishing shrimp in Hawke Channel + 3K (SFA 6) over the period 2000–09. Solid lines = non ovigerous shrimp; dotted lines = ovigerous shrimp.

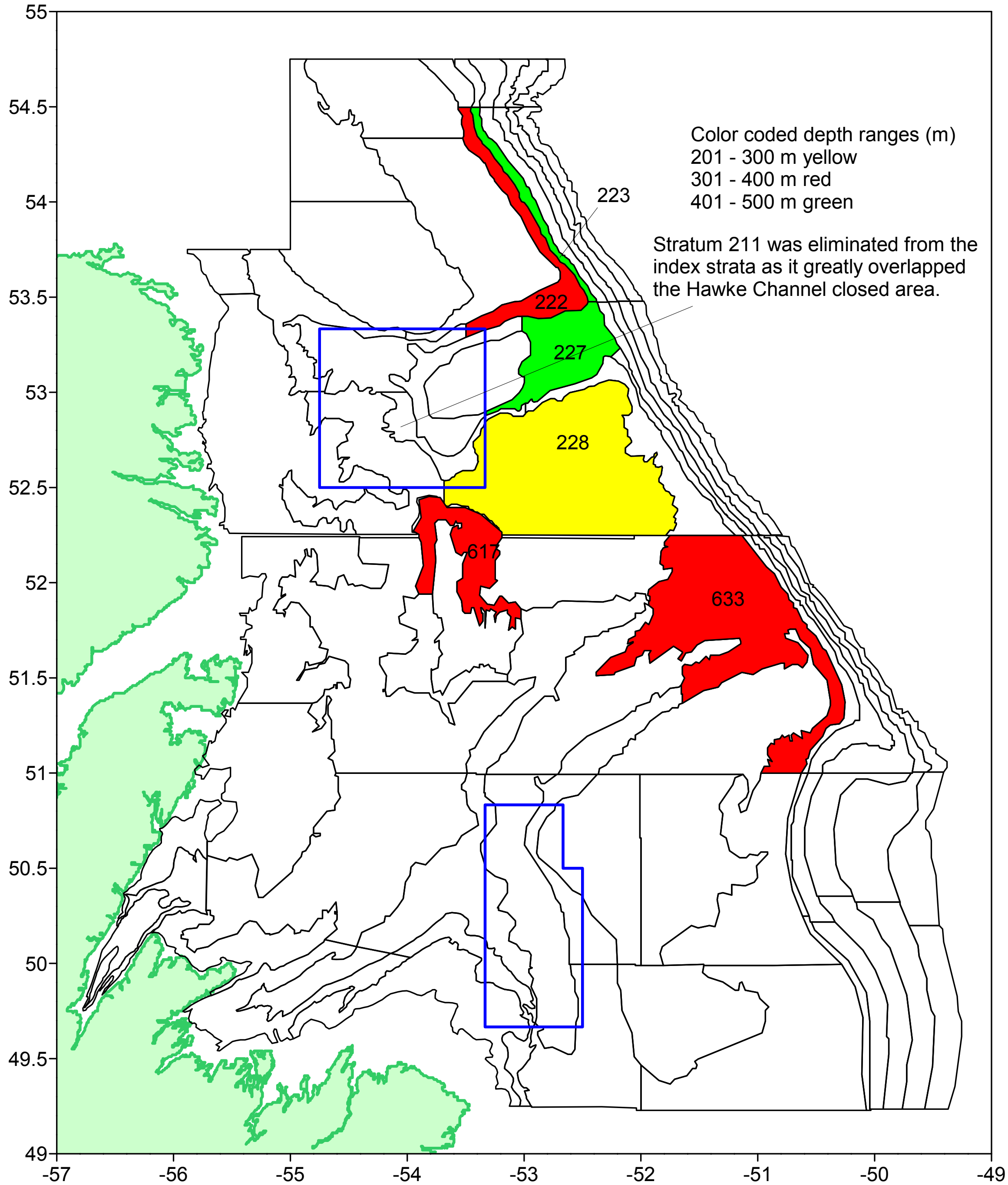


Figure 18. Index strata within SFA 6 that were consistently fished by the large vessel fleet, over the period 1992-2009. The numbers indicate the strata within Table 13.

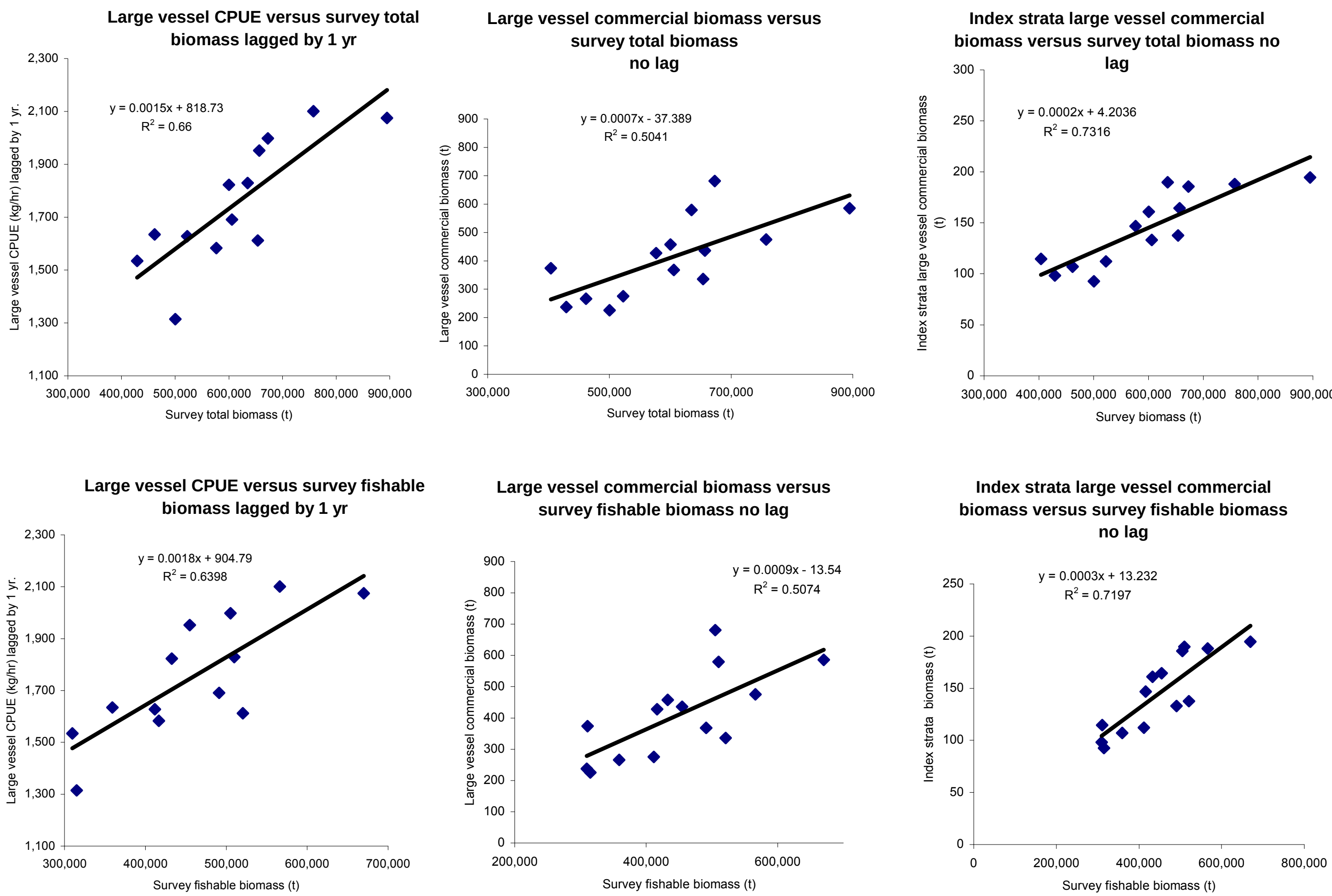


Figure 19. Relationships between large vessel CPUE, all strata commercial biomass and index strata commercial biomass indices versus survey total and fishable biomass, within SFA 6. Various lags were attempted and only the relationships with the highest r^2 are presented here.

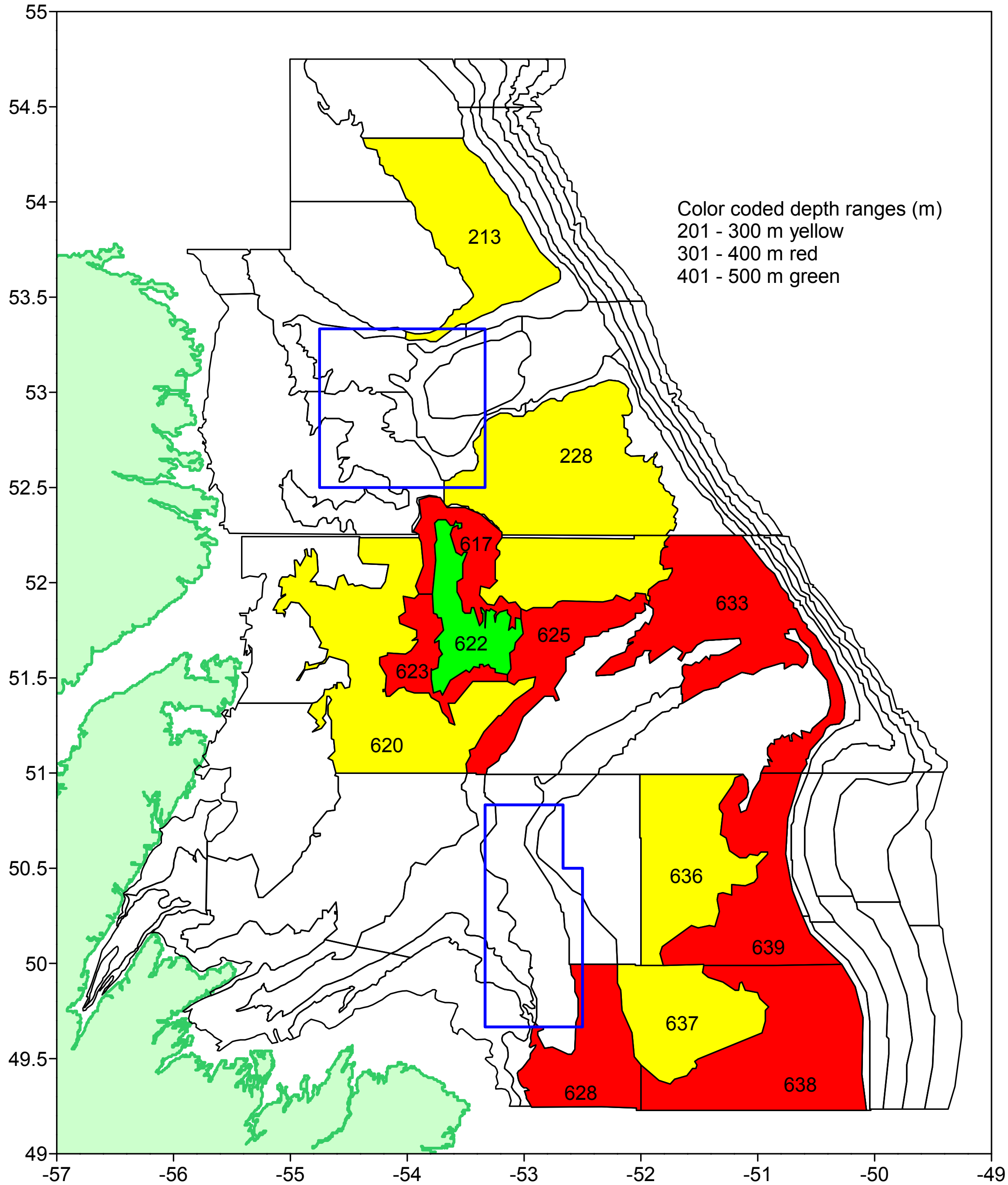


Figure 20. Index strata within SFA 6 that were consistently fished by the small vessel fleet, over the period 1998-2009. The numbers indicate the strata within Table 17.

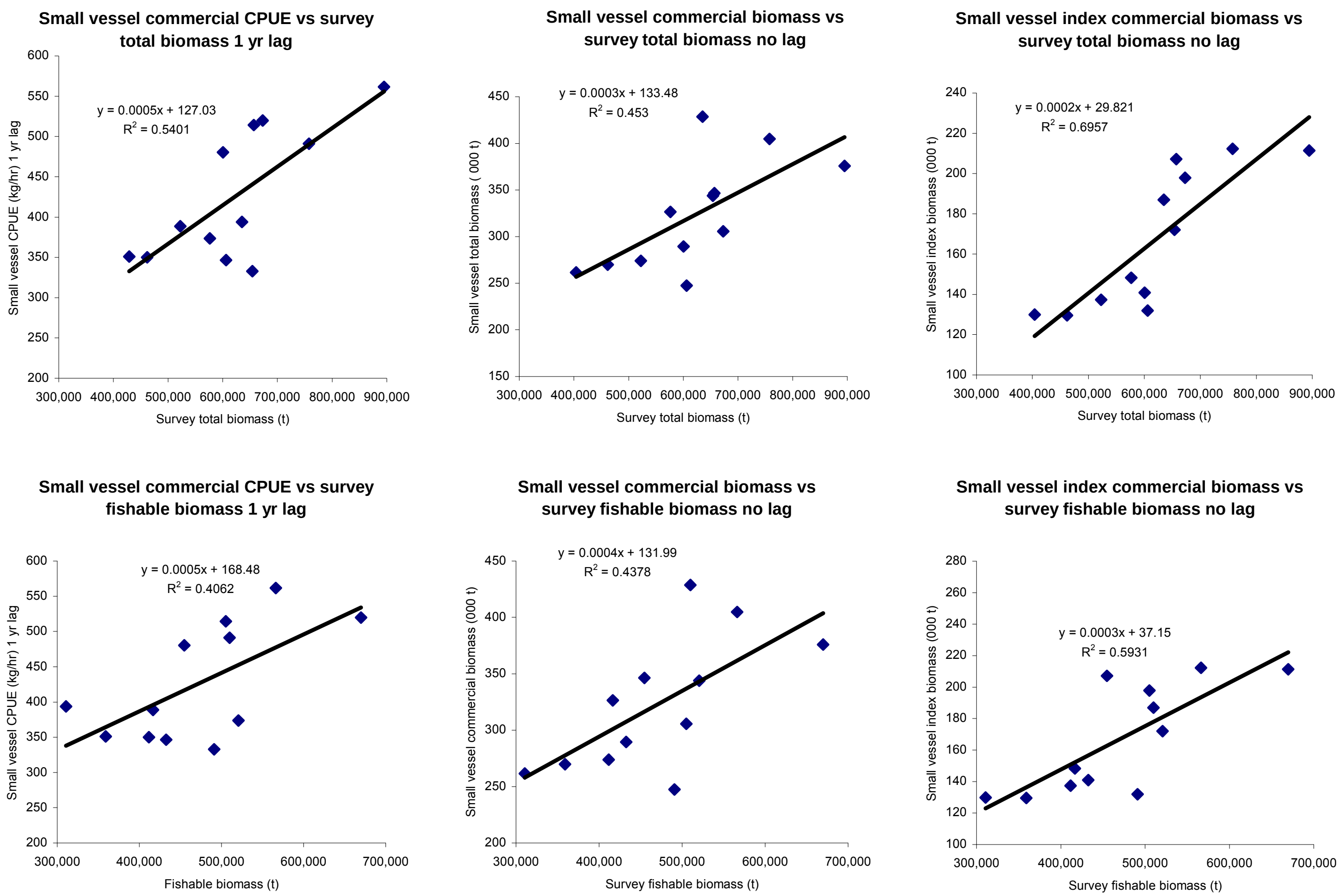


Figure 21. Relationships between small vessel CPUE, all strata commercial biomass and index strata commercial biomass indices versus survey total and fishable biomass, within SFA 6. Various lags were attempted and only the relationships with the highest r^2 are presented here.

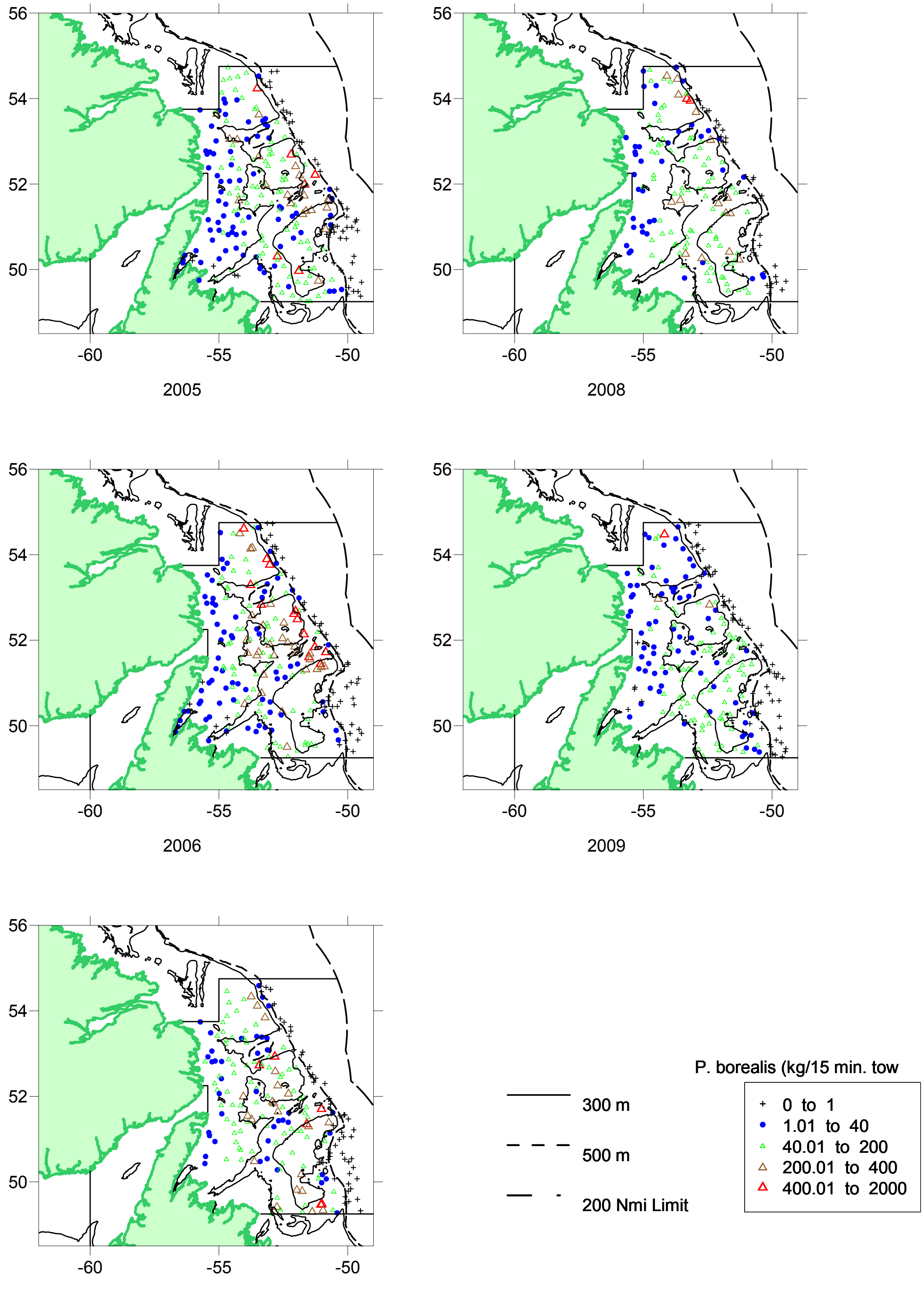


Figure 22. Distribution of Hawke Channel + 3K (SFA 6) northern shrimp (Pandalus borealis) catches (kg/tow) as obtained from the autumn research bottom trawl surveys conducted over the period 2005–09.

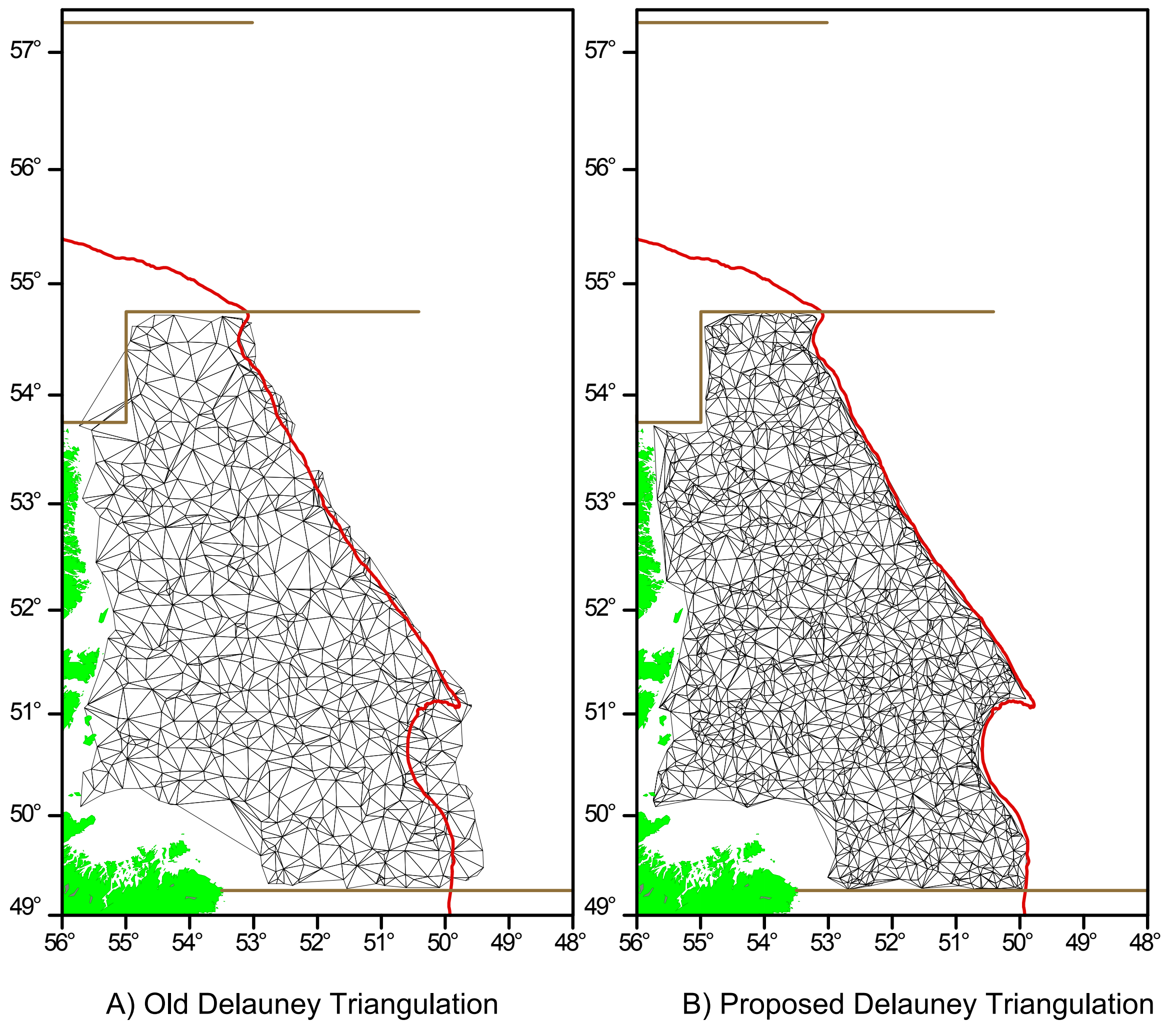


Figure 23. SFA 6 Delauney triangulations used in the Ogive Mapping calculations of survey indices. The old Delauney Triangulation file extended into deep water (>800 m) beyond where Northern Shrimp are normally found and into SFA 5. The red line indicates the 800 m depth contour while the brown line indicates the SFA 6 boundaries.

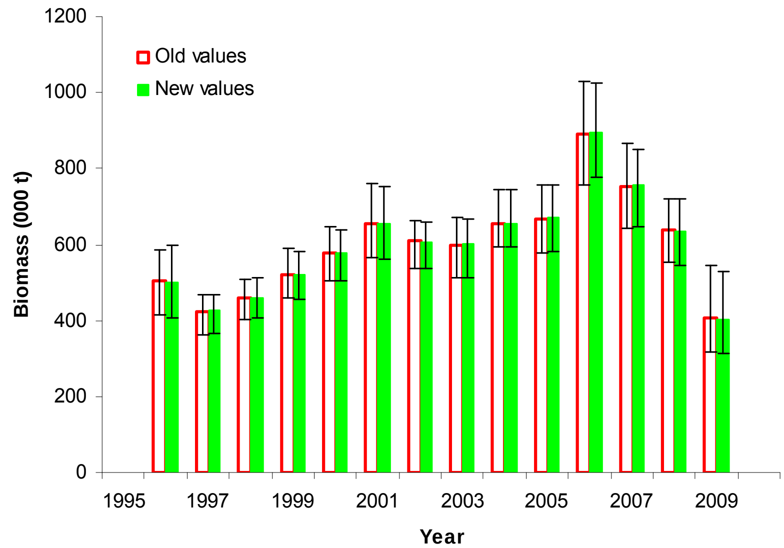


Figure 24.A comparison between the SFA 6 Northern Shrimp total biomass estimates using the old and new Delauney Triangulation and parameter files used in OGive MAP calculations. Data were from the annual Canadian multi-species bottom trawl surveys using Campelen 1800 shrimp trawl.

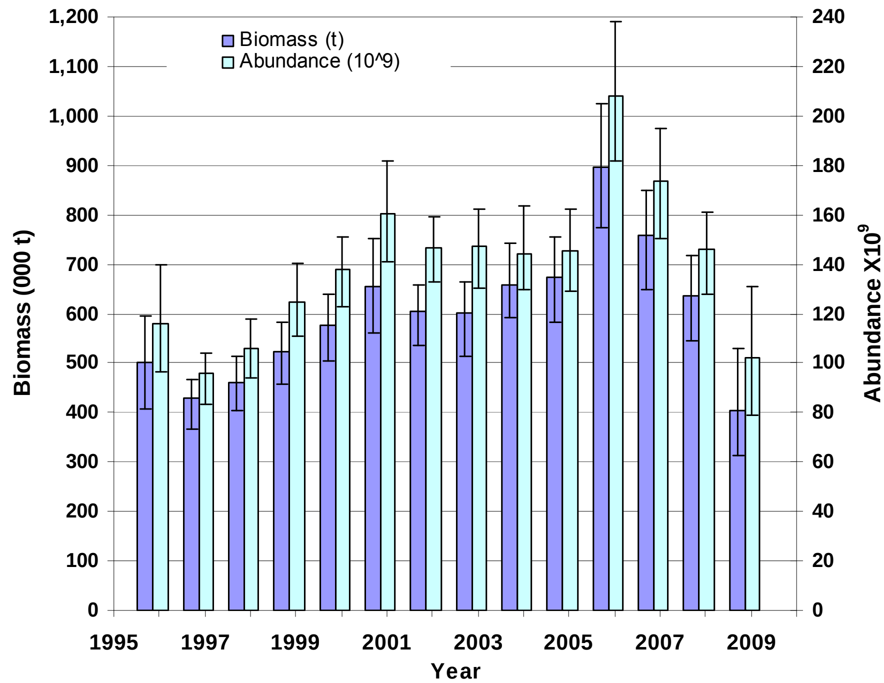


Figure 25. **Proposed** Autumn northern shrimp (Pandalus borealis) biomass and abundance indices within Hawke Channel + 3K (SFA 6), as determined using OGive MAPped calculations.

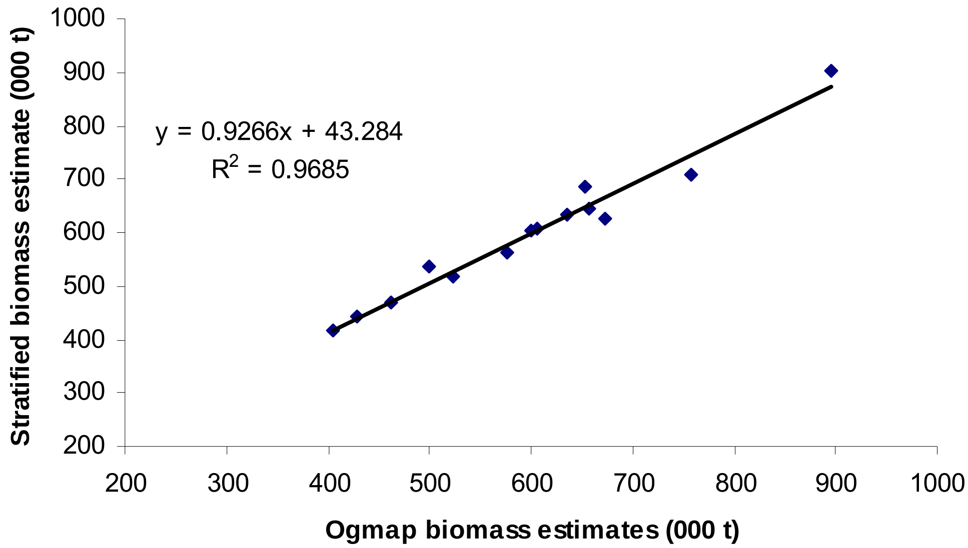


Figure 26. The relationship between SFA 6 index strata biomass indices determined through stratified areal expansion calculations and Ogmap calculations.

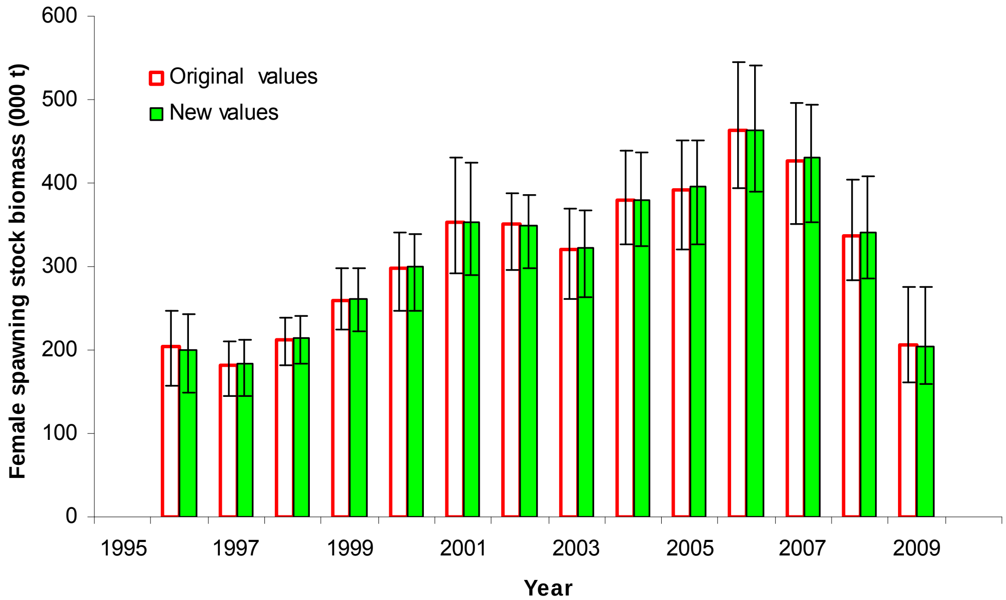


Figure 27. A comparison between the SFA 6 Northern Shrimp female spawning stock biomass (SSB)estimates using the old and new Delauney Triangulation and parameter files used in OGive MAP calculations. Data were from the annual Canadian multi-species bottom trawl surveys using Campelen 1800 shrimp trawl.

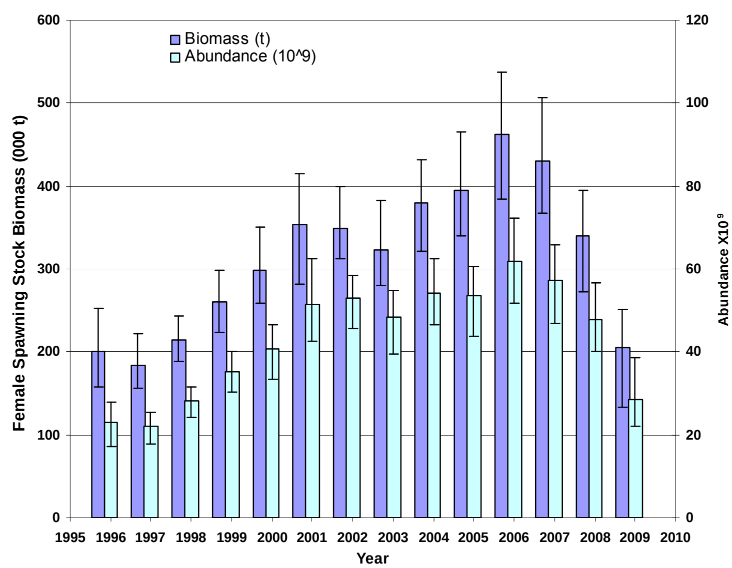


Figure 28. Proposed Autumn northern shrimp (Pandalus borealis) female spawning stock biomass and abundance indices within Hawke Channel + 3K (SFA 6), as determined using OGive MAPped calculations.

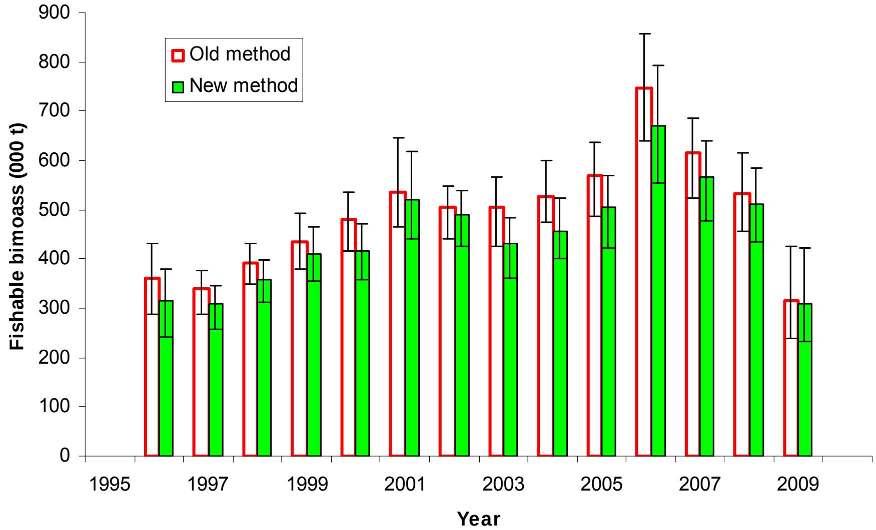


Figure 29. A comparison between the SFA 6 Northern Shrimp fishable biomass estimates using the old and new definitions, Delauney Triangulation and parameter files used in OGive MAP calculations. Data were from the annual Canadian multi-species bottom trawl surveys using Campelen 1800 shrimp trawl.

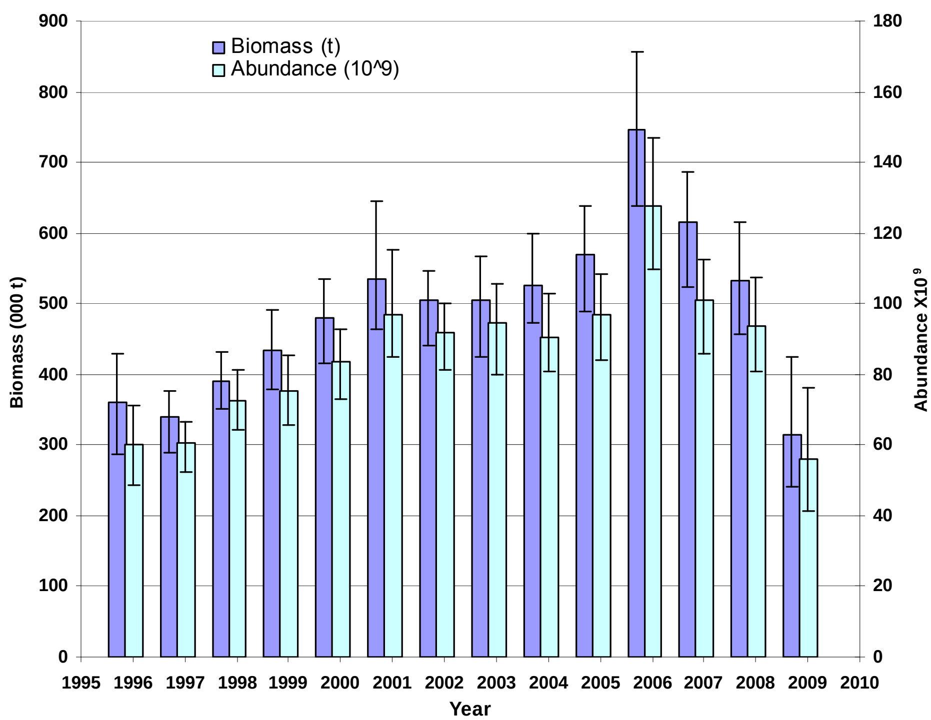


Figure 30. Proposed Autumn northern shrimp (Pandalus borealis) fishable biomass and abundance indices within Hawke Channel + 3K (SFA 6), as determined using OGive MAPped calculations using the new definition of fishable biomass, Delauney triangulation and parameter files.

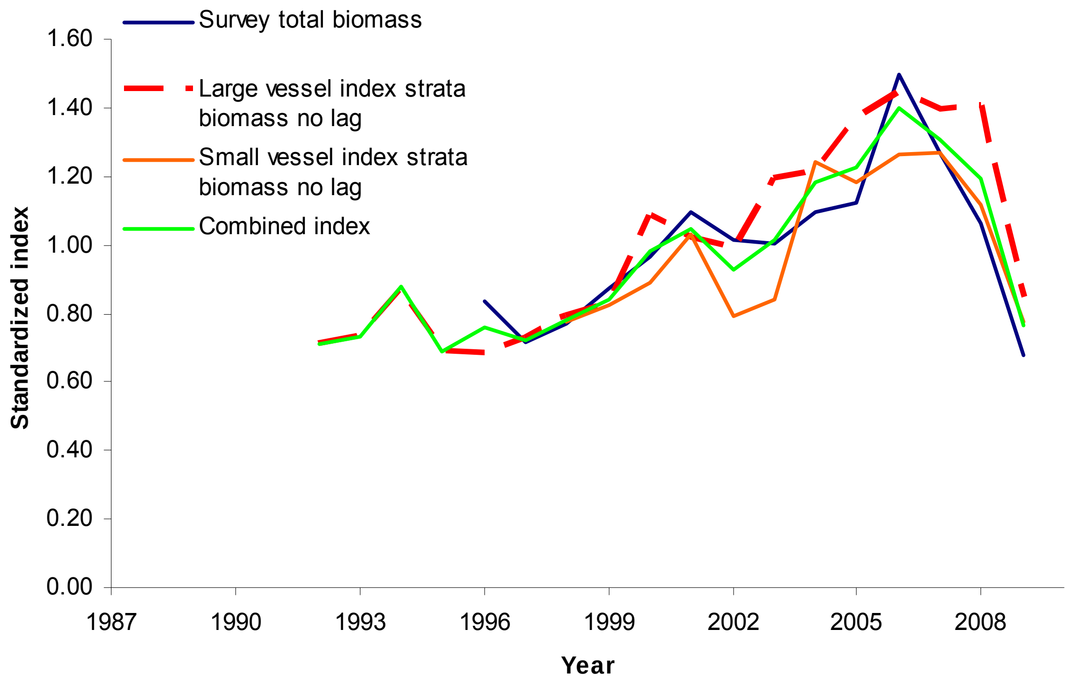


Figure 31. Proposed combined index of biomass for SFA 6. This index is the average of the large vessel index strata biomass, survey total biomass (Ogmap estimate) and small vessel index strata biomass indices each standardized by dividing individual indices into their respective means.

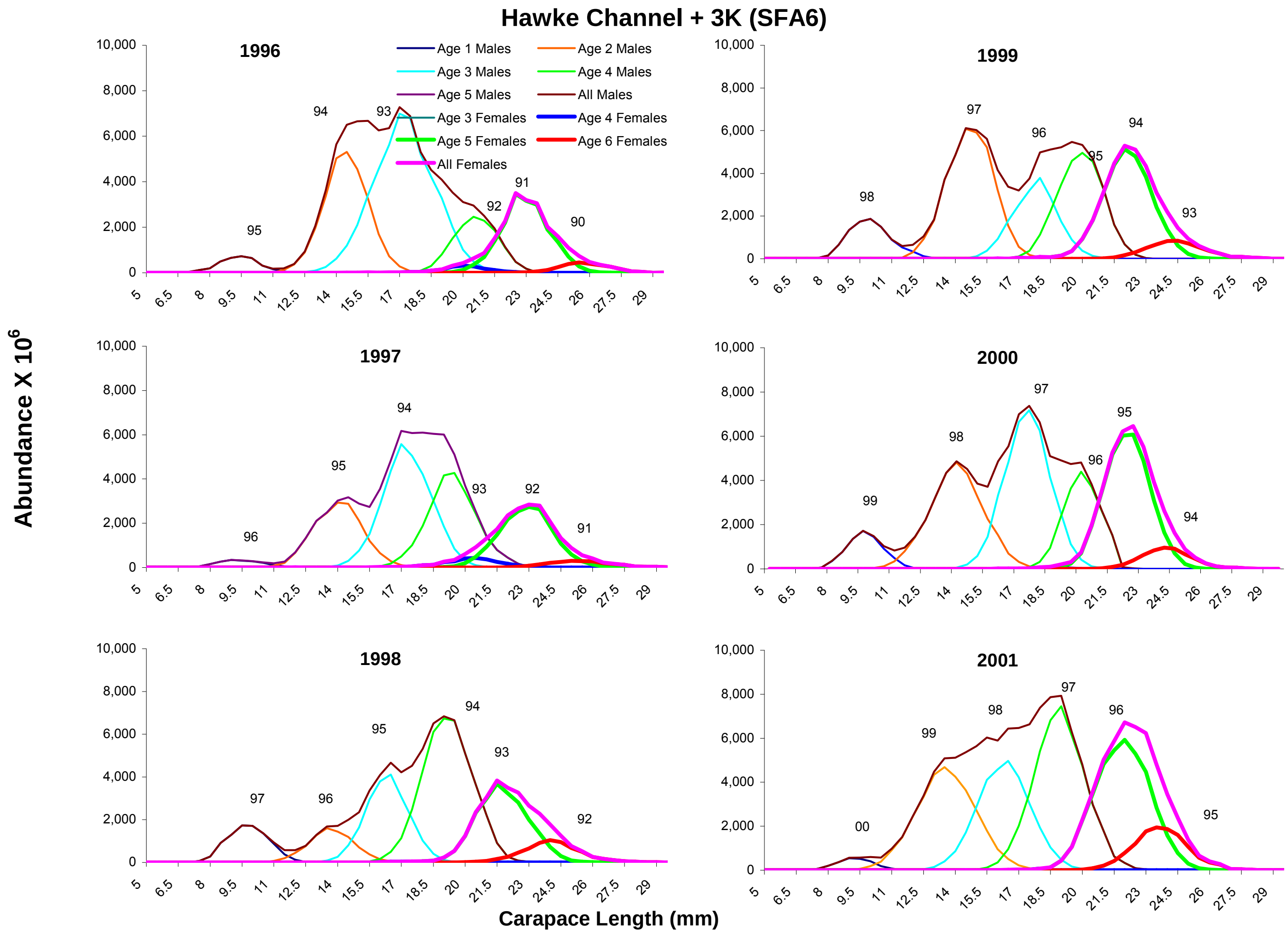


Figure 32. Abundance at length for Hawke Channel + 3K (SFA 6) Northern Shrimp (Pandalus borealis) estimated from OGive MAPped calculations of autumn multi-species bottom trawl survey data, 1996–2009.

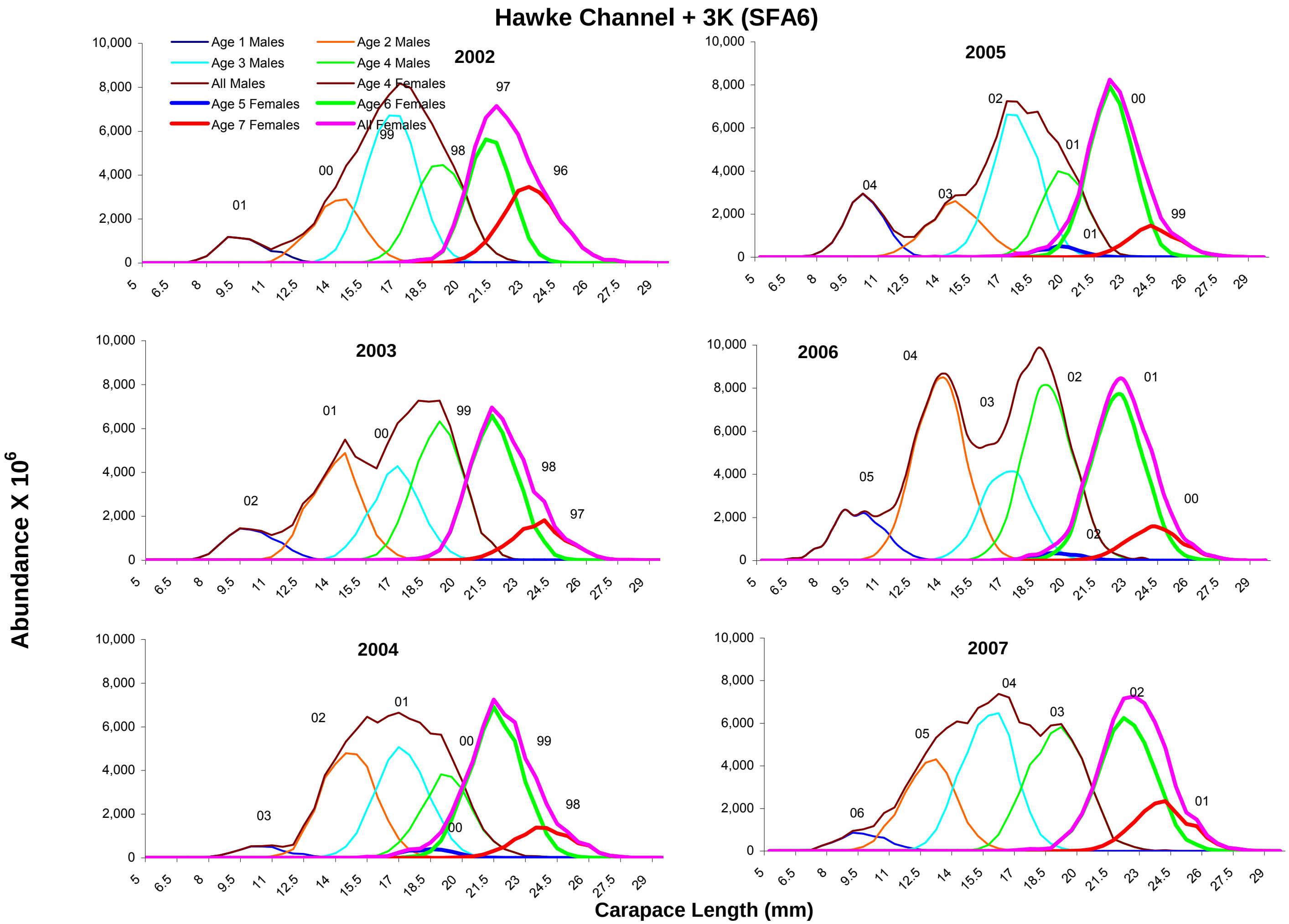


Figure 32. (Cont'd)

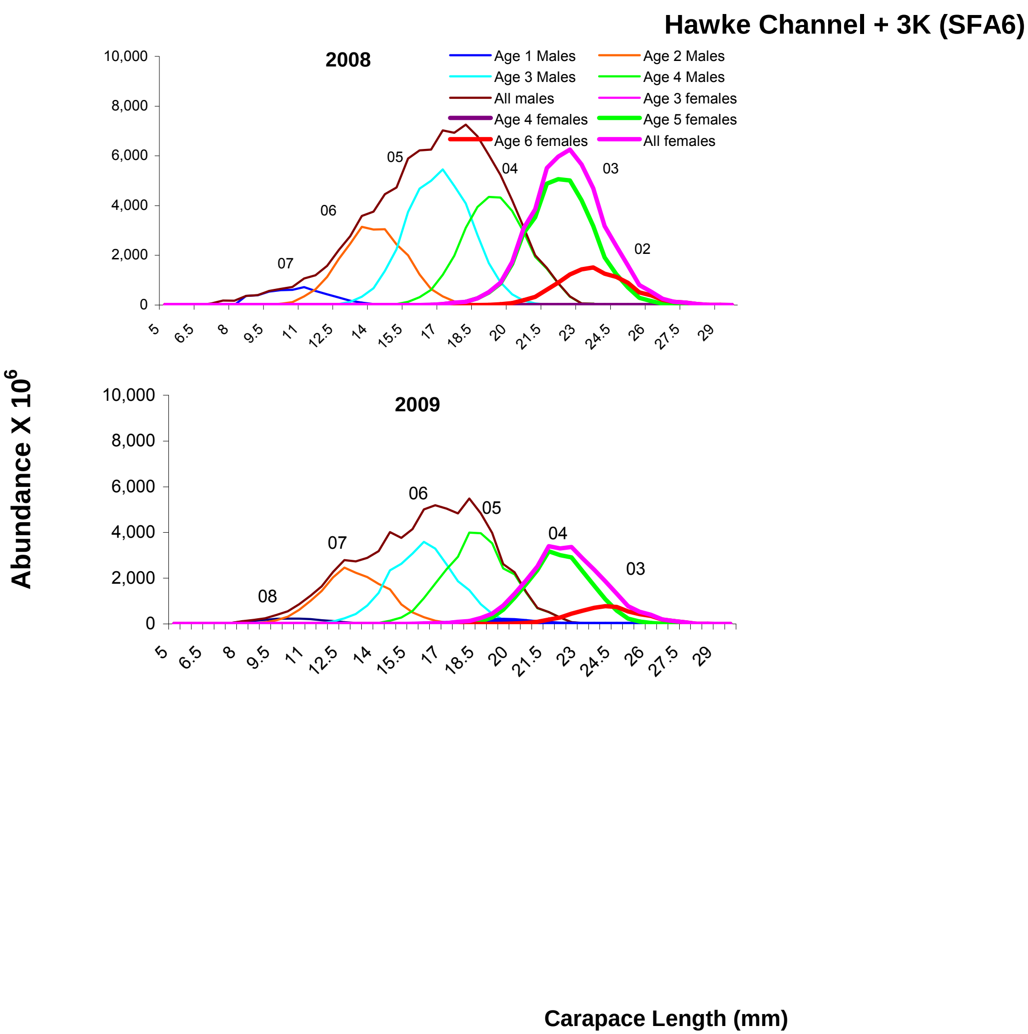


Figure 32. (Cont'd).

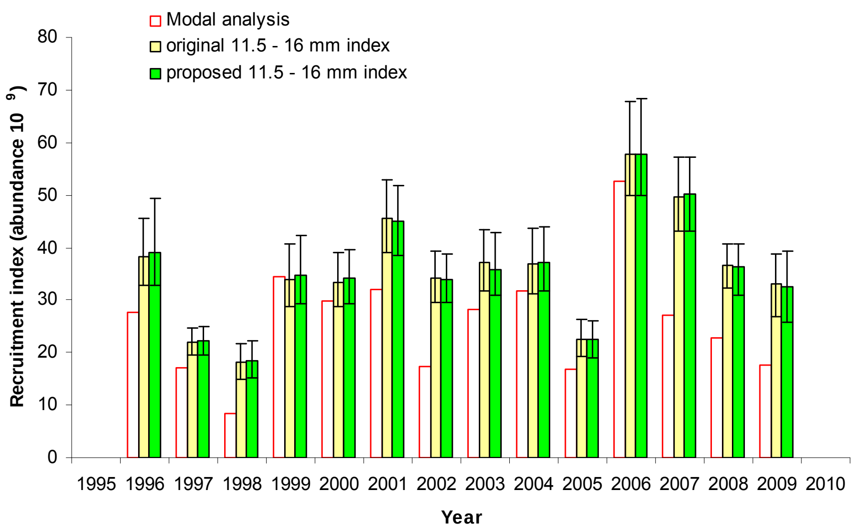


Figure 33. Hawke Channel + 3K (SFA 6) Northern shrimp recruitment indices using the abundances of age 2 males from modal analysis, the original definition (abundance of all males and unidentified Pandalus 11.5–16 mm carapace lf), Delauney triangulation and parameter files compared with the new estimates using the new definitions (abundances of all males + females with 11.5–16 mm carapace lf) and new Delauney triangulation and parameter files used in Ogmap calculations. These estimates were calculated from 1996-2009 Canadian autumn multi species bottom trawl research surveys (standard tows = 15 min at 3.0 Nmi/hr).

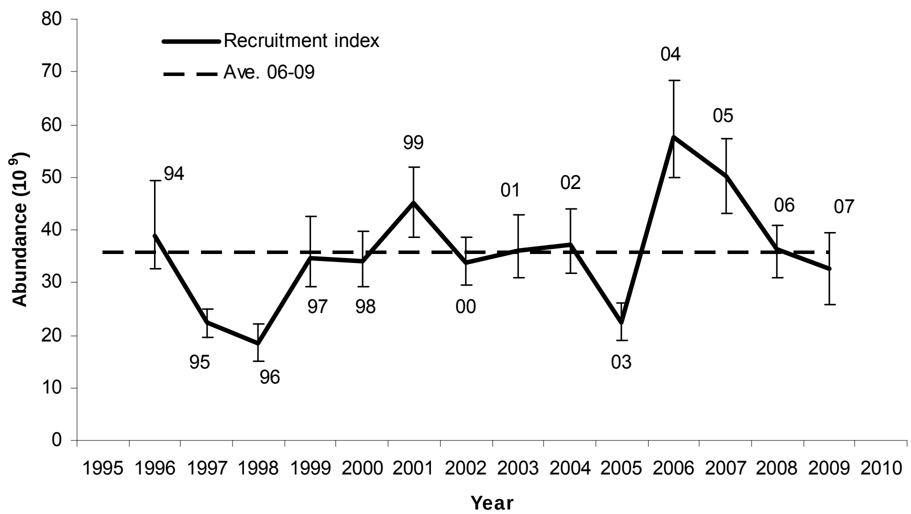


Figure 34. **Proposed recruitment index** (abundances of all males + females with 11.5–16 mm carapace lf) and new Delauney triangulation and parameter files used in Ogmap calculations.

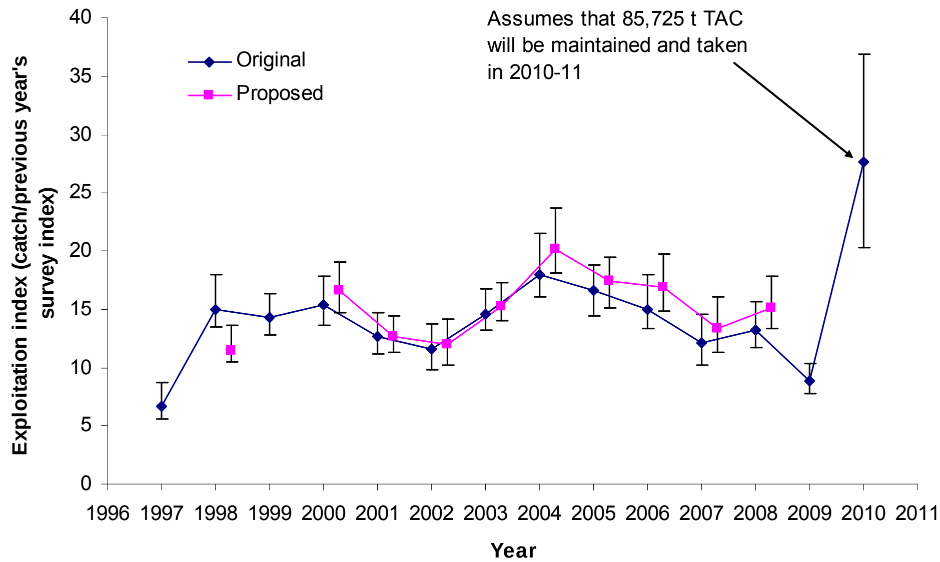
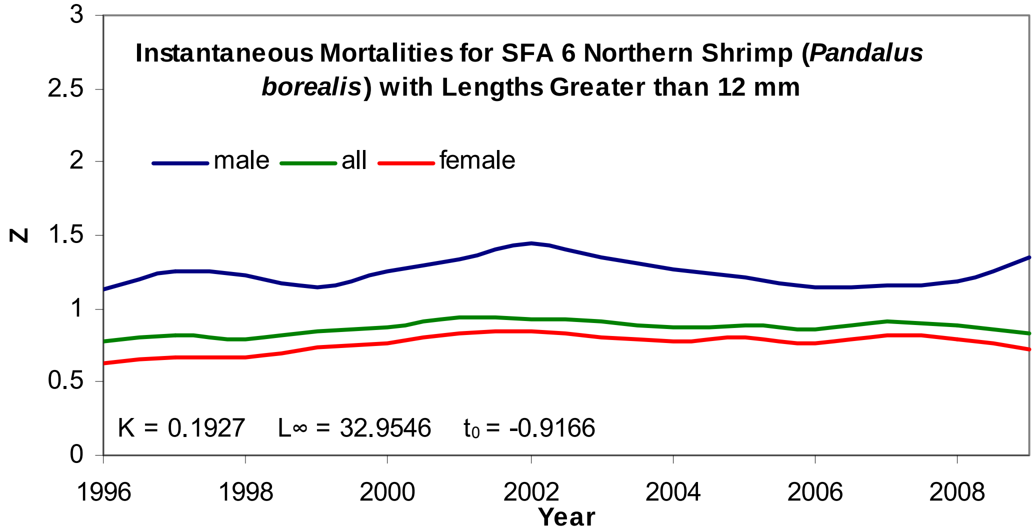


Figure 35. Original formulation of SFA 6 exploitation rate indices (total catch/ fishable biomass index from the previous year expressed as percent) and proposed formulation (abundance of shrimp removed by the fishery/ abundance from the fishable portion of the resource). Both indices are expressed as percent while error bars indicate 95% confidence intervals.



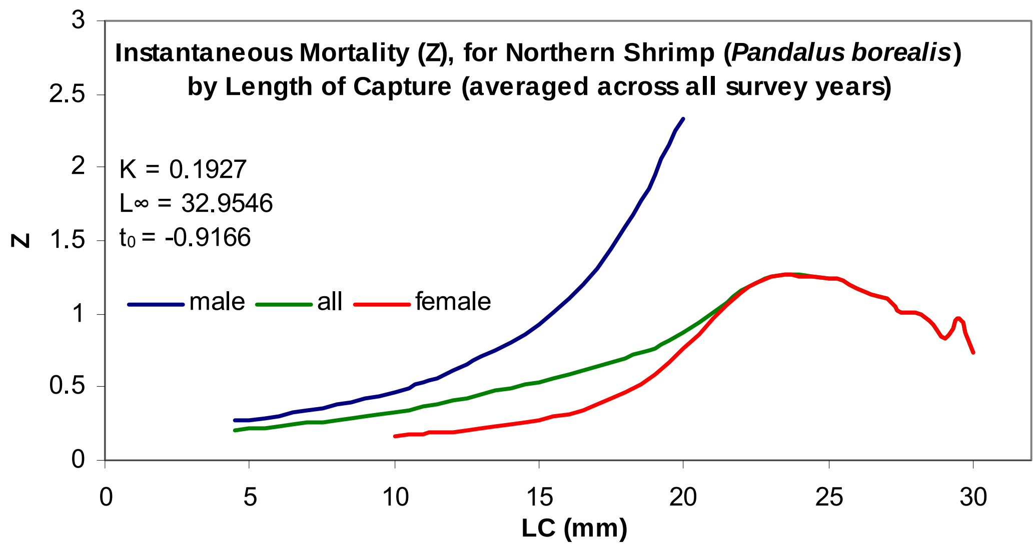


Figure 36. Length based mortality estimates for Northern Shrimp (Pandalus borealis), within SFA 6 over the period 1996–2009.

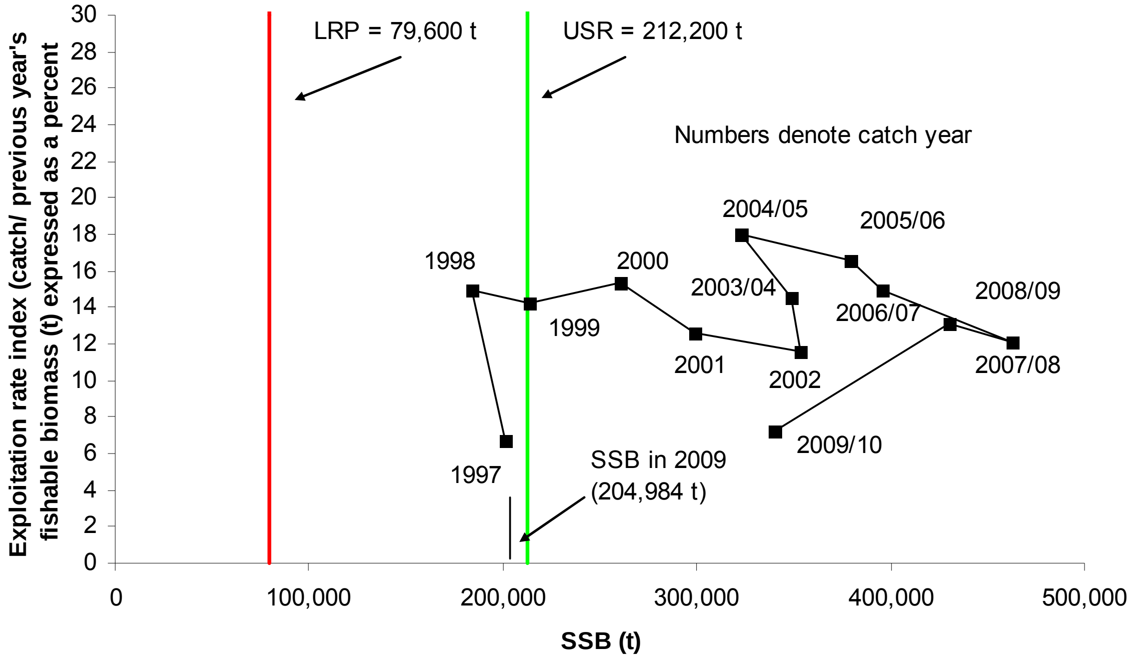
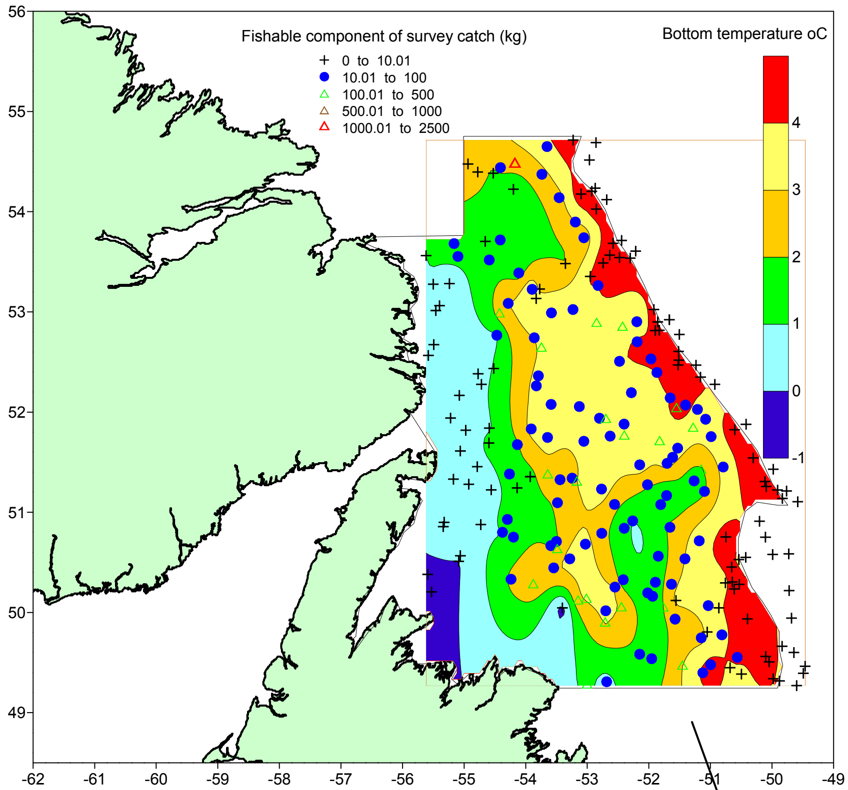
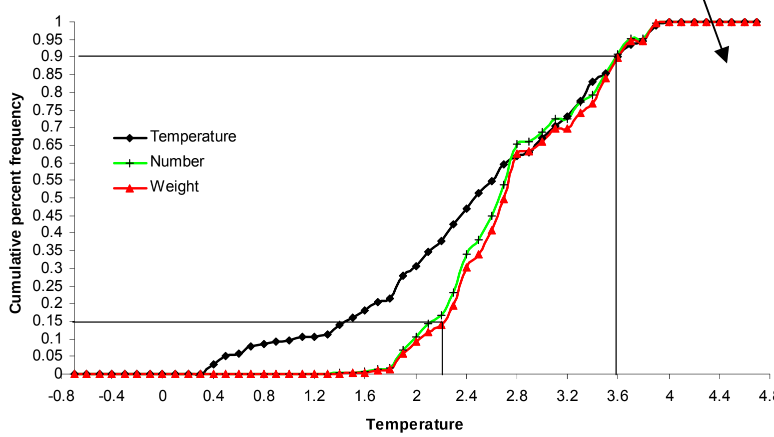


Figure 37. SFA 6 precautionary approach using an Upper Stock Reference (USR = 80% of the geometric mean of SSB over a productive period (1996–2003)) and a Lower Reference Point (LRP = 30% of the geometric mean of SSB over a productive period (1996–2003)) superimposed with the exploitation rate trajectory over time.



A) SFA 6 fishable shrimp catch (kg) and bottom temperature from the 2009 autumn survey. Bottom temperatures were kriged.



B) SFA 6 shrimp cumulative percent fishable shrimp catch (kg) at temperature from the 2009 autumn survey.

Figure 38. An example of a weighted cumulative percent plot showing that 75% of the fishable shrimp catch, from the autumn survey, is found in 2-4°C bottom temperatures. The area occupied by this temperature range was used as an environmental index. Weighting was done to account for the stratified random sample design.

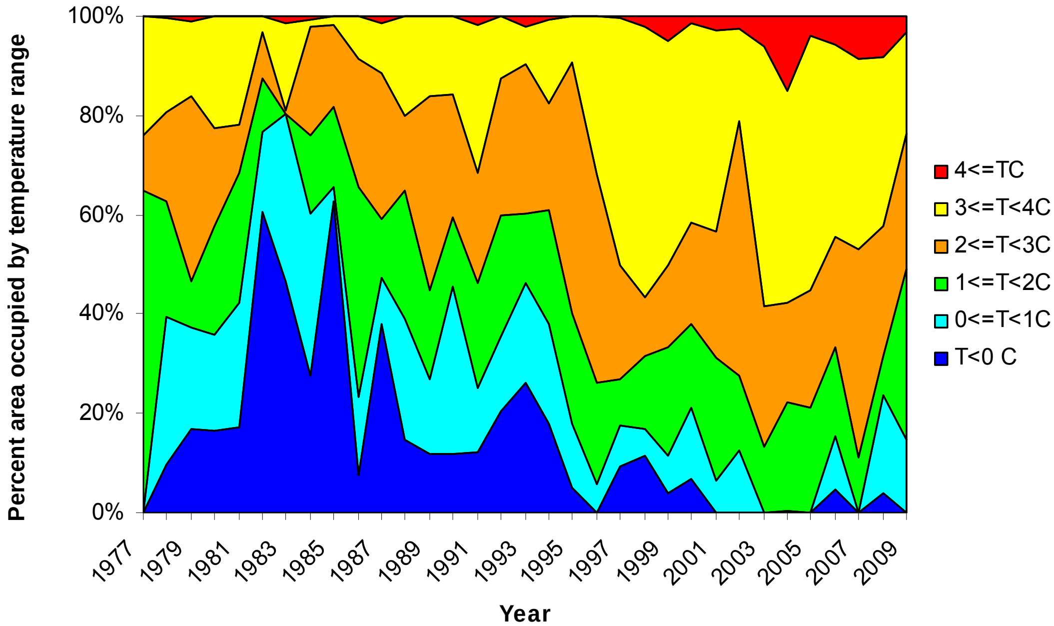


Figure 39. Percent area occupied by autumn bottom temperatures as determined during Canadian DFO oceanographic and multi-species surveys. This plot is based upon areal expansion of average temperatures within each stratum by year.

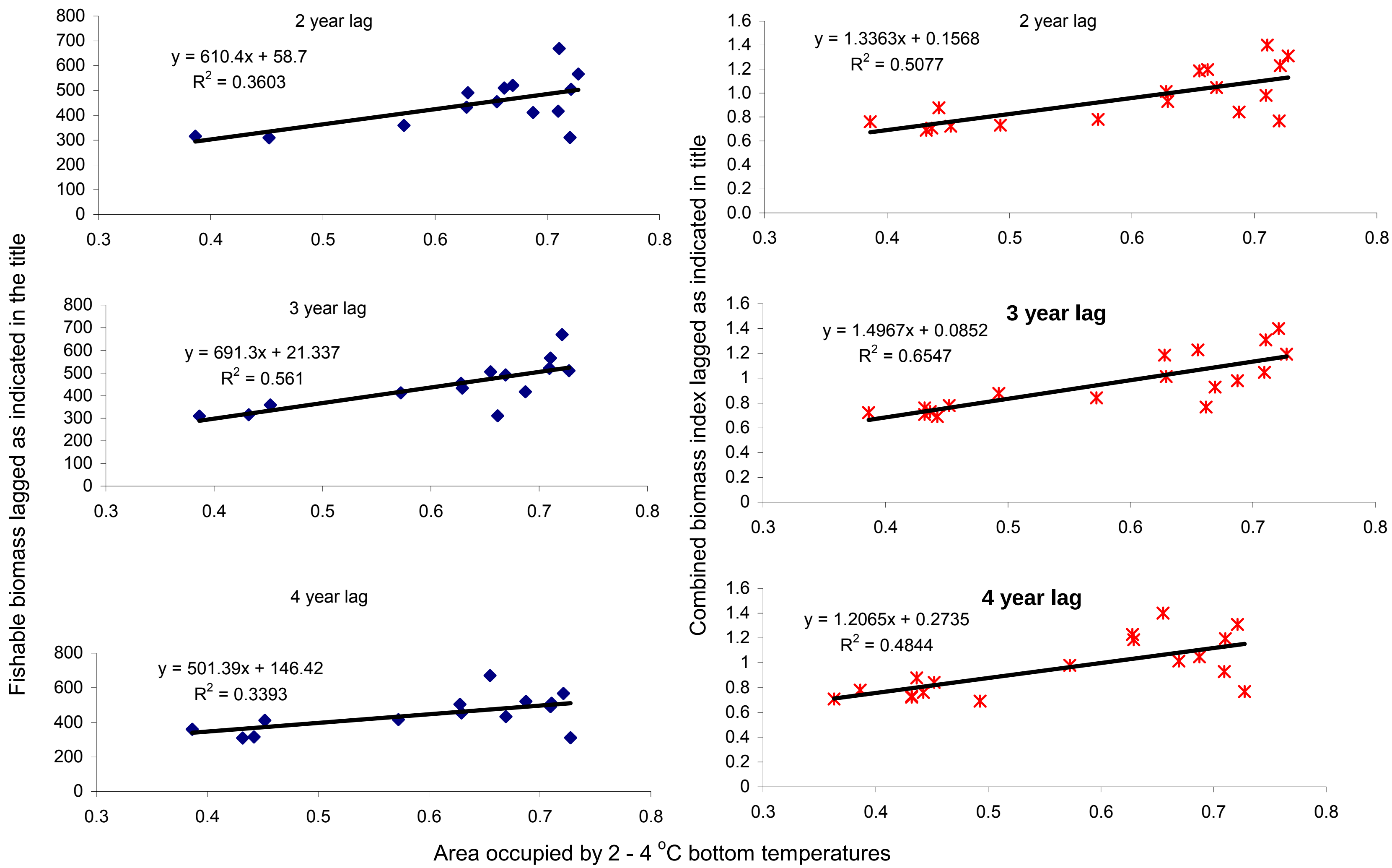
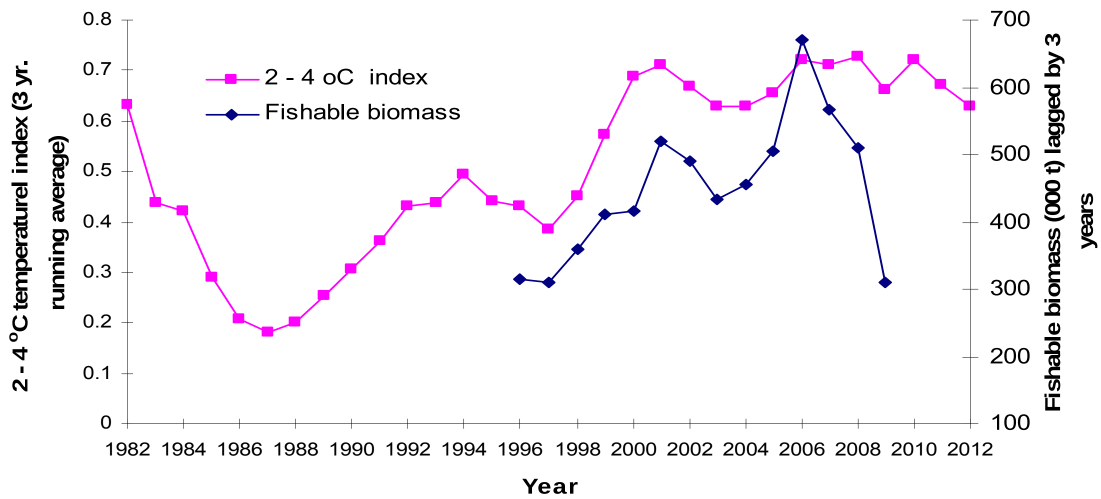
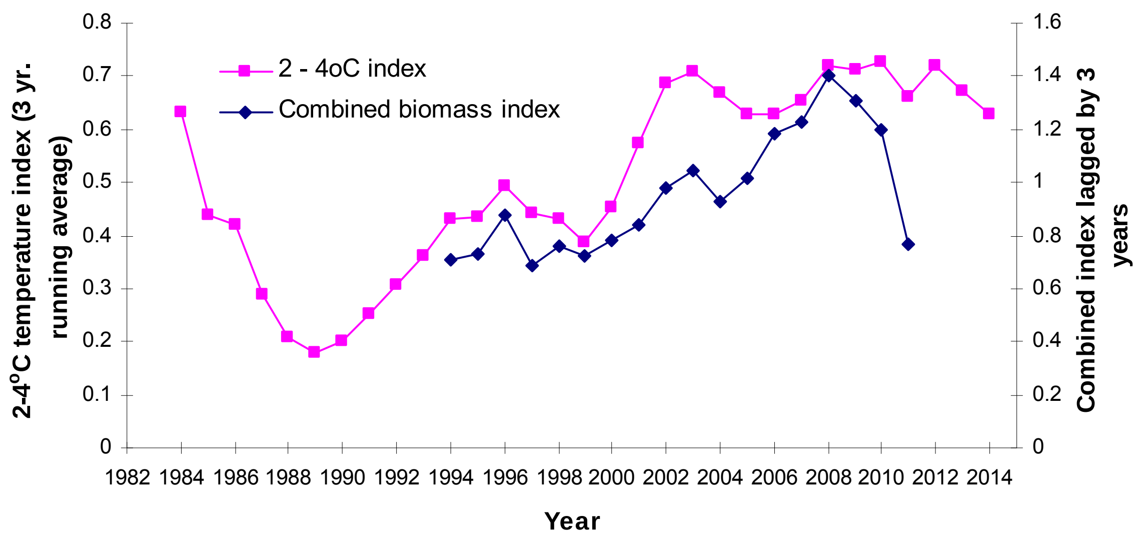


Figure 40. Regression analysis providing the appropriate lag period for fishable (blue diamonds) and combined biomass indices (red stars) versus area occupied by 2–4°C bottom temperatures in SFA 6.



A) Fishable biomass overlain upon environmental index



B) Combined index overlain upon environmental index.

Figure 41. SFA 6 fishable biomass and combined biomass indices overlain upon the environmental index trajectory over time. Between 1996 and 2006 both indices explain 72% of the respective relationships with the areal index; however the relationship decreased to 56% by 2009 when using fishable biomass and 65% when using the combined index.

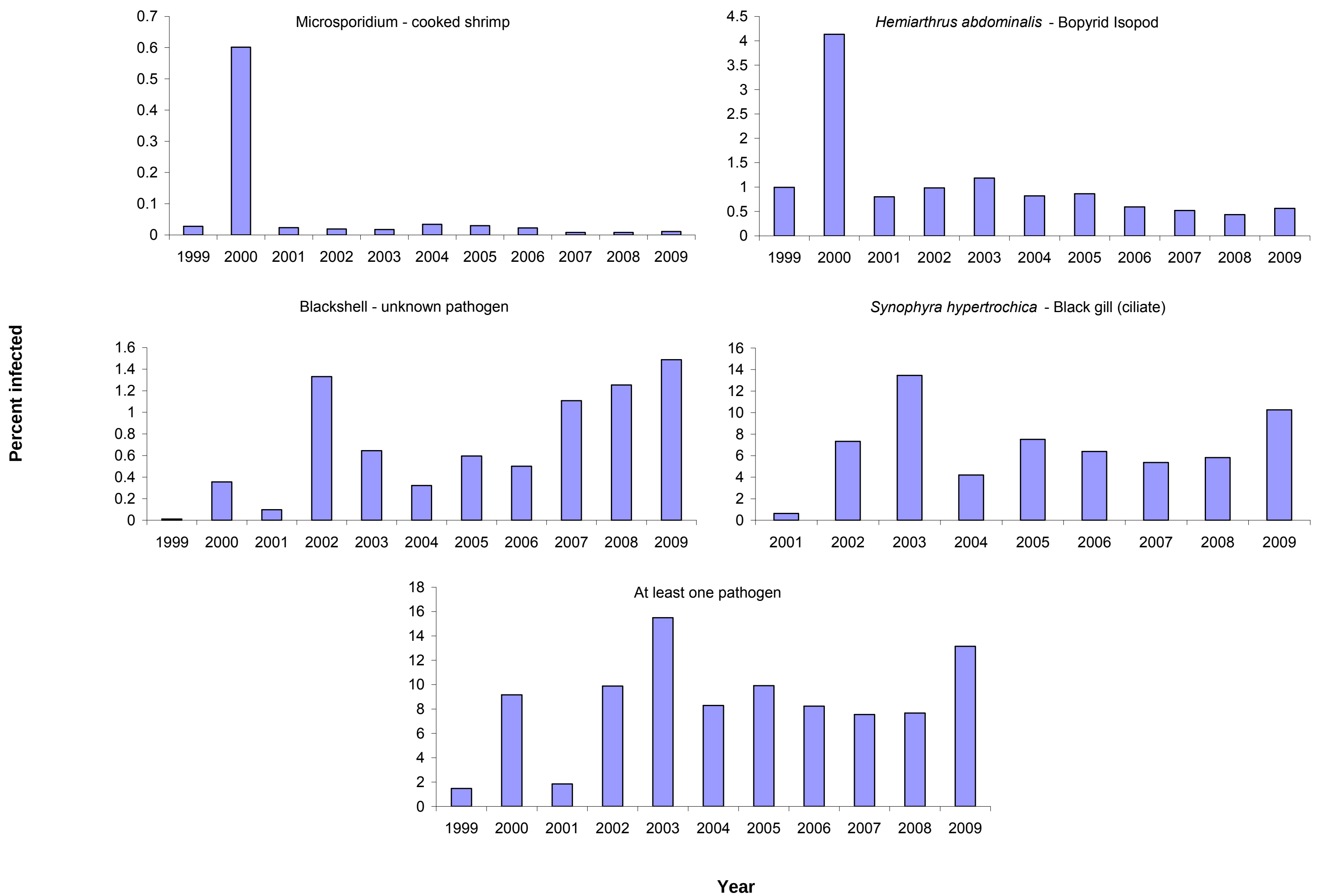


Figure 42.A baseline of numerically important Northern Shrimp pathogens found in Hawke Channel + 3K (SFA 6) between 1999 and 2009.

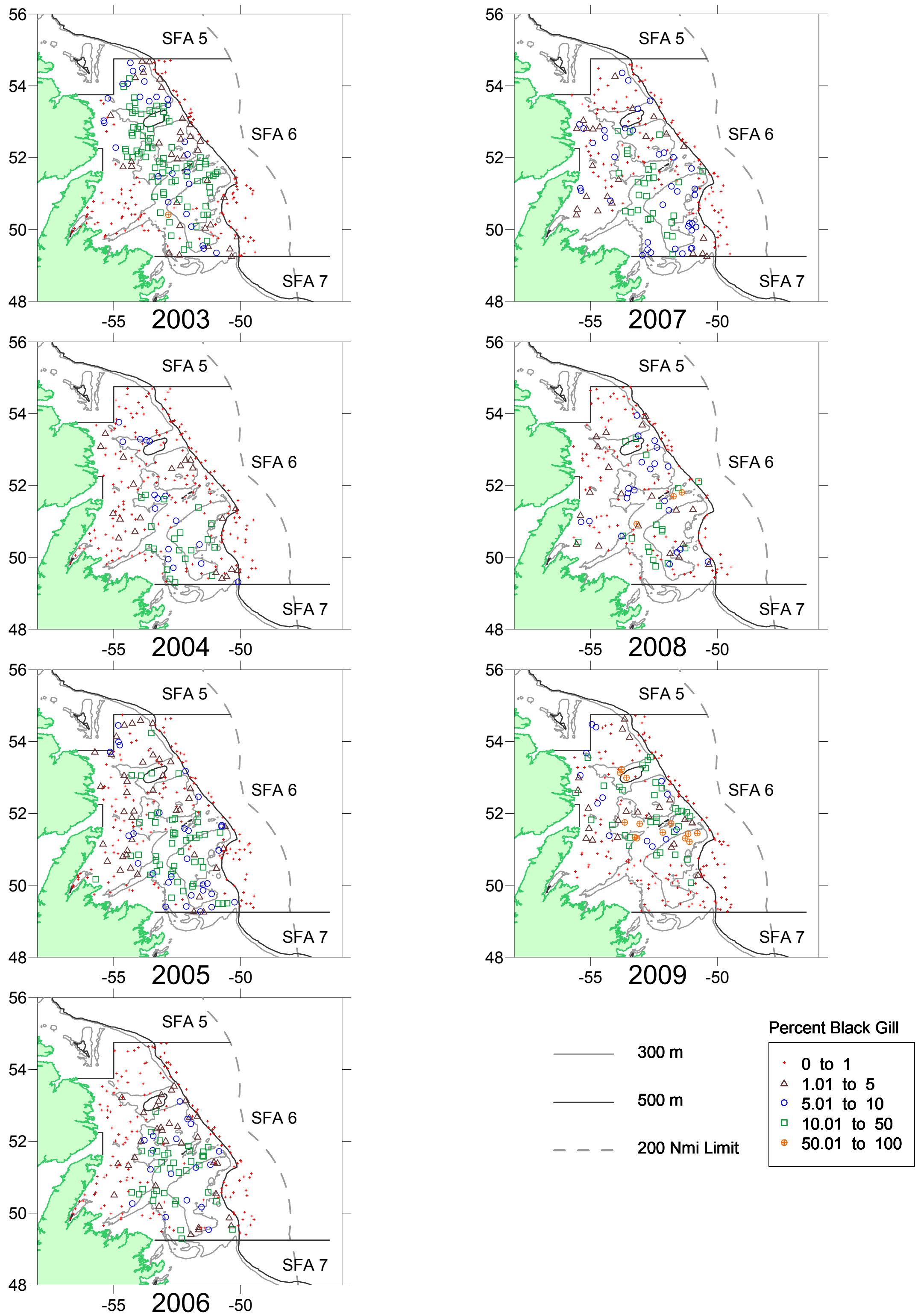


Figure 43. The incidence of a ciliate (*Synophyra hypertrophica*) that feeds upon hymolymph within the gills of Northern shrimp causing the condition referred to as black gill. Samples were collected during the autumn bottom trawl survey into SFA 6 over the period 2003–09.

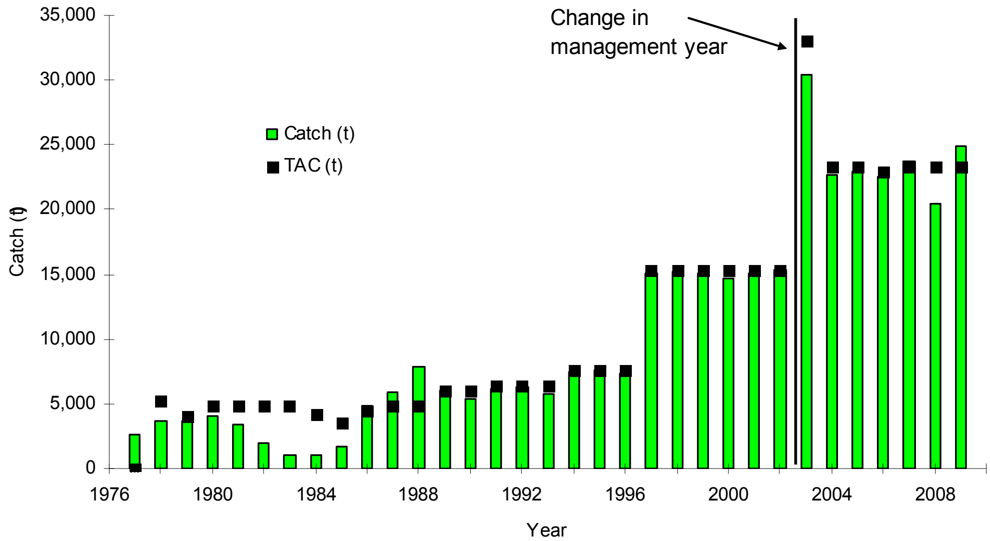


Figure 44. Historic northern shrimp catches (SFA 5) and TAC's for the period 1977–2009. In 2003, the management year changed from Jan. 1–Dec. 31 to Apr. 1–Mar. 31. Catches are preliminary for the 2009-10 management year.

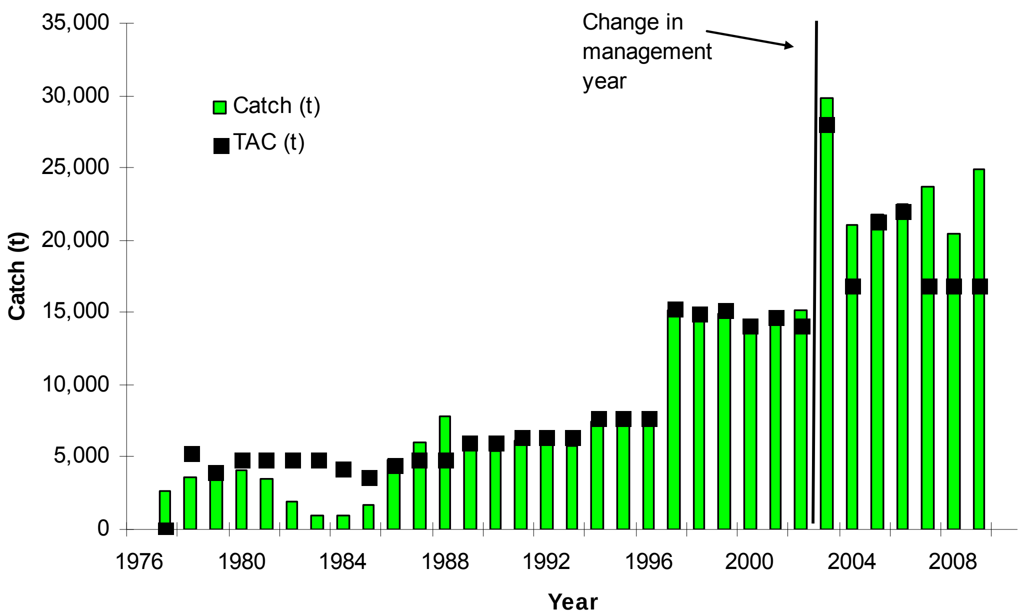


Figure 45.Historic large vessel northern shrimp catches (SFA 5) and TAC's for the period 1977–2009. In 2003, the management year changed from Jan. 1–Dec. 31 to Apr. 1–Mar. 31. Catches are preliminary for the 2009-10 management year.

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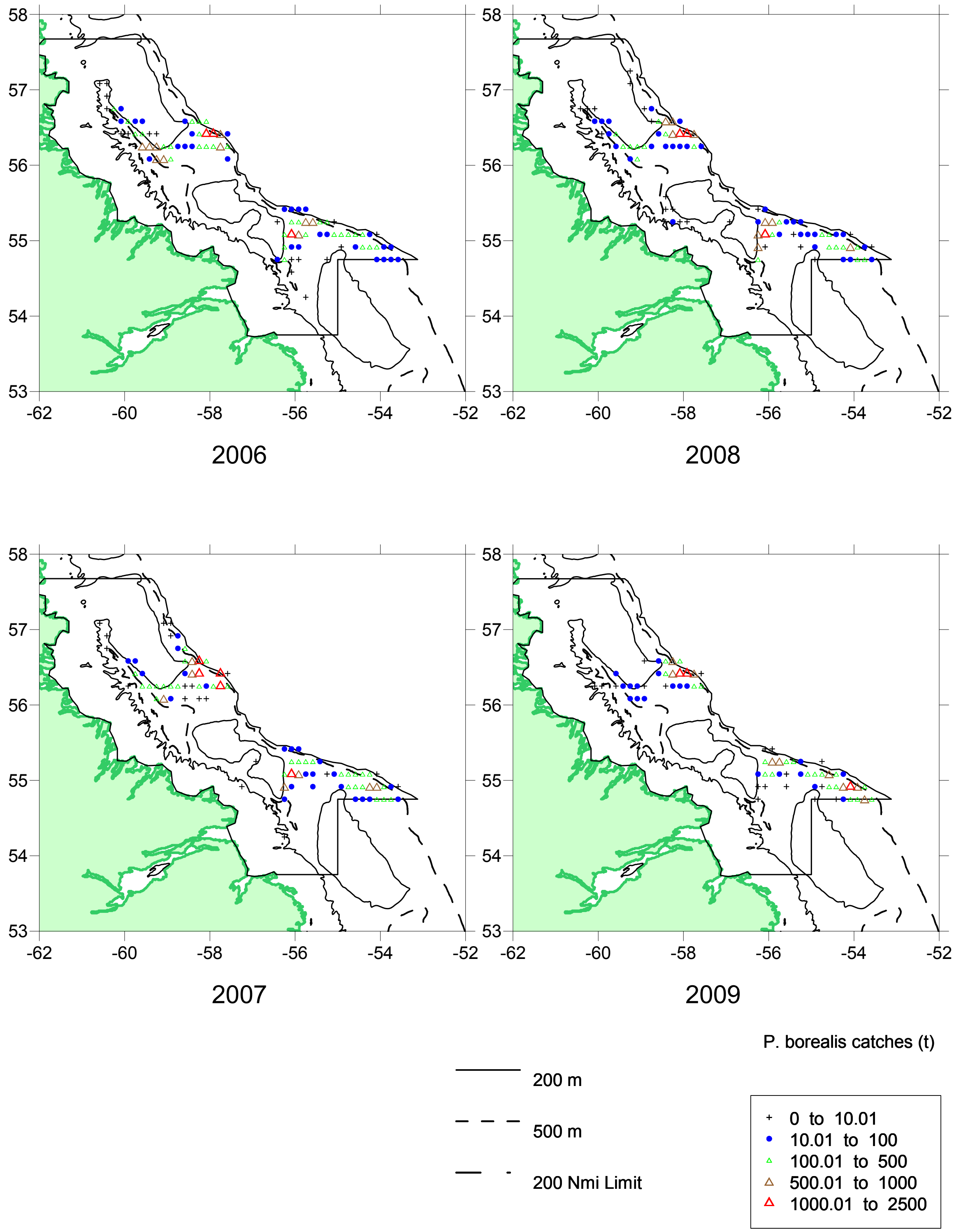


Figure 46. Distribution of large vessel (>500 t) shrimp catches in Hopedale + Cartwright Channels (SFA 5). (Observer data aggregated into 10 min X 10 min cells).

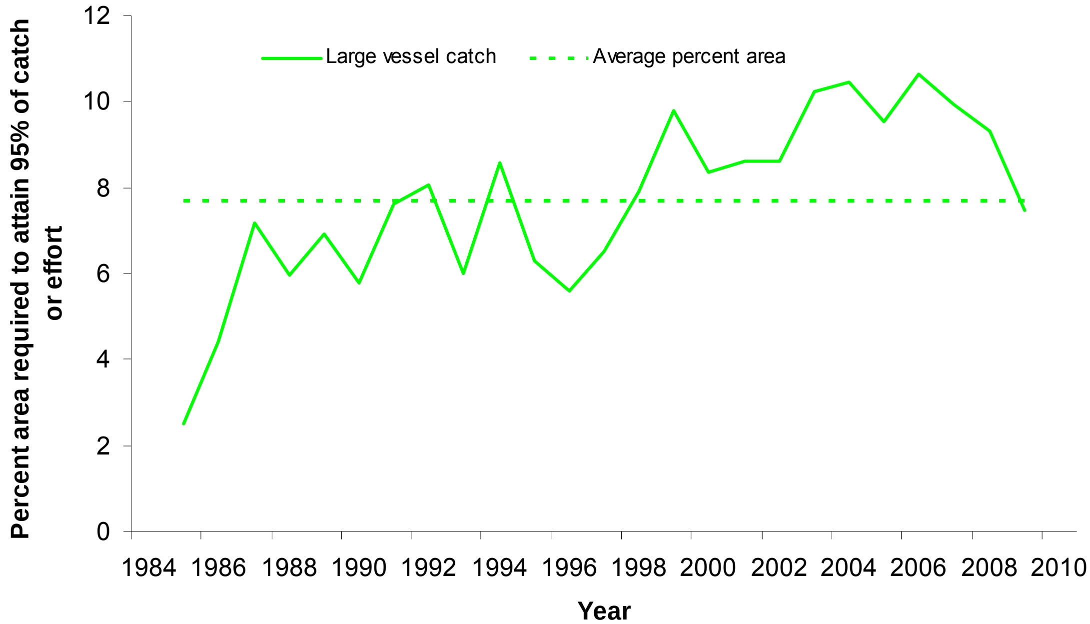


Figure 47. The percent total area within SFA 5 necessary to obtain 95% of the large vessel shrimp fishery catch, 1985–2009.

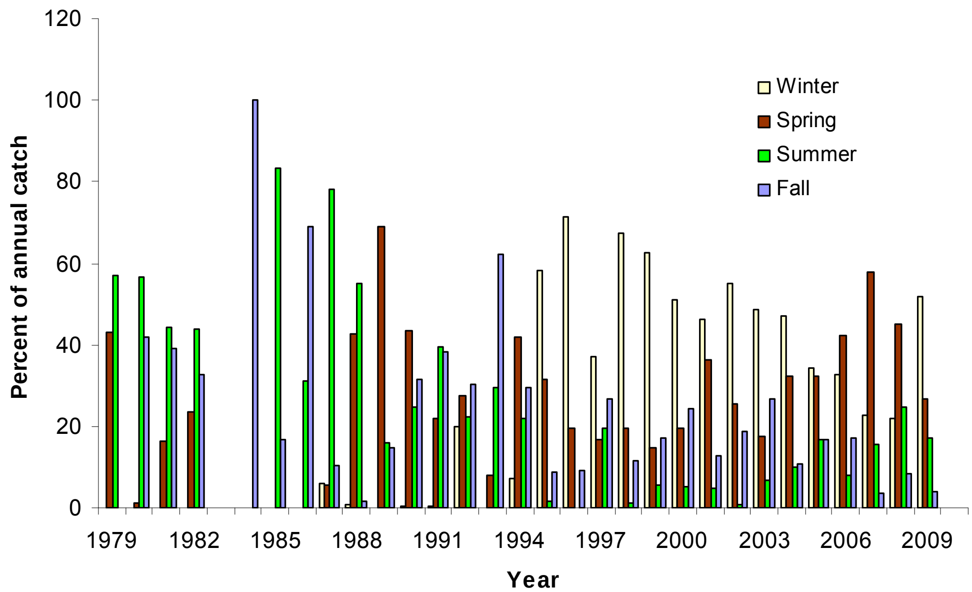
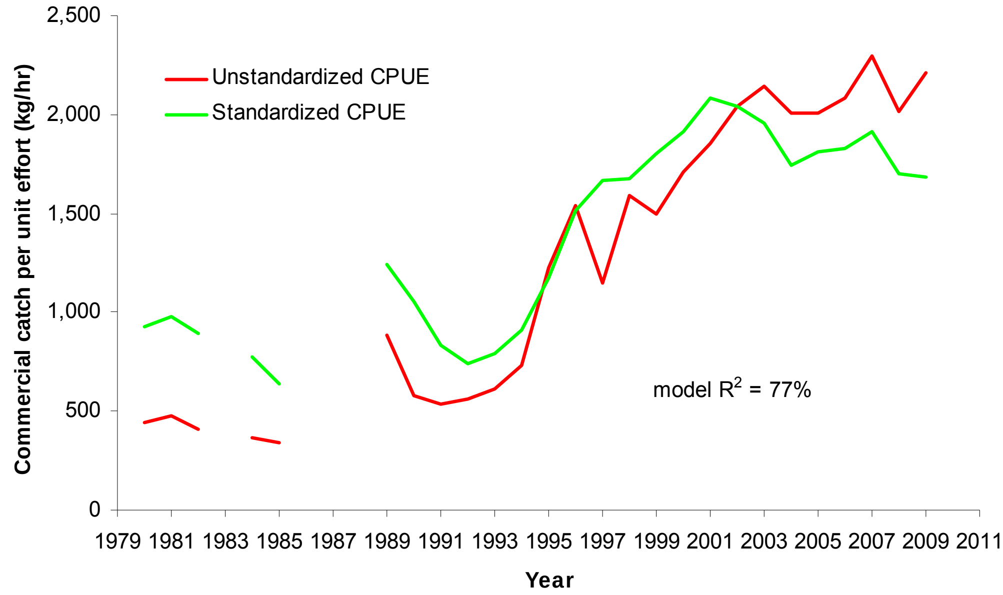
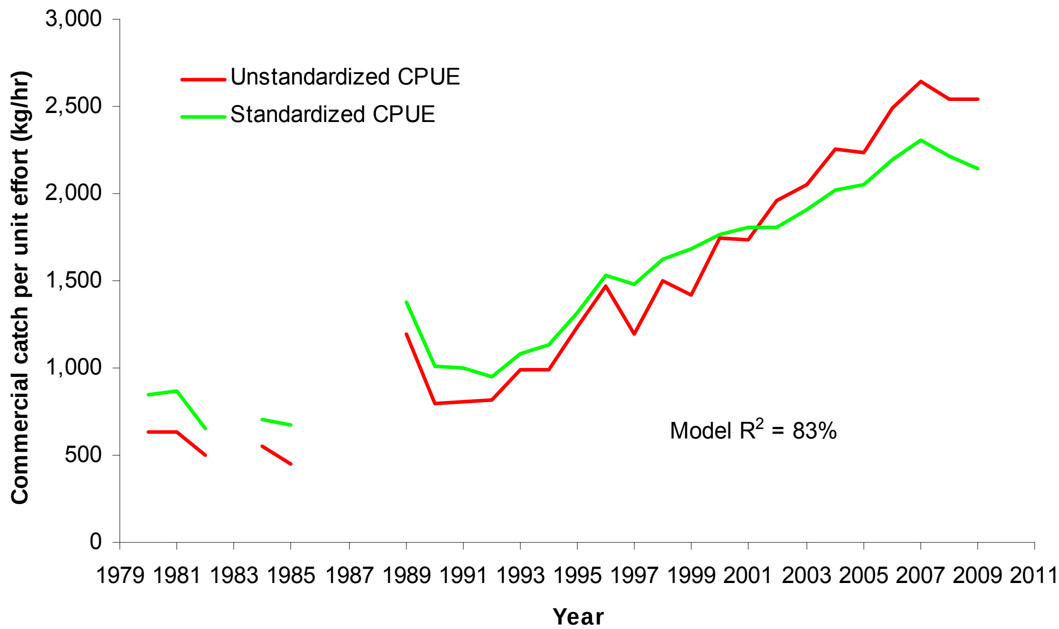


Figure 48. Seasonality of the large vessel (>500 t) shrimp fishery within Hopedale + Cartwright Channels (SFA 5) as determined from percent annual catch by season.



A) ***Original*** *model formulation*.



B) ***Proposed*** *model formulation.*

Figure 49. A comparison of large vessel SFA 5 commercial catch rates (kg/hr) developed using the original model formulation (Observer data; single trawl no window data only, history>3 yrs; all months; all areas, year, month and area model) and the proposed model formulation (Observer data; single and double trawl no window data; history > 3yrs; all months; area 53 removed; year, month, area and gear model).

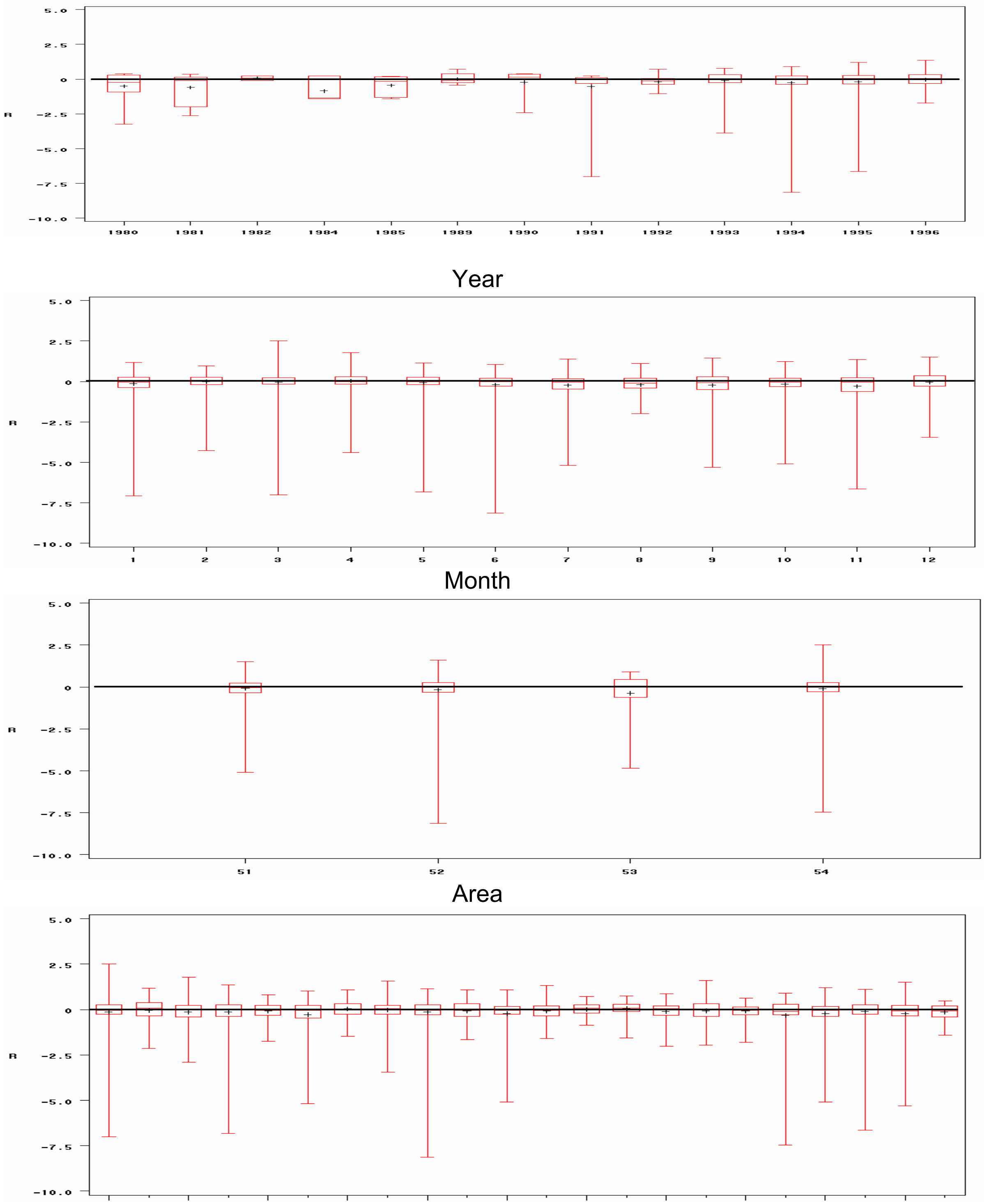


Figure 50.The distribution of residuals around estimated values for parameters used in the original large vessel (>500 t) shrimp catch rate model for Hopedale + Cartwright Channels (SFA 5), 1980–2009.

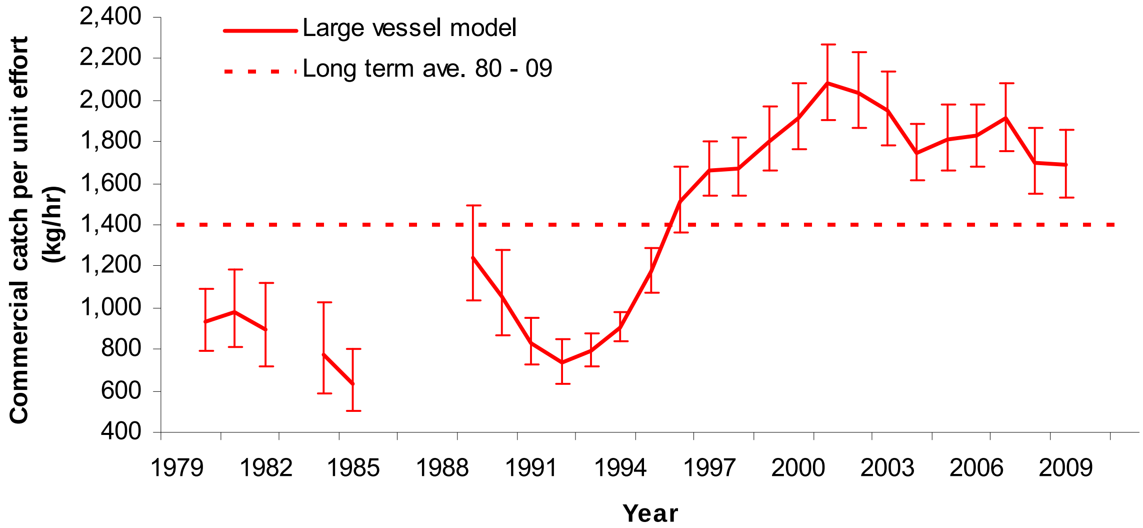


Figure 51. Proposed SFA 5 large vessel standardized CPUE (error bars indicate 95% confidence intervals).

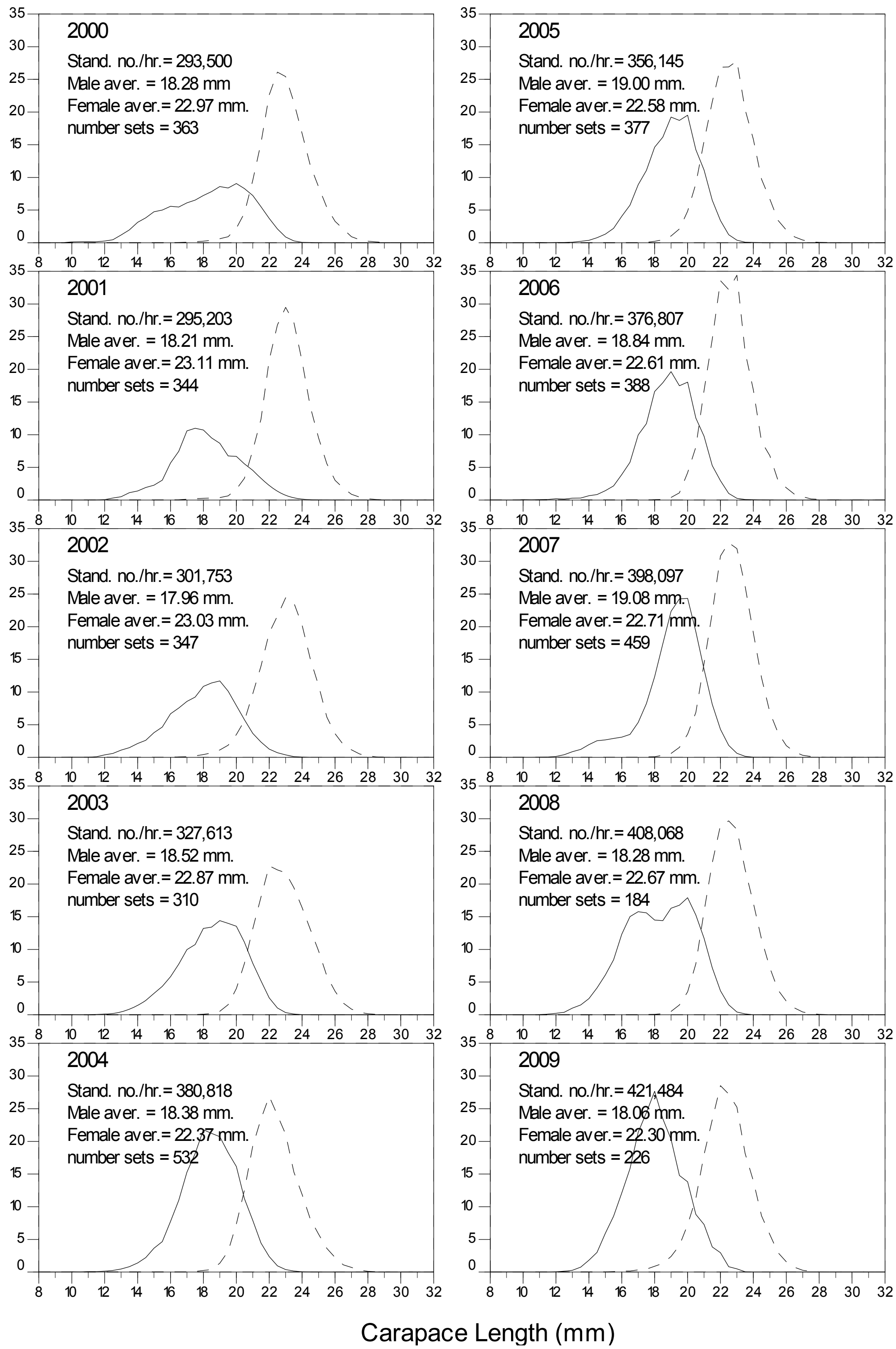


Figure 52. Observed northern shrimp length frequencies (000's per hr.) from the Canadian large vessel (=>500 t) fleet fishing shrimp in Hopedale + Cartwright Channels (SFA 5) over the period 2000–09. Solid lines = males; dotted lines = females.

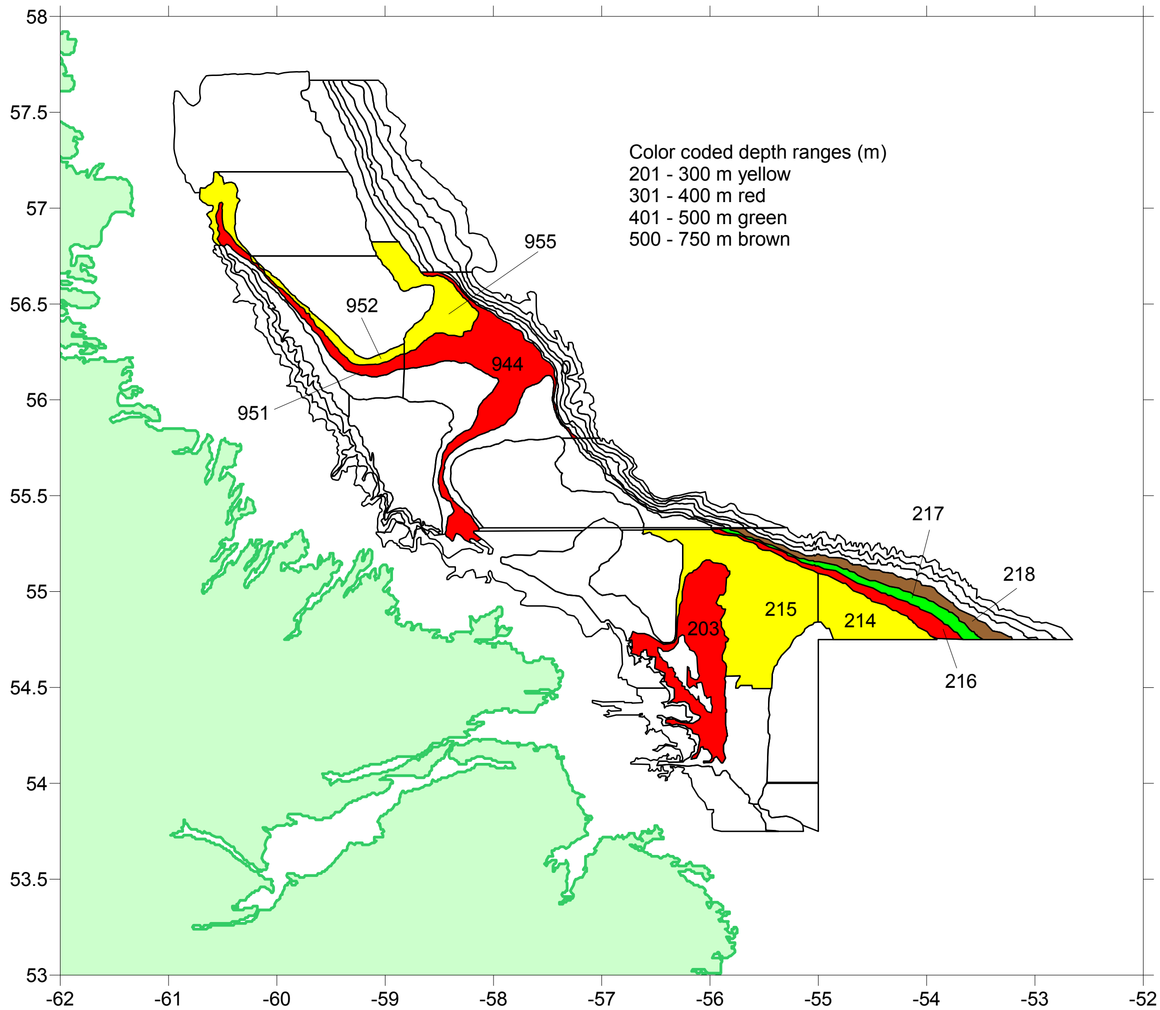


Figure 53. Index strata within SFA 5 that were consistently fished by the large vessel fleet, over the period 1994–2009. The numbers indicate the strata within Table 36.

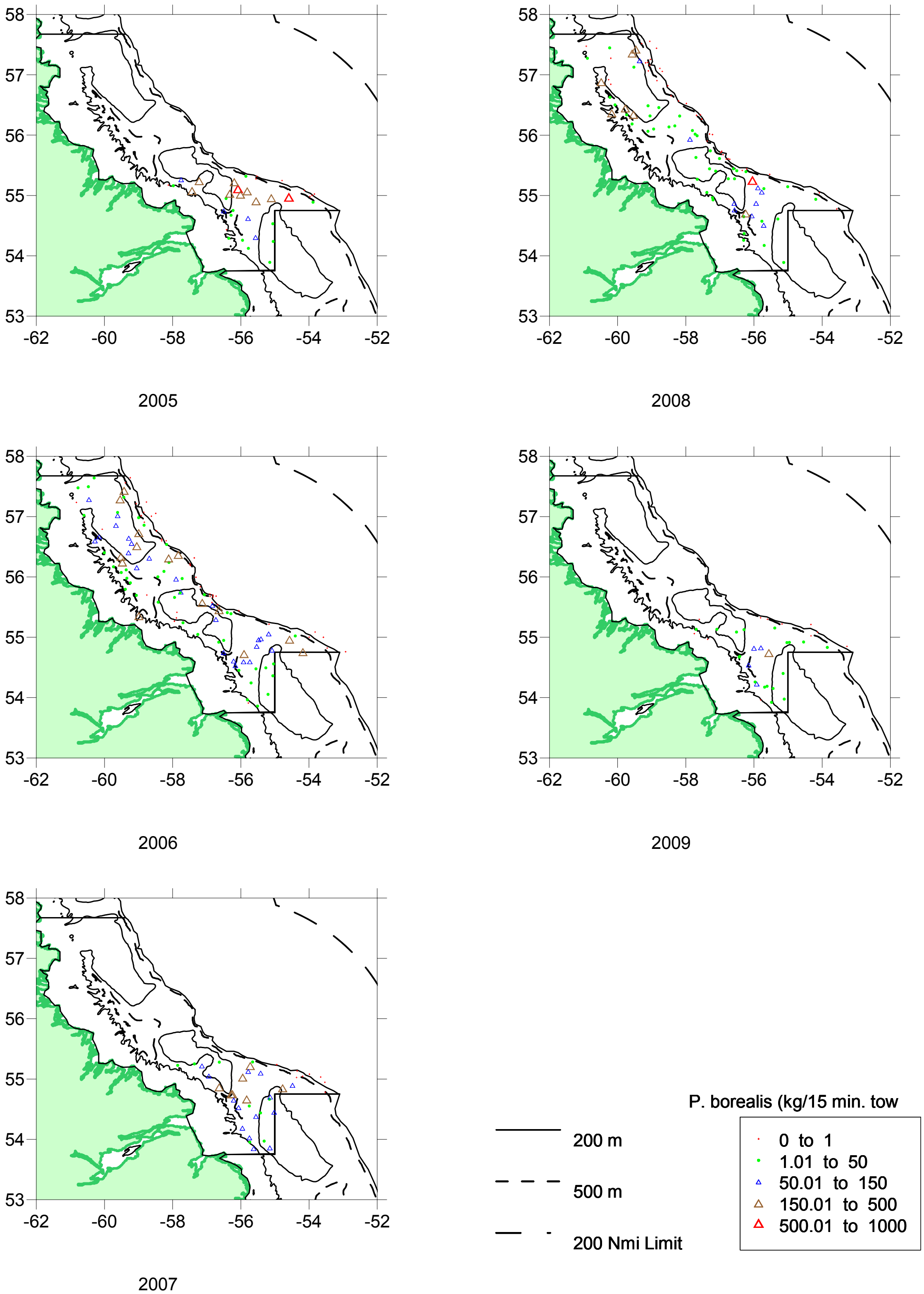
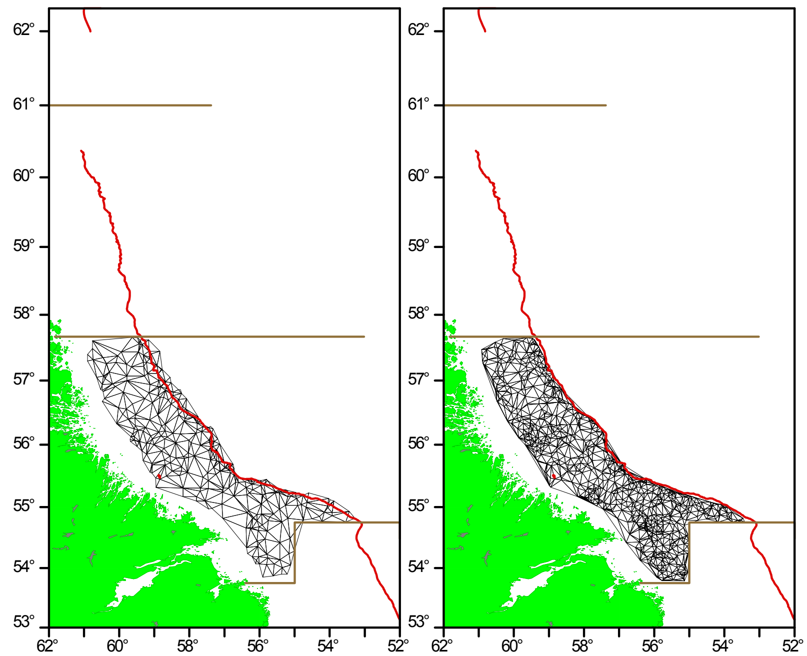
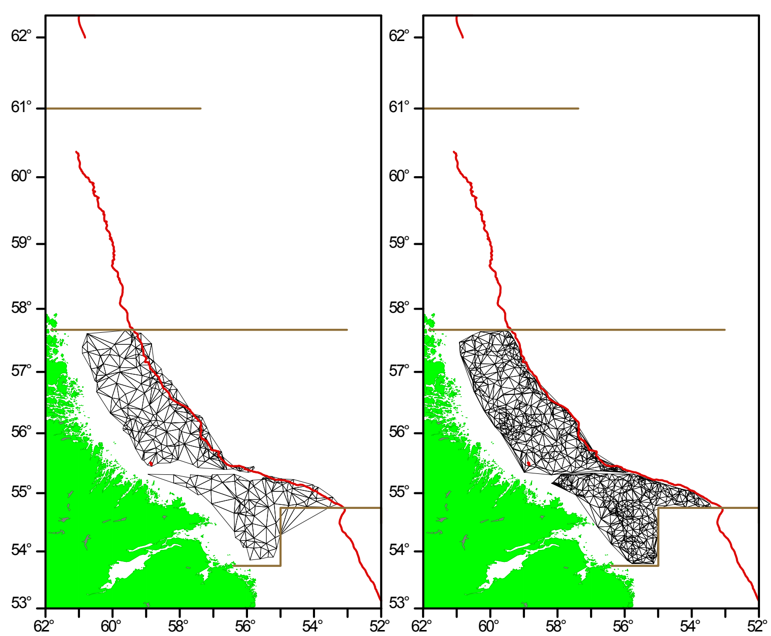


Figure 54. Distribution of Hopedale and Cartwright Channel (SFA 5) Northern Shrimp (Pandalus borealis) catches (kg/tow) as obtained from the autumn research bottom trawl surveys conducted over the period 2005–09.



A) *Old version of the SFA 5 triangulation*

B) *Proposed version of the SFA 5 triangulation*



C) *Old version of Hopedale + Cartwright Channel triangulations*

D) *Proposed version of the Hopedale + Cartwright triangulations*

Figure 55. Old and proposed versions of the SFA 5, Hopedale Channel and Cartwright Channel Delauney triangulations.

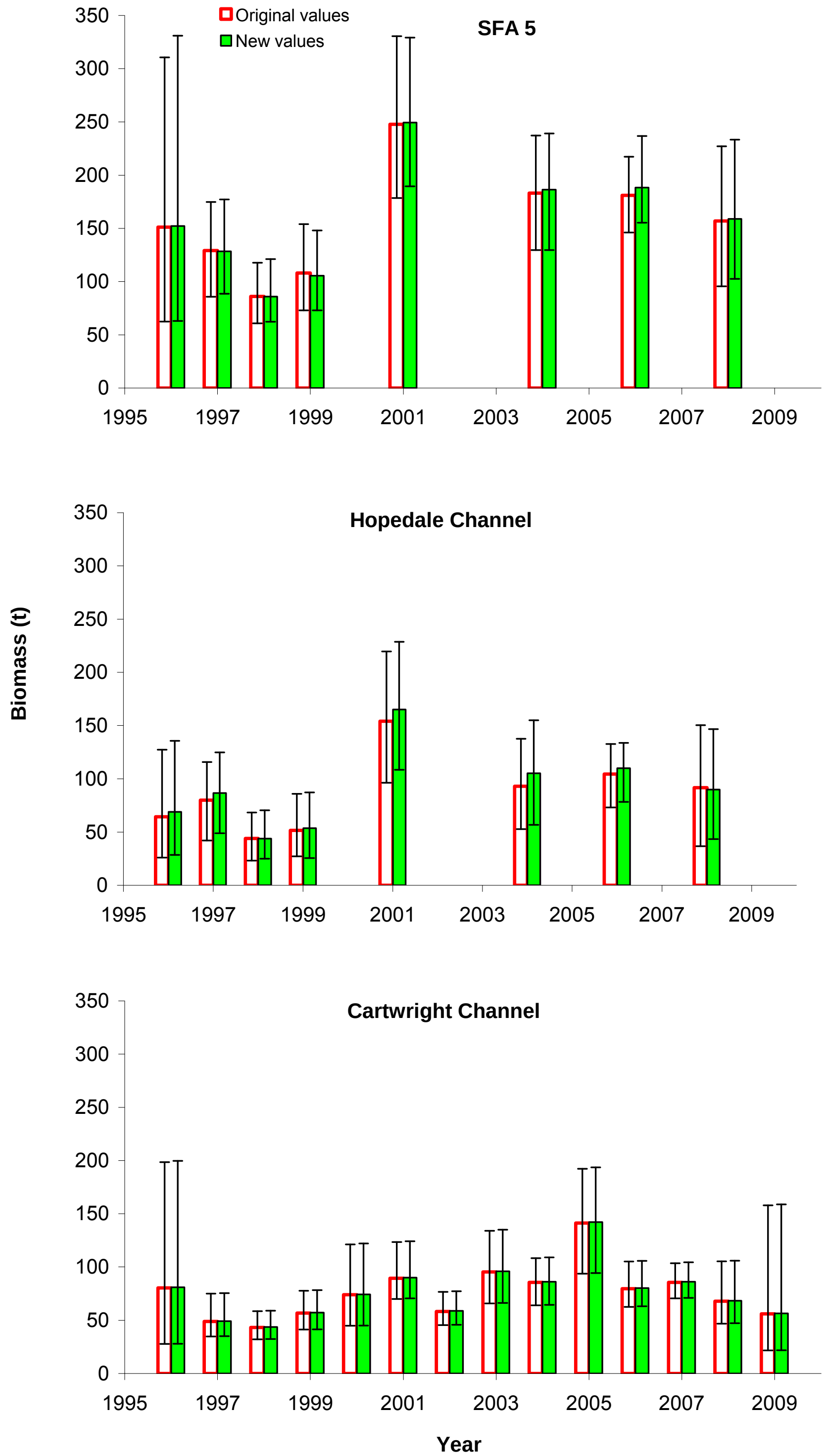


Figure 56. A comparison between the SFA 5 Northern Shrimp (*Pandalus borealis*) total biomass estimates using the old and new Delauney triangulation and parameter files used in Ogmap calculations. Data were obtained from annual Canadian multi species bottom trawl surveys using a Campelen 1800 shrimp trawl.

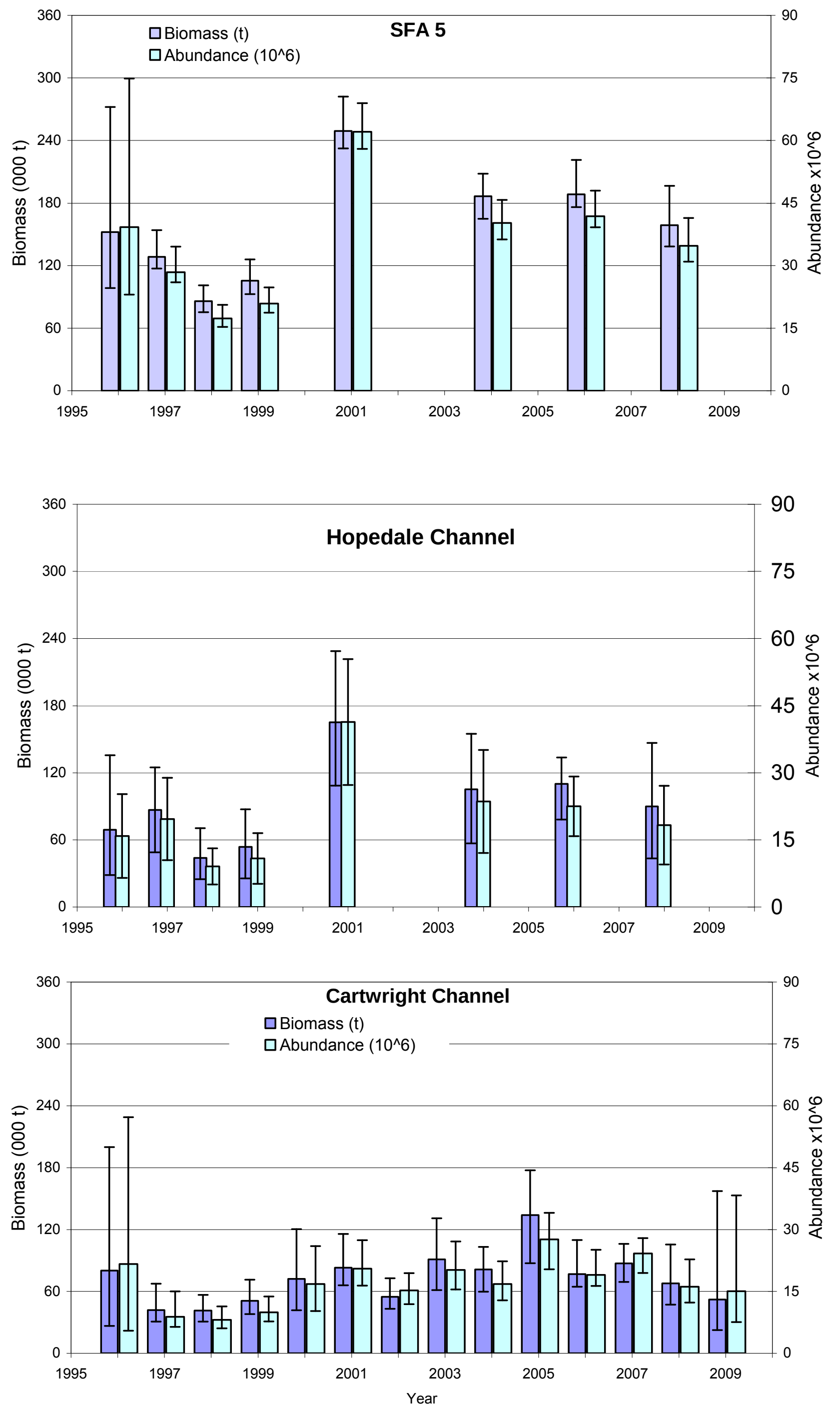


Figure 57. Autumn Northern Shrimp (*Pandalus borealis*) biomass and abundance indices within Hopedale + Cartwright Channels (SFA 5), as determined using OGive MAPped calculations. Data were from the annual Canadian multi species bottom trawl surveys using a Campelen 1800 shrimp trawl.

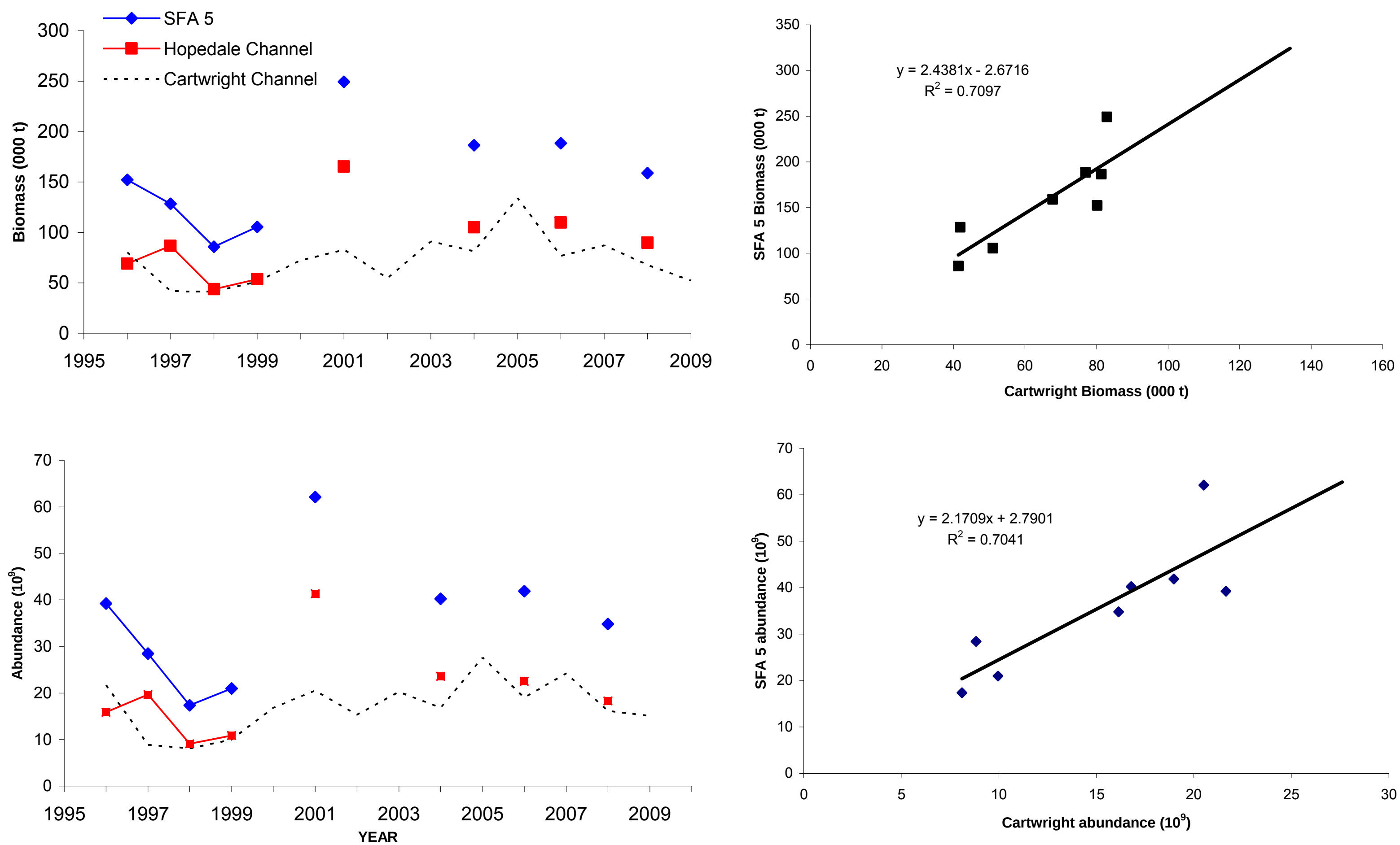


Figure 58. Preliminary relationships between Cartwright Channel abundance and biomass indices with the respective indices for the entire of SFA 5.

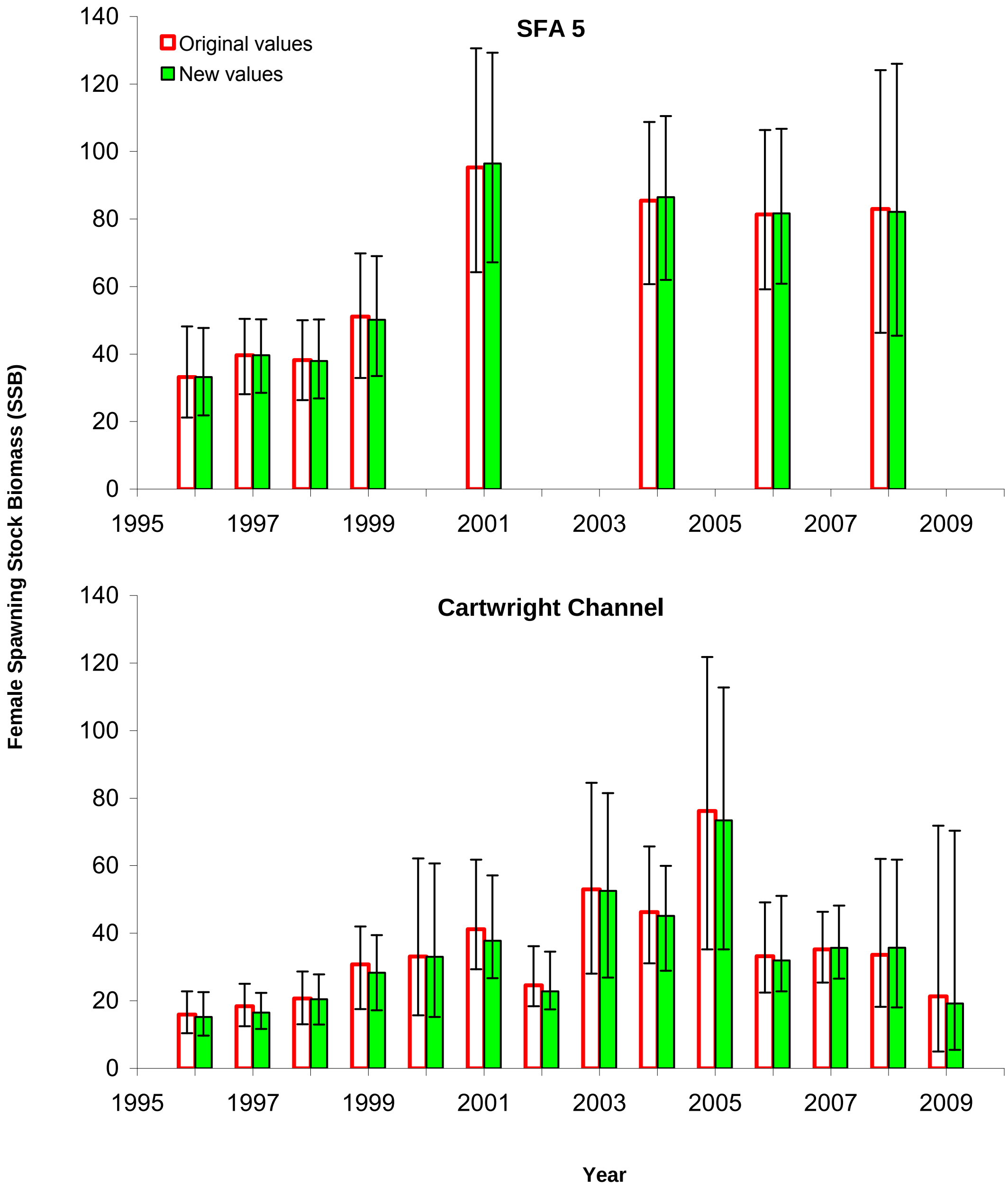


Figure 59. A comparison between SFA 5 Northern Shrimp female spawning stock biomass (SSB) estimates using the old and new Delauney triangulation and parameter files used in Ogmap calculations. Data were from the annual Canadian multi species bottom trawl surveys using the Campelen 1800 shrimp trawl.

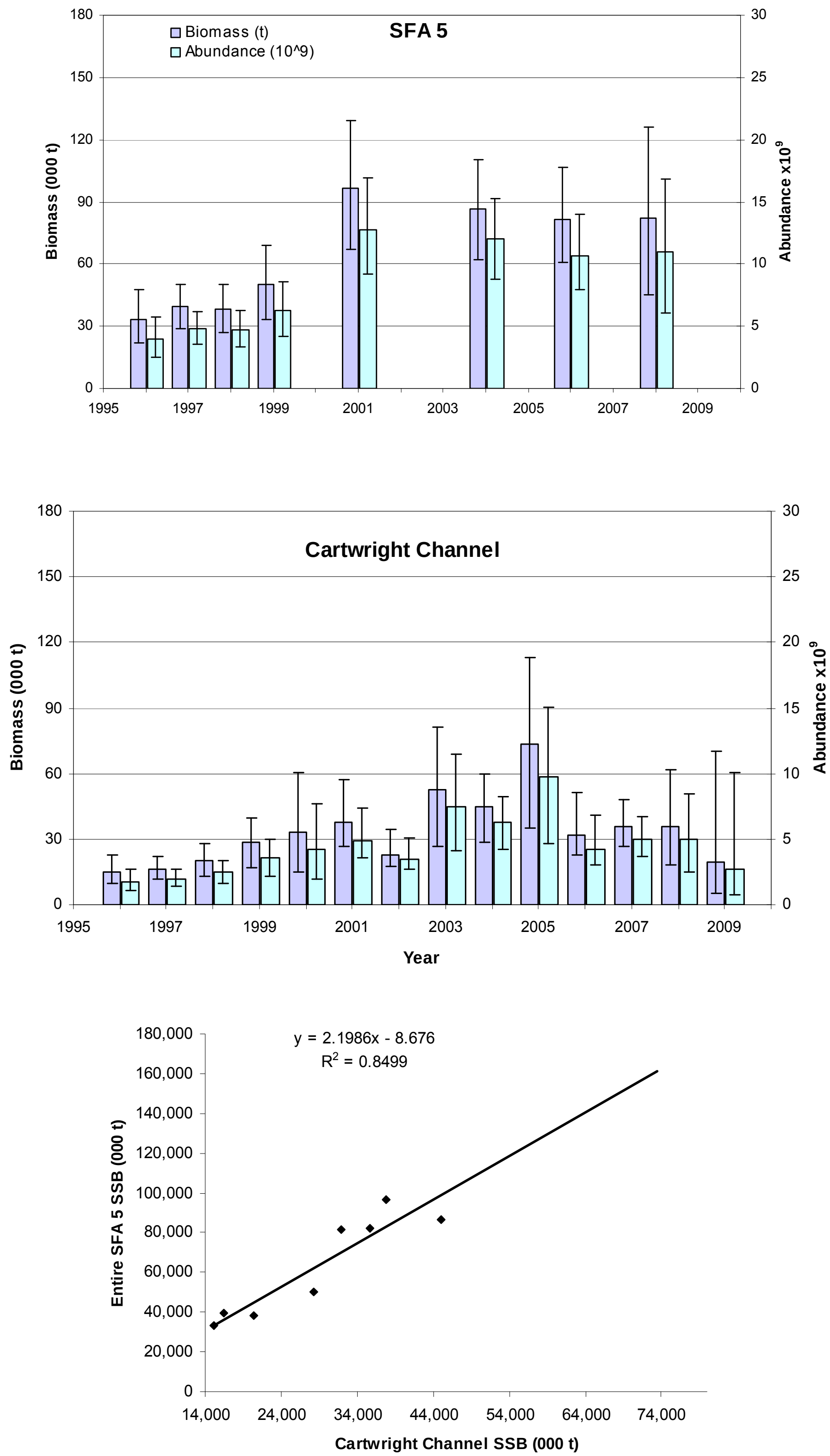


Figure 60. **Proposed** autumn Northern Shrimp (*Pandalus borealis*) female spawning stock biomass (SSB) and abundance indices within Hopedale and Cartwright Channels (SFA 5), as determined using <u>OG</u>ive <u>MAP</u>ped calculations.

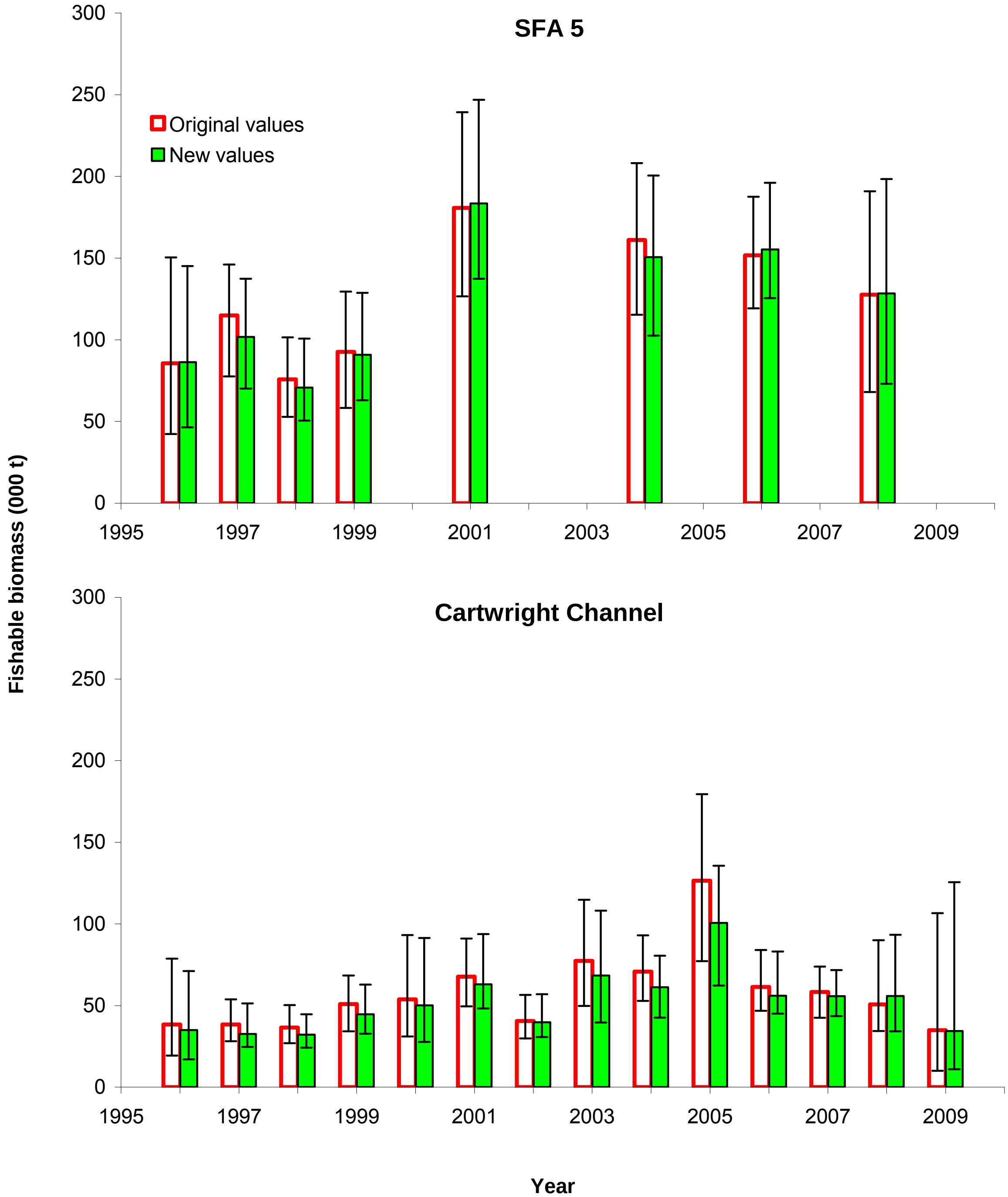


Figure 61. A comparison between SFA 5 Northern Shrimp fishable biomass estimates using the old and new definitions of fishable biomass, Delauney triangulation and parameter files used in Ogmap calculations. Data were from the annual Canadian multi species bottom trawl surveys using the Campelen 1800 shrimp trawl.

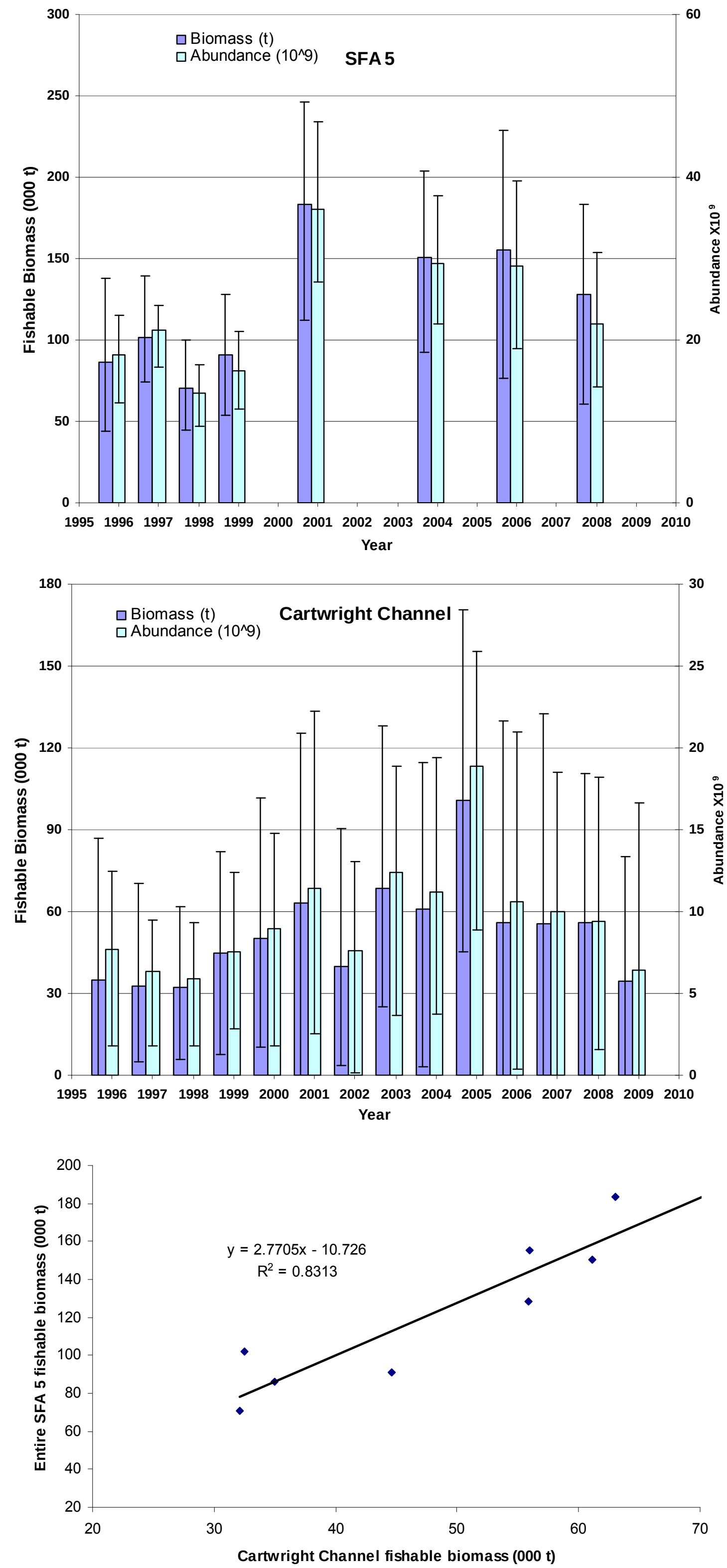


Figure 62. **Proposed** autumn Northern Shrimp (*Pandalus borealis*) fishable biomass and abundance indices within Hopedale and Cartwright Channels (SFA 5), as determined using OGive MAPped calculations.

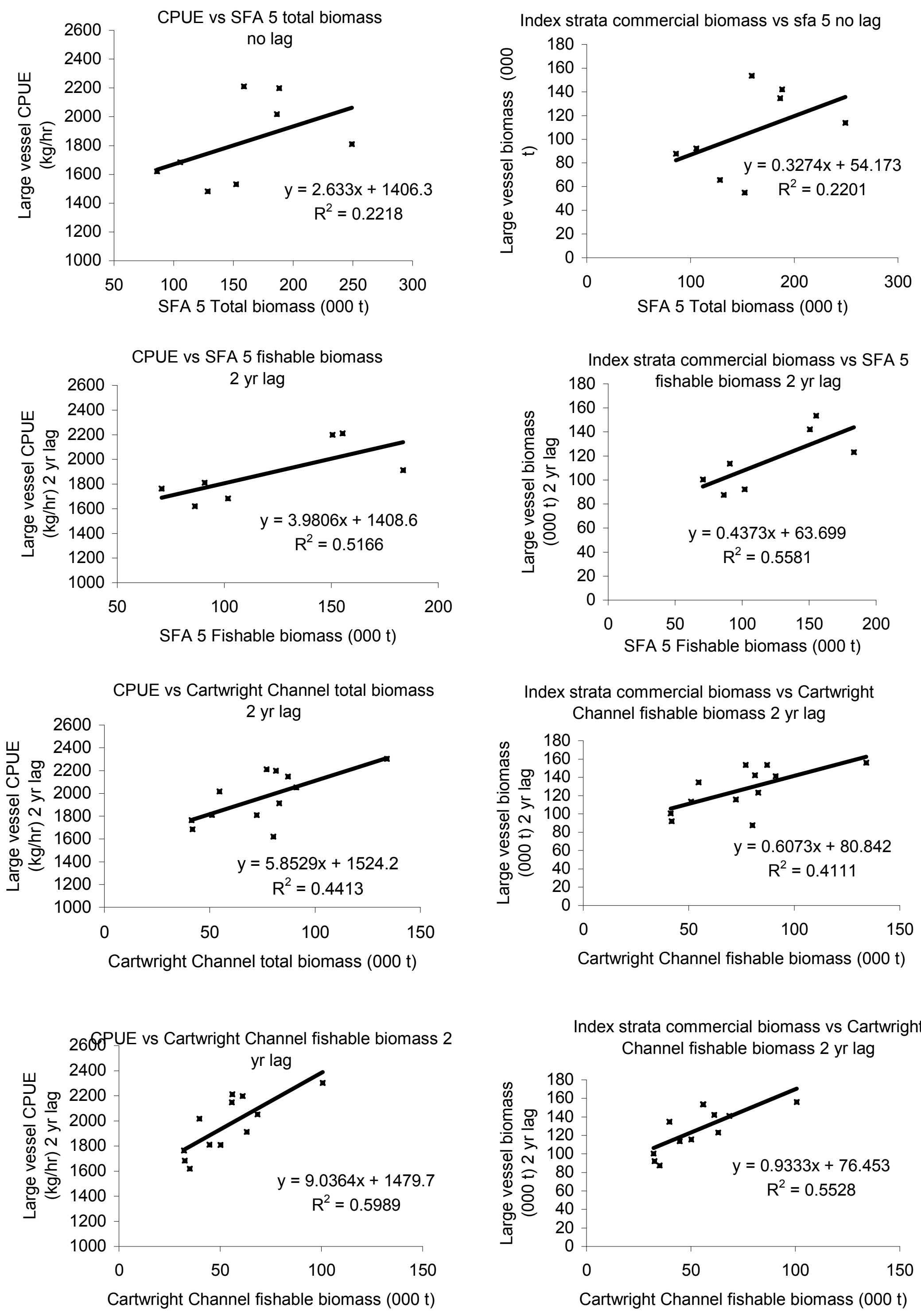


Figure 63. Relationships between large vessel CPUE and index strata commercial biomass indices versus survey total and fishable biomass, within SFA 5 and Cartwright Channel. Various lags were attempted and only the relationships with the highest r^2 are presented here.

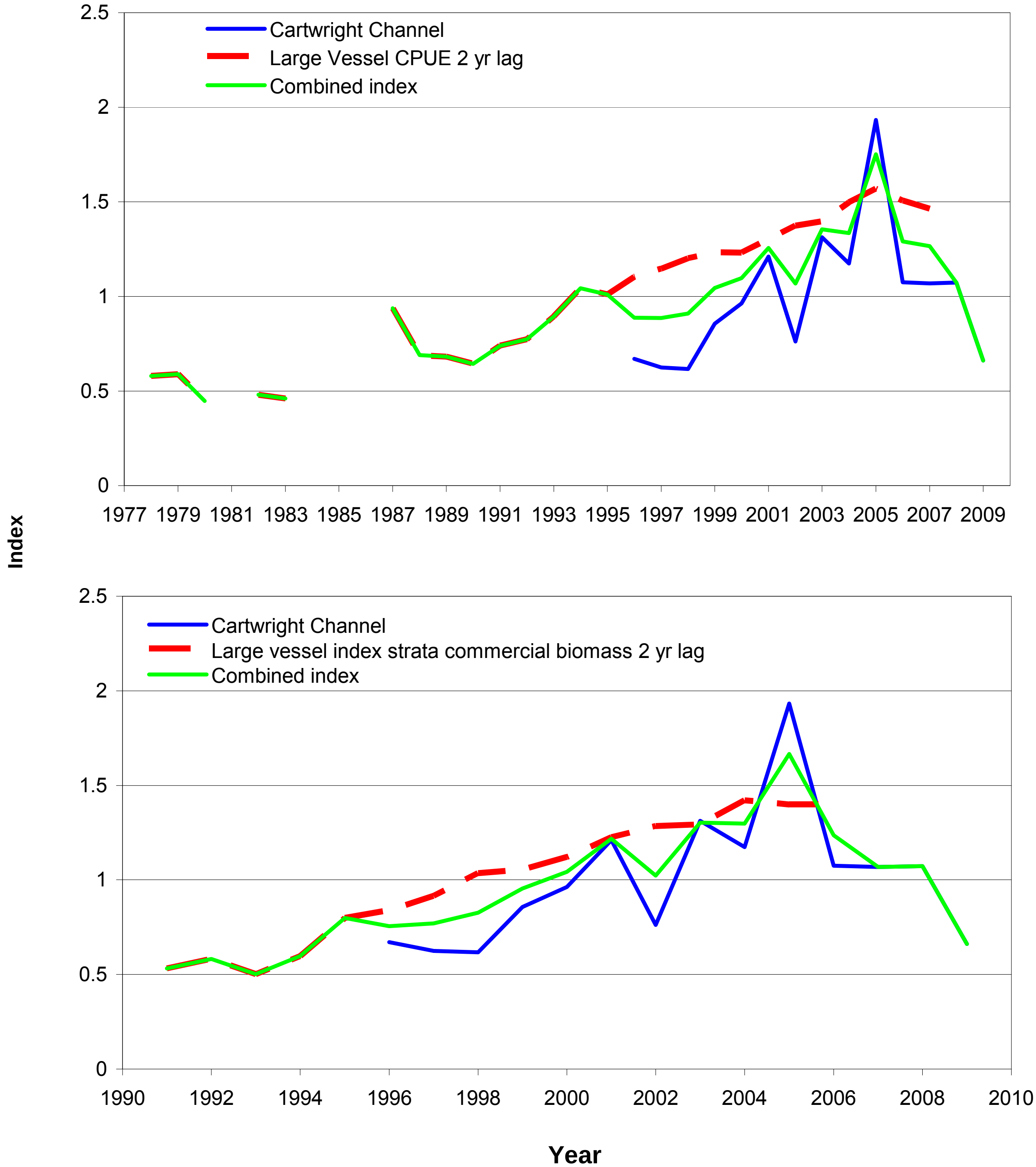


Figure 64. **Proposed combined indices** of biomass for SFA 5. One index is an average of survey fishable biomass and large vessel CPUE lagged by two years while the other is an average of survey fishable biomass and largevessel index strata biomass also lagged by two years. In each case, the input indices were standardized by dividing each index by its long term mean.

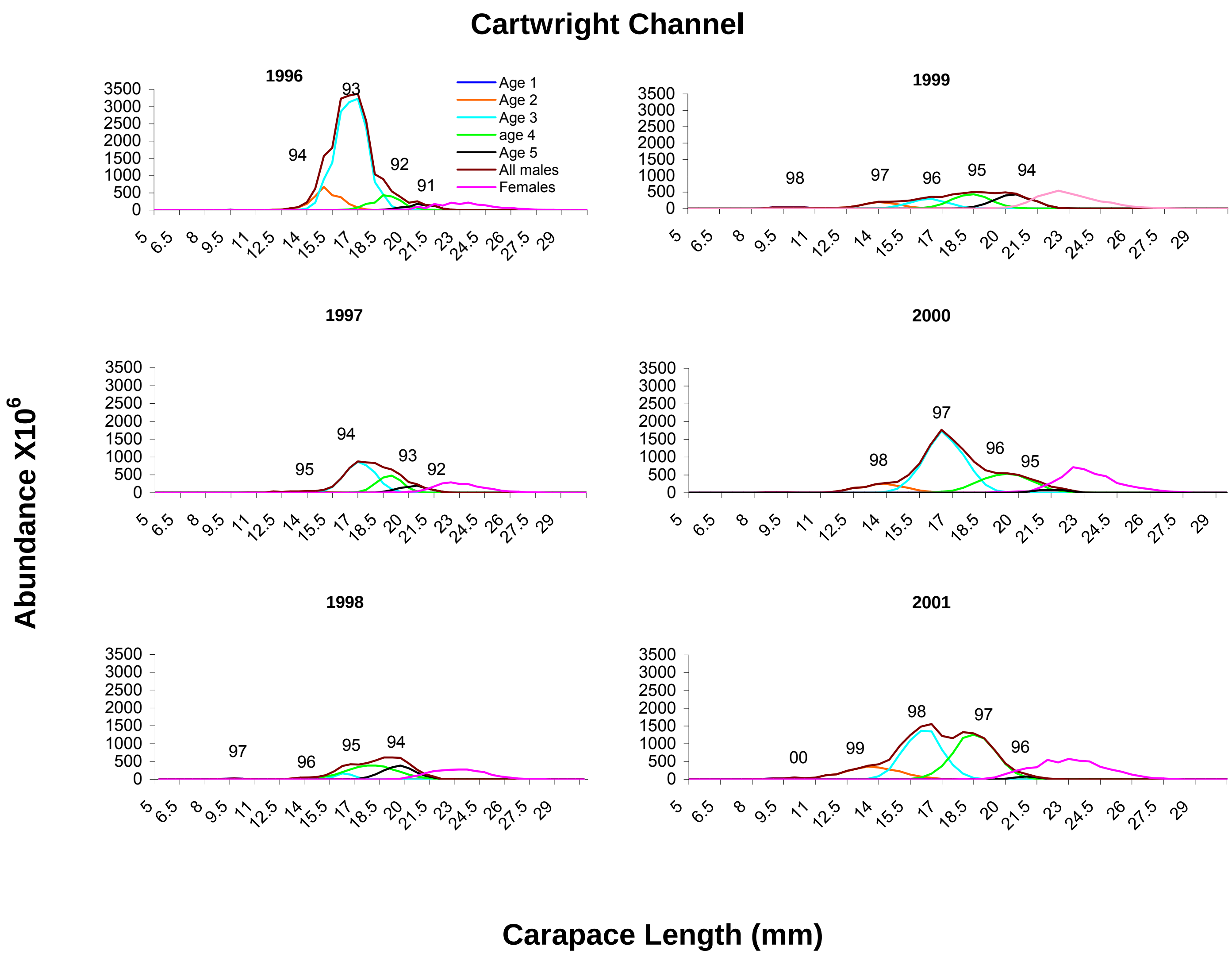


Figure 65. Abundance at length for Cartwright Channel Northern Shrimp (*Pandalus borealis*) estimated from OGive MAPped calculations of autumn multi species bottom trawl survey data, 1996–2009.

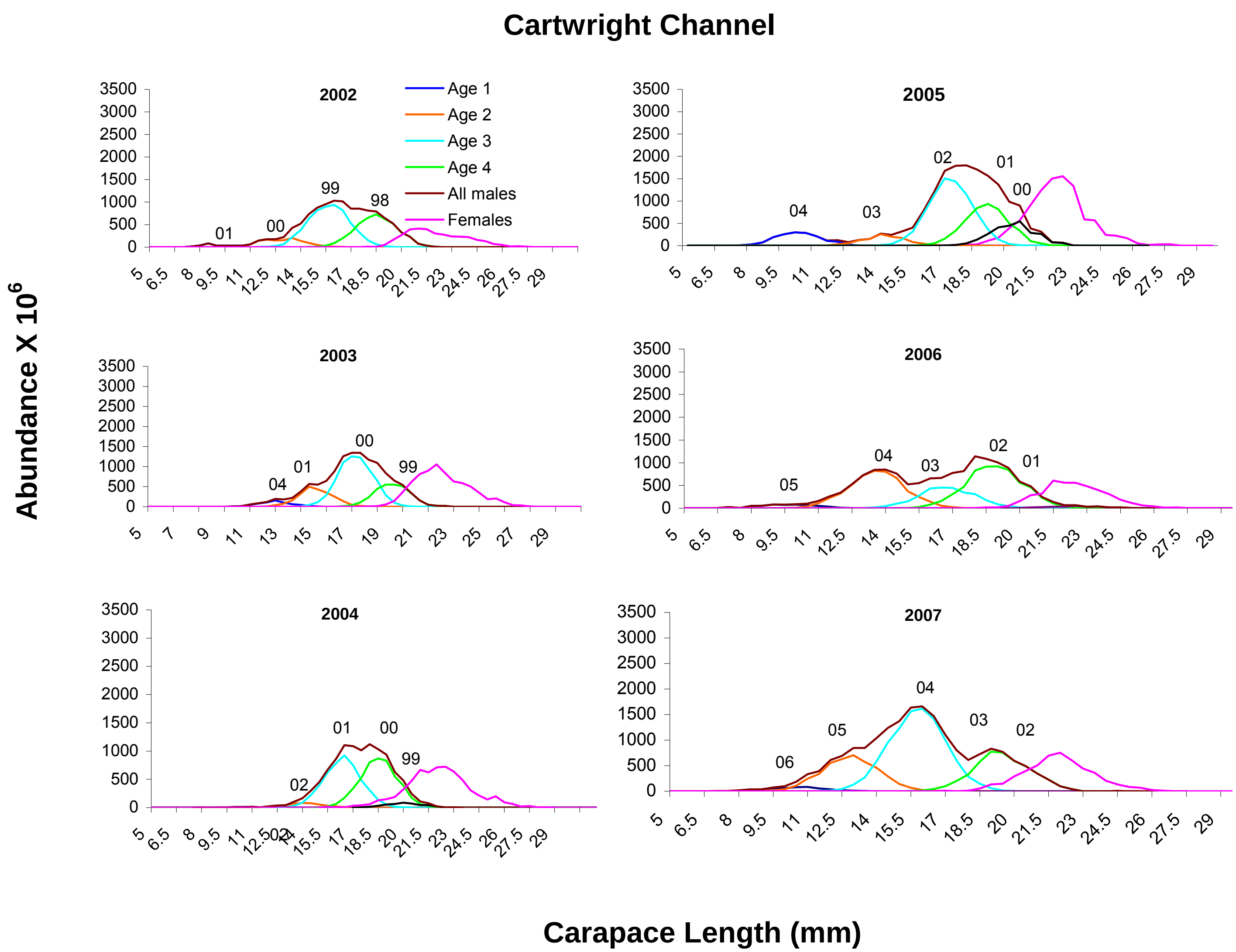


Figure 65. (Cont'd)

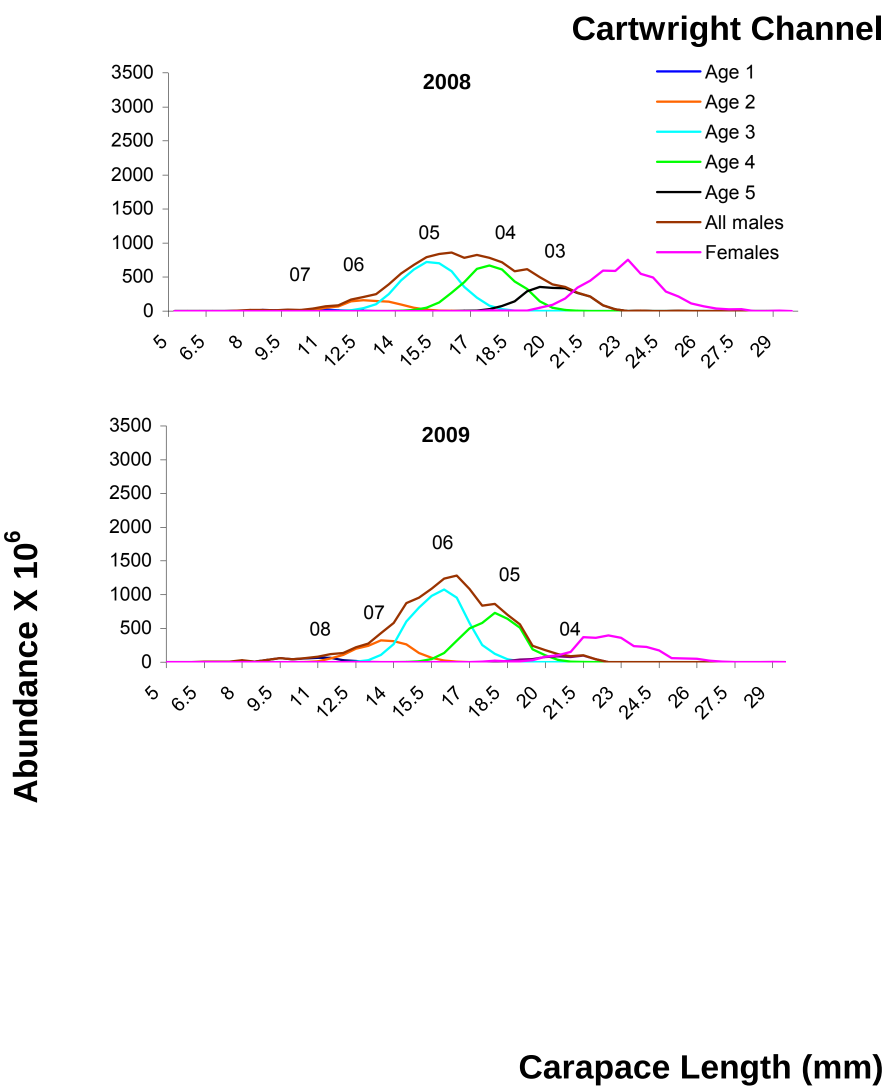


Figure 65. (Cont'd)

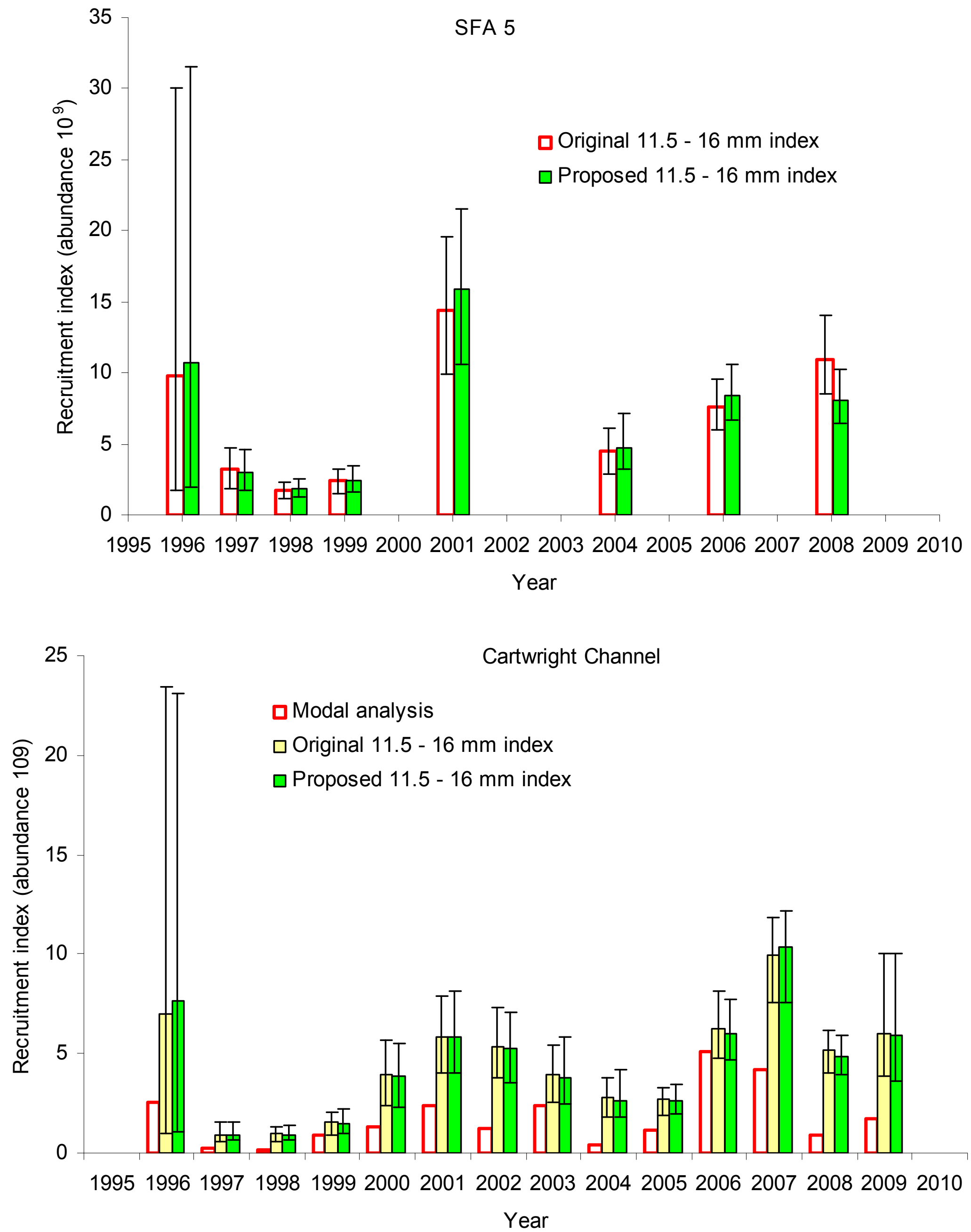
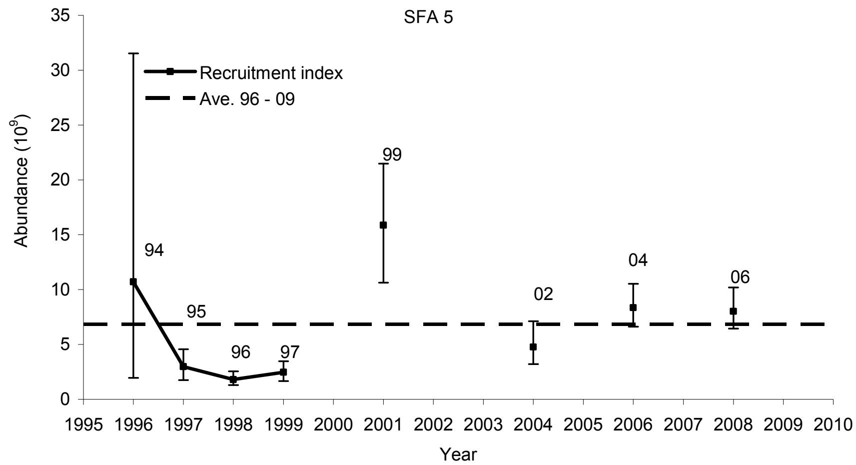
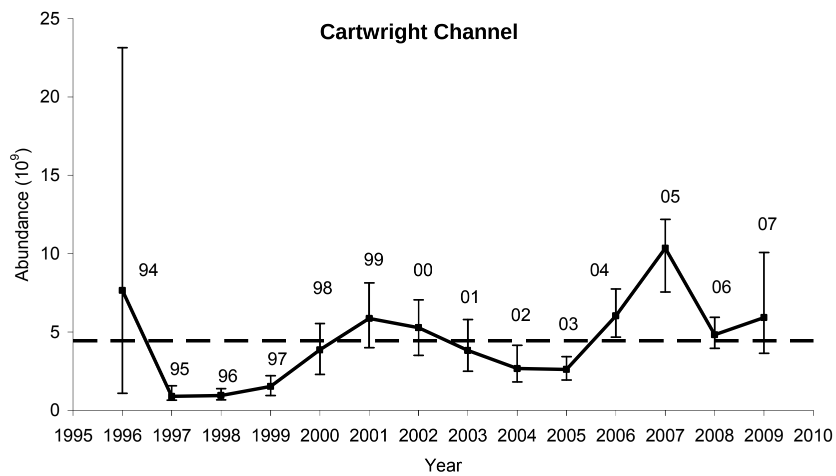


Figure 66. SFA 5 and Cartwright Channel (SFA 6) Northern shrimp recruitment indices using the abundances of age 2 males from modal analysis, the original definition (abundance of all males and unidentified Pandalus 11.5–16 mm carapace lf), Delauney triangulation and parameter files compared with the new estimates using the new definitions (abundances of all males + females with 11.5–16 mm carapace lf) and Delauney triangulation and parameter files used in Ogmap calculations. These estimates were calculated from 1996-2009 Canadian autumn multi species bottom trawl research surveys (standard tows = 15 min at 3.0 Nmi/hr).





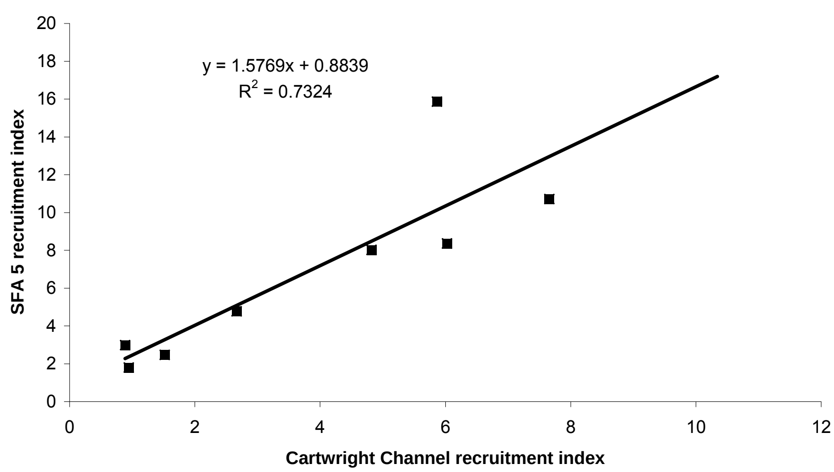


Figure 67. **Proposed** recruitment indices (abundances of all males + females with 11.5–16 mm carapace lf) within SFA 5 and Cartwright Channel as well as regression analysis showing the relationship between the indices within SFA 5 and Cartwright Channel.

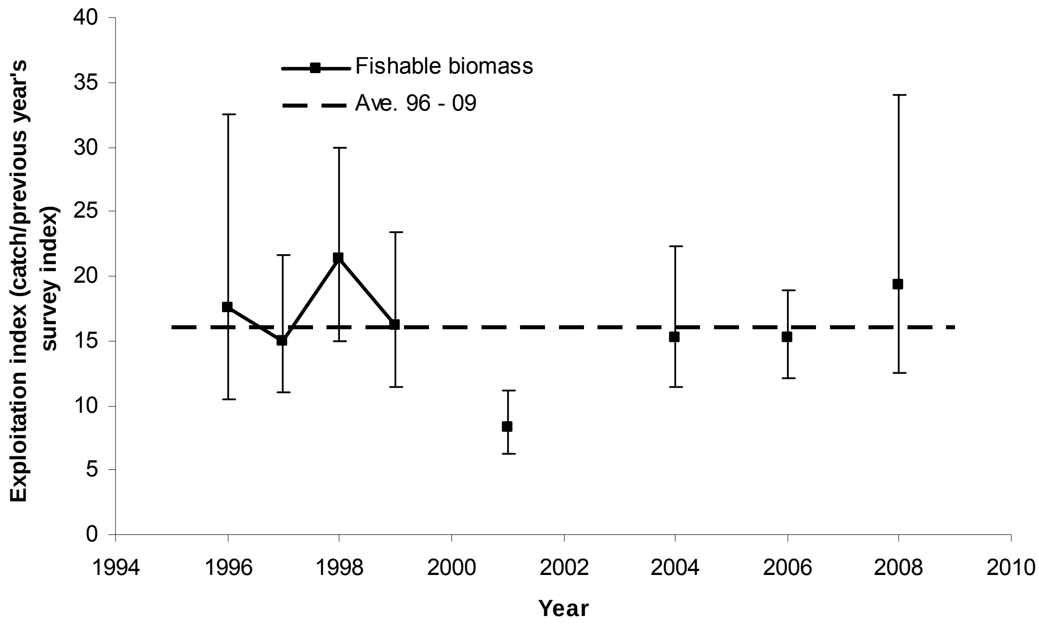


Figure 68. SFA 5 exploitation rate indices over the period 1996–2009 (total catch/ fishable biomass index from the previous year; error bars indicate 95% confidence intervals).

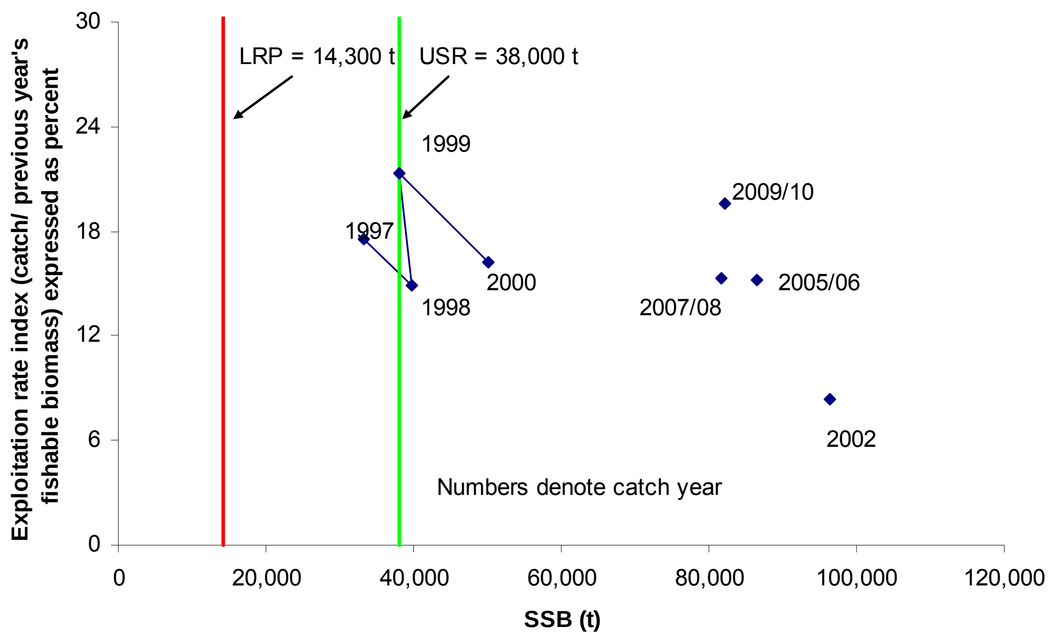


Figure 69. SFA 5 precautionary approach using an Upper Stock Reference (USR = 80% of the geometric mean of SSB over a productive period (1996–2001)) and a Lower Reference Point (LRP = 30% of the geometric mean of SSB over a productive period (1996–2001)) superimposed with the exploitation rate trajectory over time.

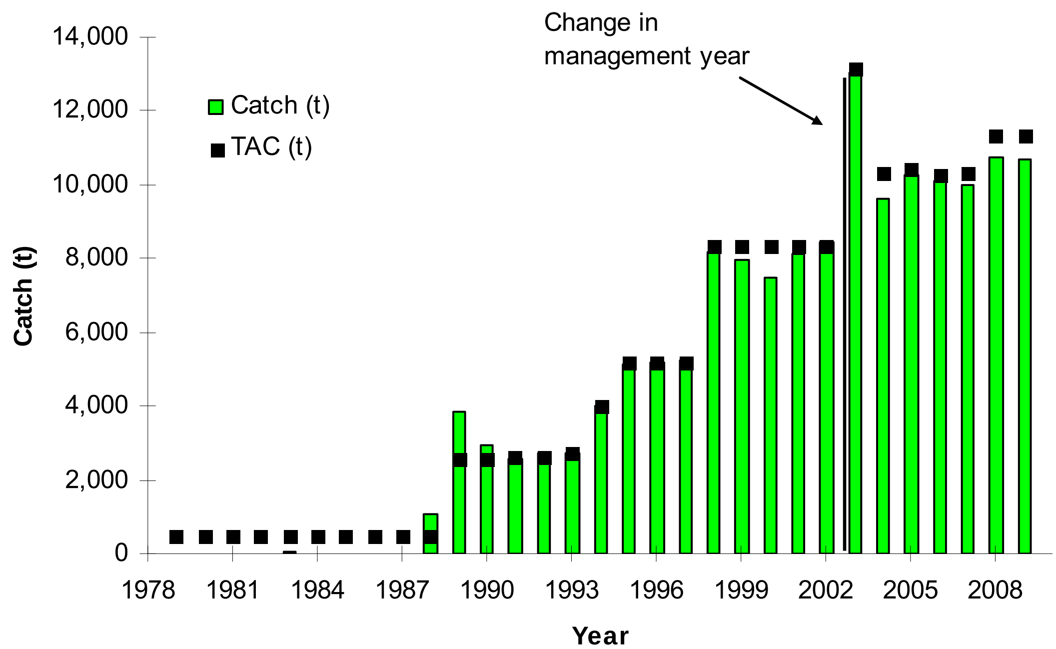


Figure 70. Historic northern shrimp catches (SFA 4) and TAC's for the period 1978–2009. In 2003, the management year changed from Jan. 1 Dec. 31 to Apr. 1–Mar. 31.

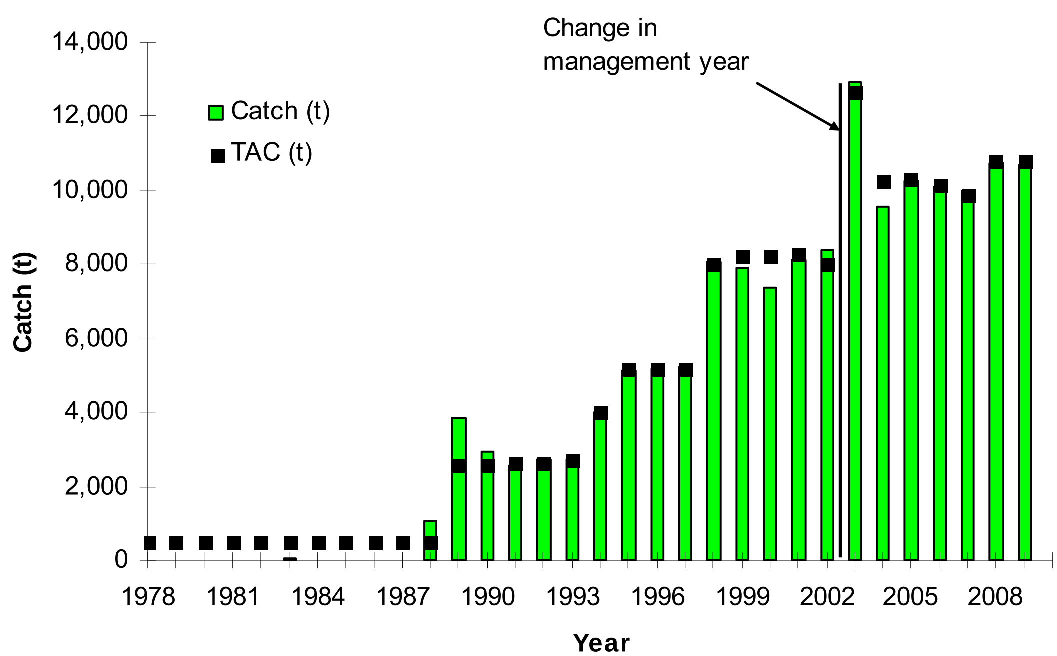


Figure 71. Historic large vessel northern shrimp catches (SFA 4) and TAC's for the period 1978–2009. In 2003, the management year changed from Jan. 1–Dec. 31 to Apr. 1–Mar. 31.

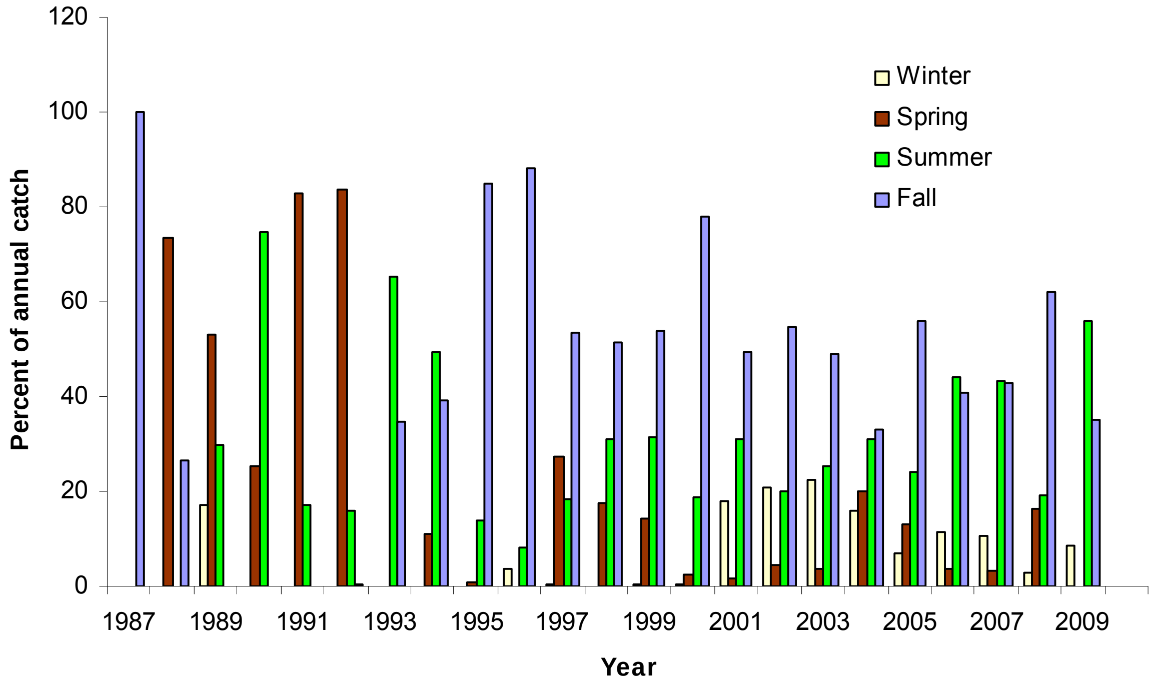


Figure 72. Seasonality of the large vessel (>500 t) shrimp fishery within SFA 4 as determined by percent of annual catch by season.

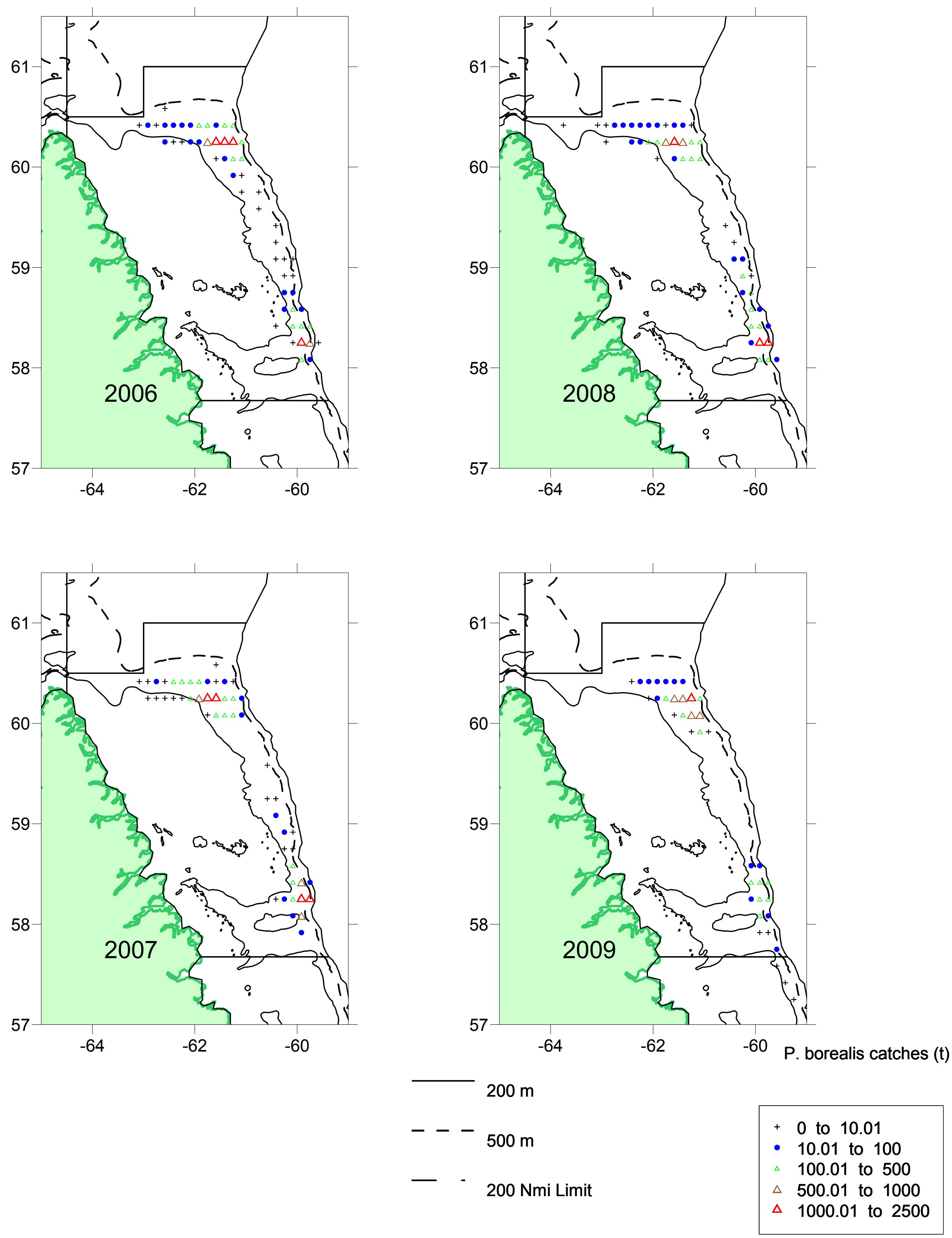


Figure 73.Distribution of large vessel (>500 t) shrimp catches in NAFO Division 2G (SFA 4). (Observer data aggregated into 10 min X 10 min cells).

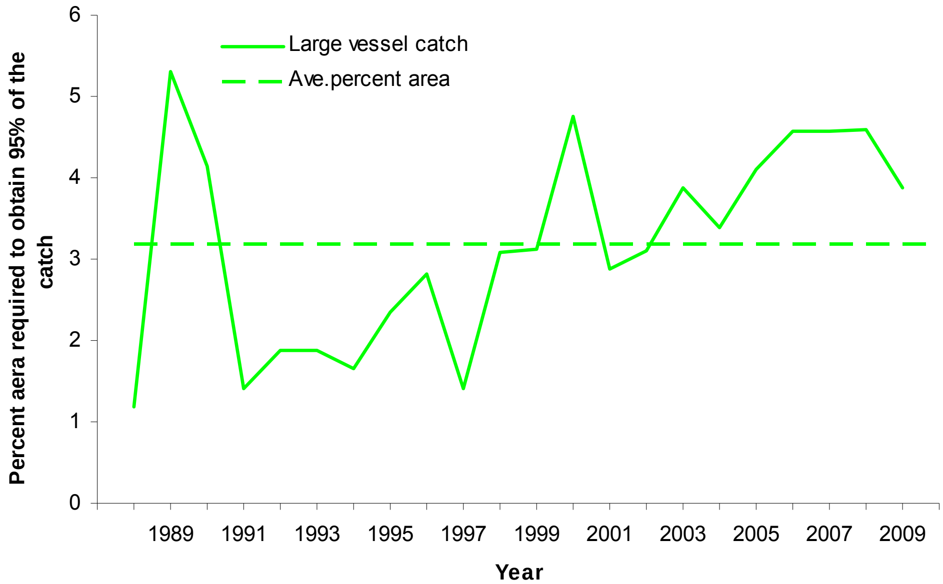
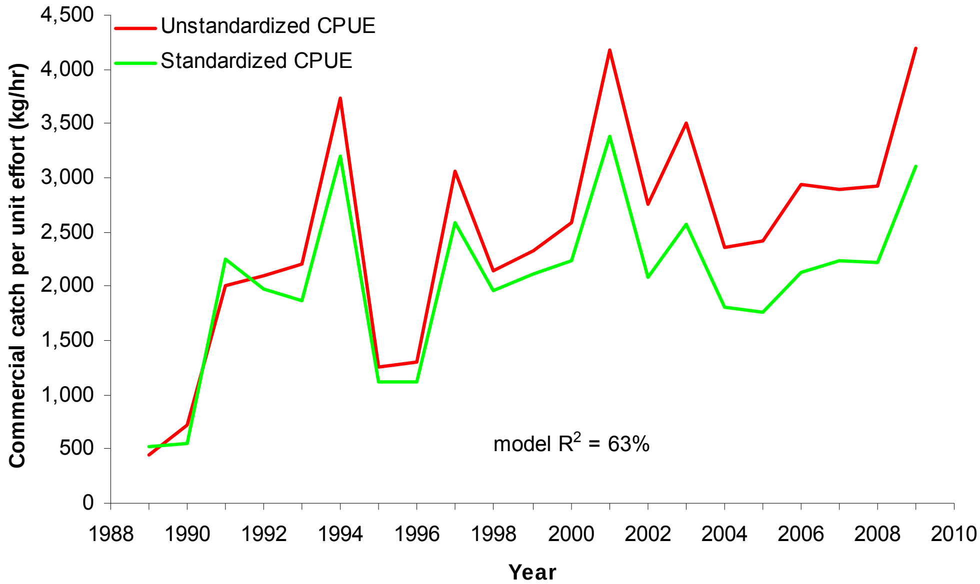
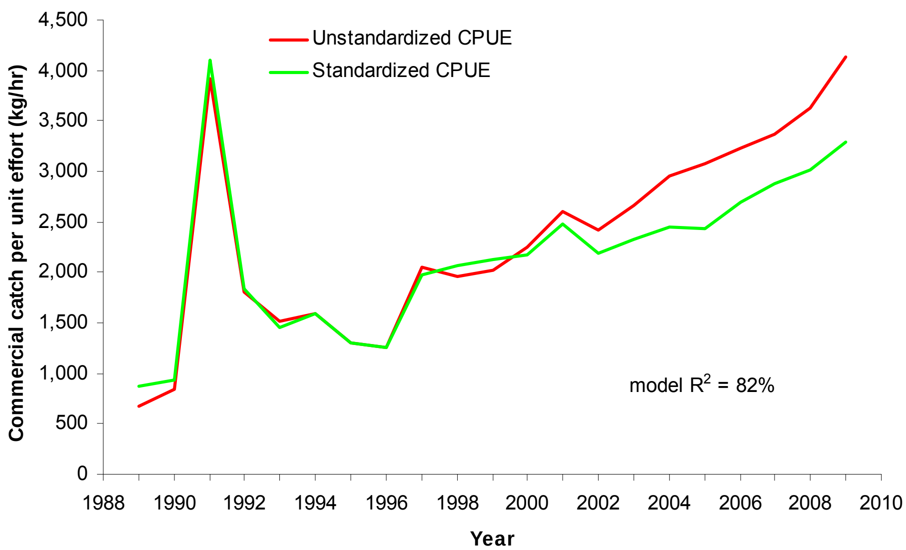


Figure 74. The percent total area within SFA 4 necessary to obtain 95% of the large vessel shrimp fishery catch, 1988–2009.



***A) Original** model formulation.*



***B) Proposed** model formulation.*

Figure 75. A comparison of large vessel SFA 4 commercial catch rates (kg/hr) developed using the original model formulation (Observer data; single trawl no window data only, history>3 yrs; all months; all areas, year, month and vessel model) and the proposed model formulation (Observer data; single and double trawl no window data; history > 3yrs; July–December data; year, month, vessel model).

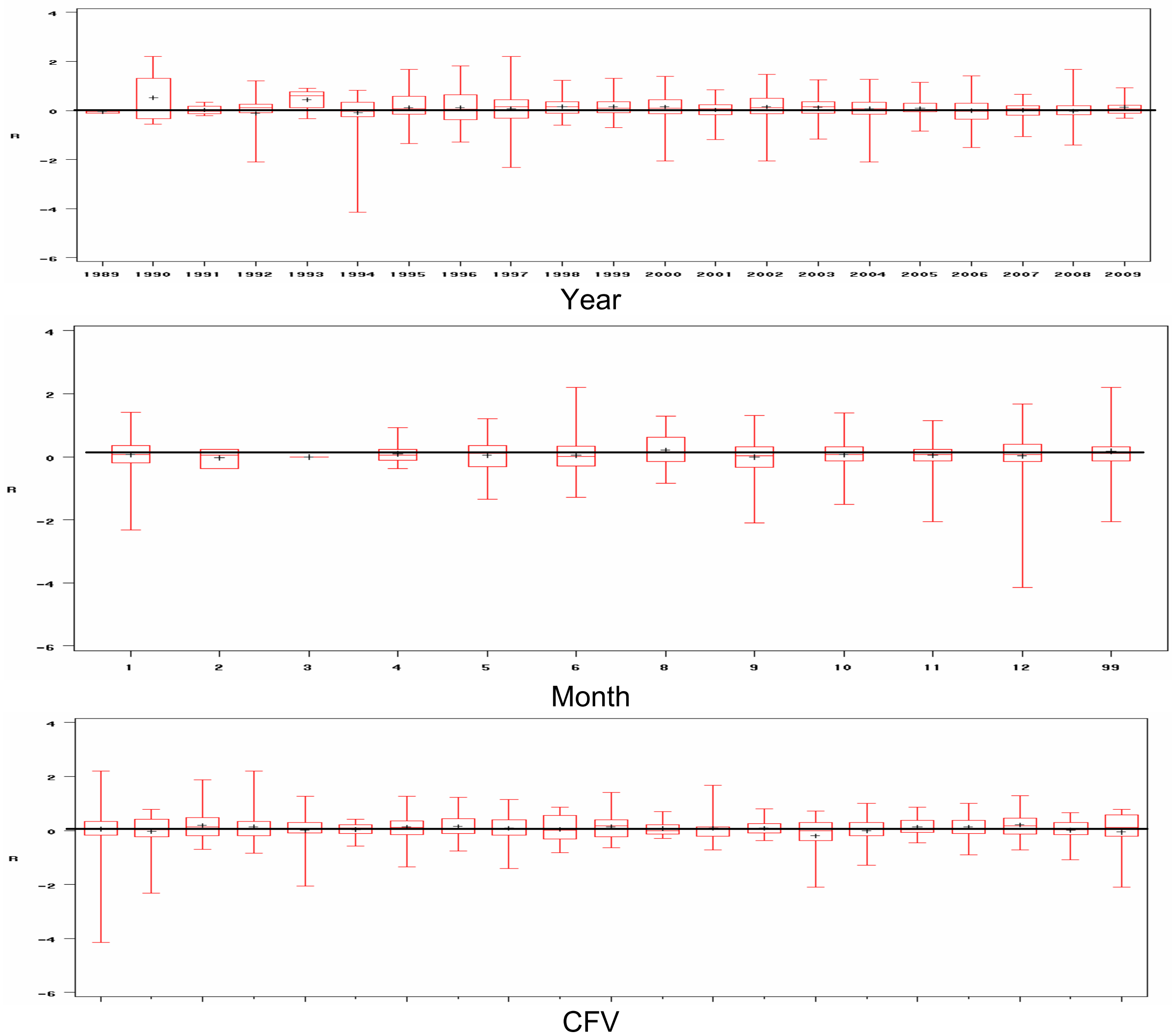


Figure 76. The distribution of residuals around estimated values for parameters used in the original large vessel (>500 t) shrimp catch rate model for NAFO Div. 2G (SFA 4), 1989–2009.

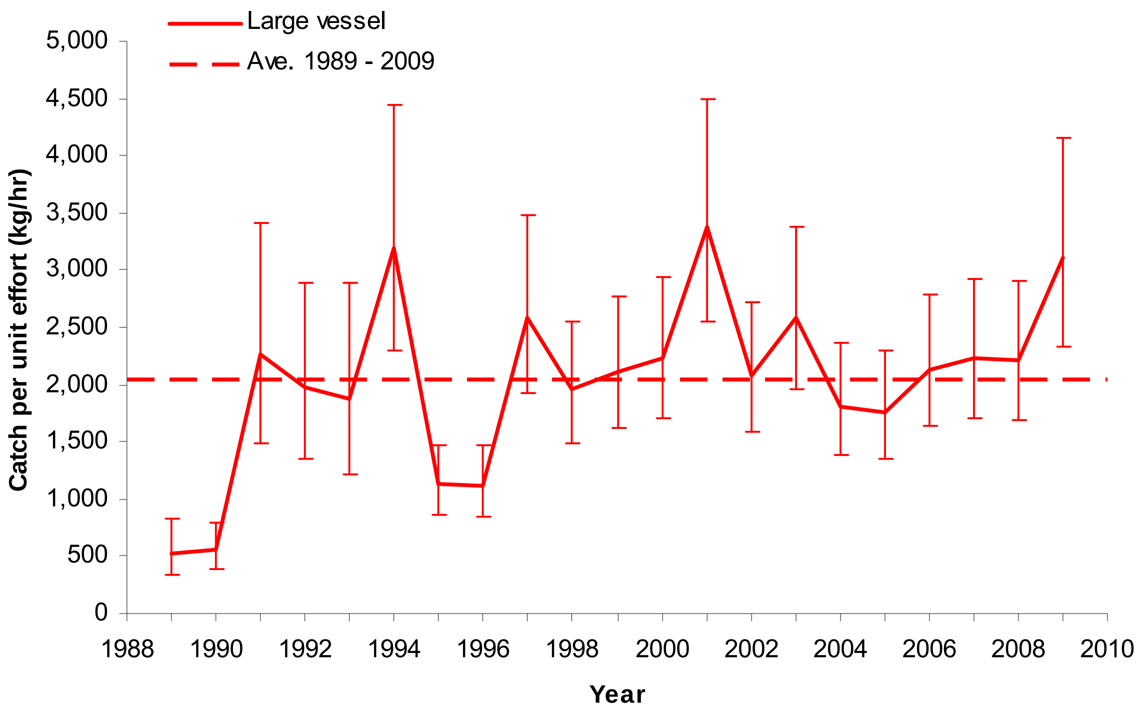


Figure 77.Original SFA 4 large vessel standardized CPUE (error bars indicated 95% confidence intervals).

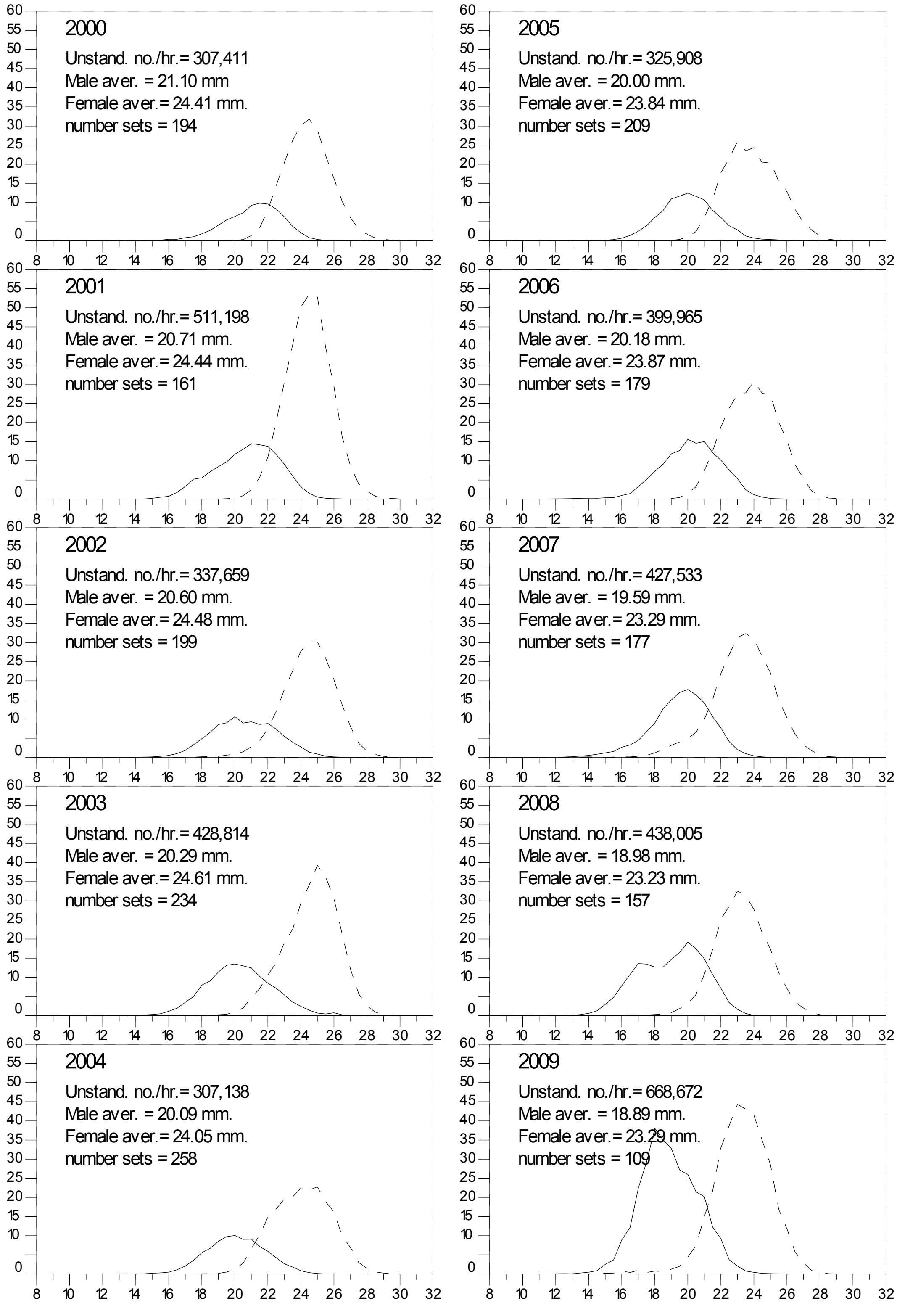


Figure 78. Observed northern shrimp length frequencies (000's per hour) from the Canadian large vessel (>500 t) fleet fishing in NAFO Division 2G (SFA 4) over the period 2000–09. (Solid lines = males; dotted lines = females).

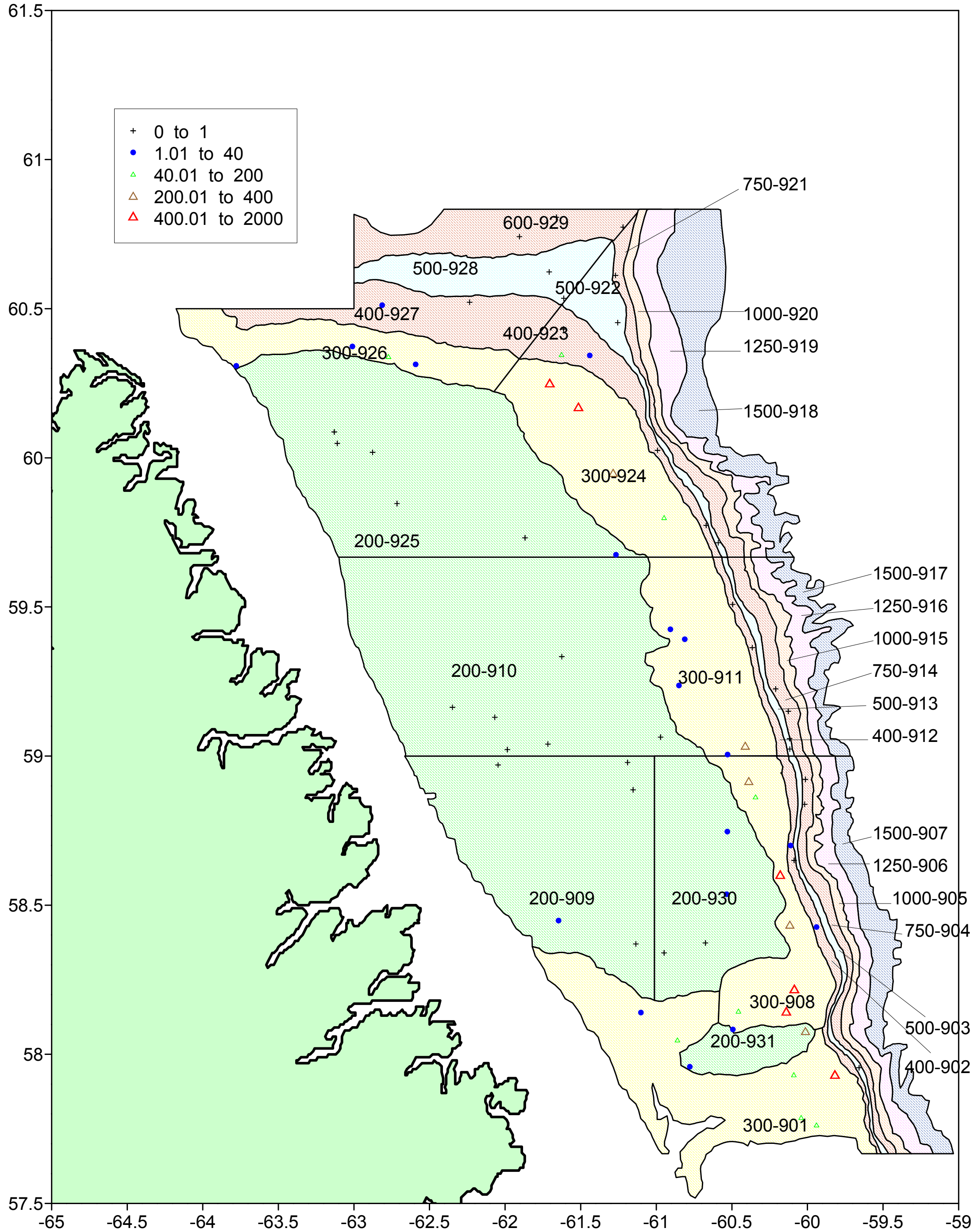


Figure 79. Distribution of NAFO Division 2G (SFA 4) northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from the July 2007 Northern Shrimp Research Foundation–DFO joint northern shrimp bottom trawl survey. Tows were 15 minutes in duration and made use of a Campelen 1800 shrimp trawl.

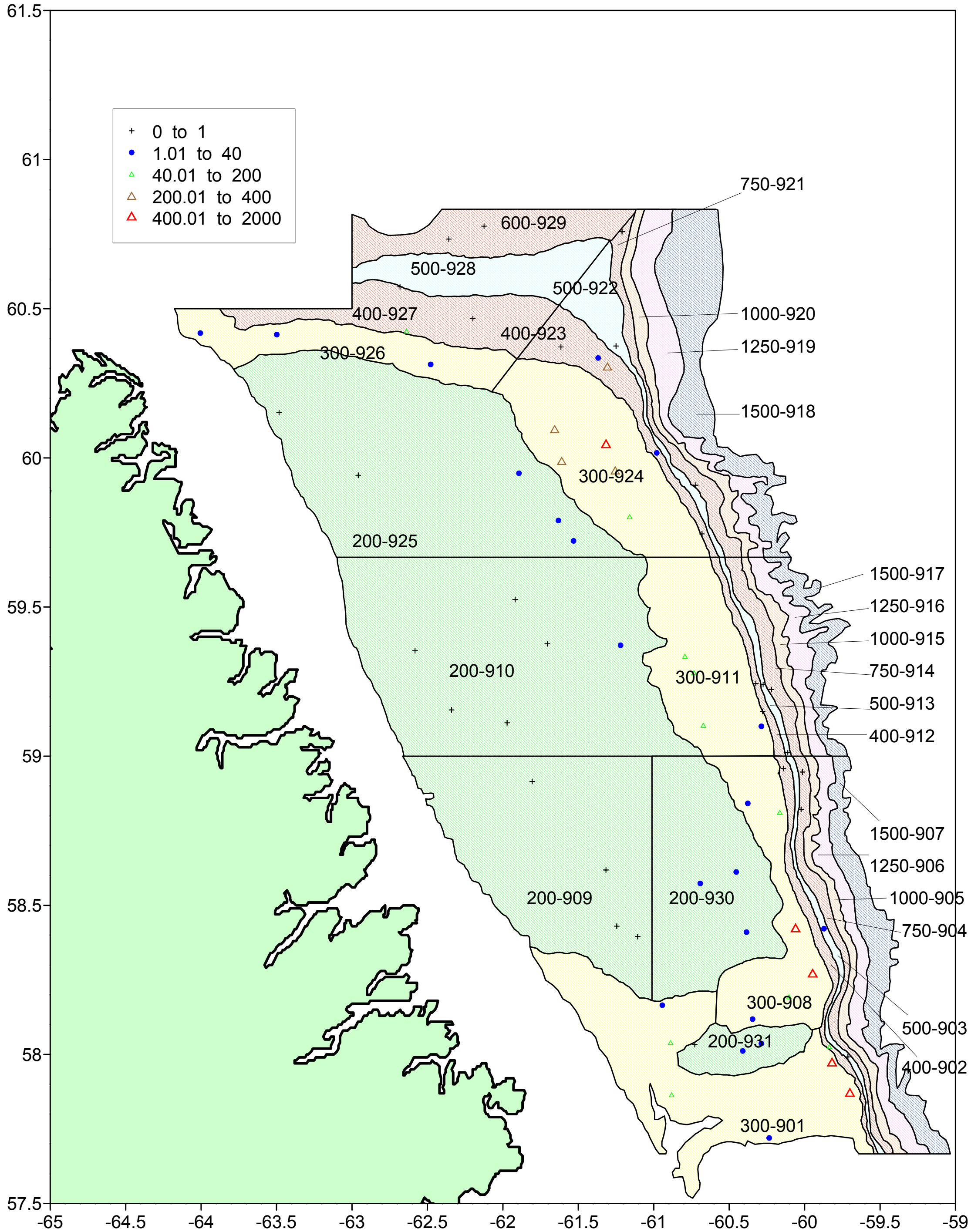


Figure 80. Distribution of NAFO Division 2G (SFA 4) northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from the July 2008 Northern Shrimp Research Foundation–DFO joint northern shrimp bottom trawl survey. Tows were 15 minutes in duration and made use of a Campelen 1800 shrimp trawl.

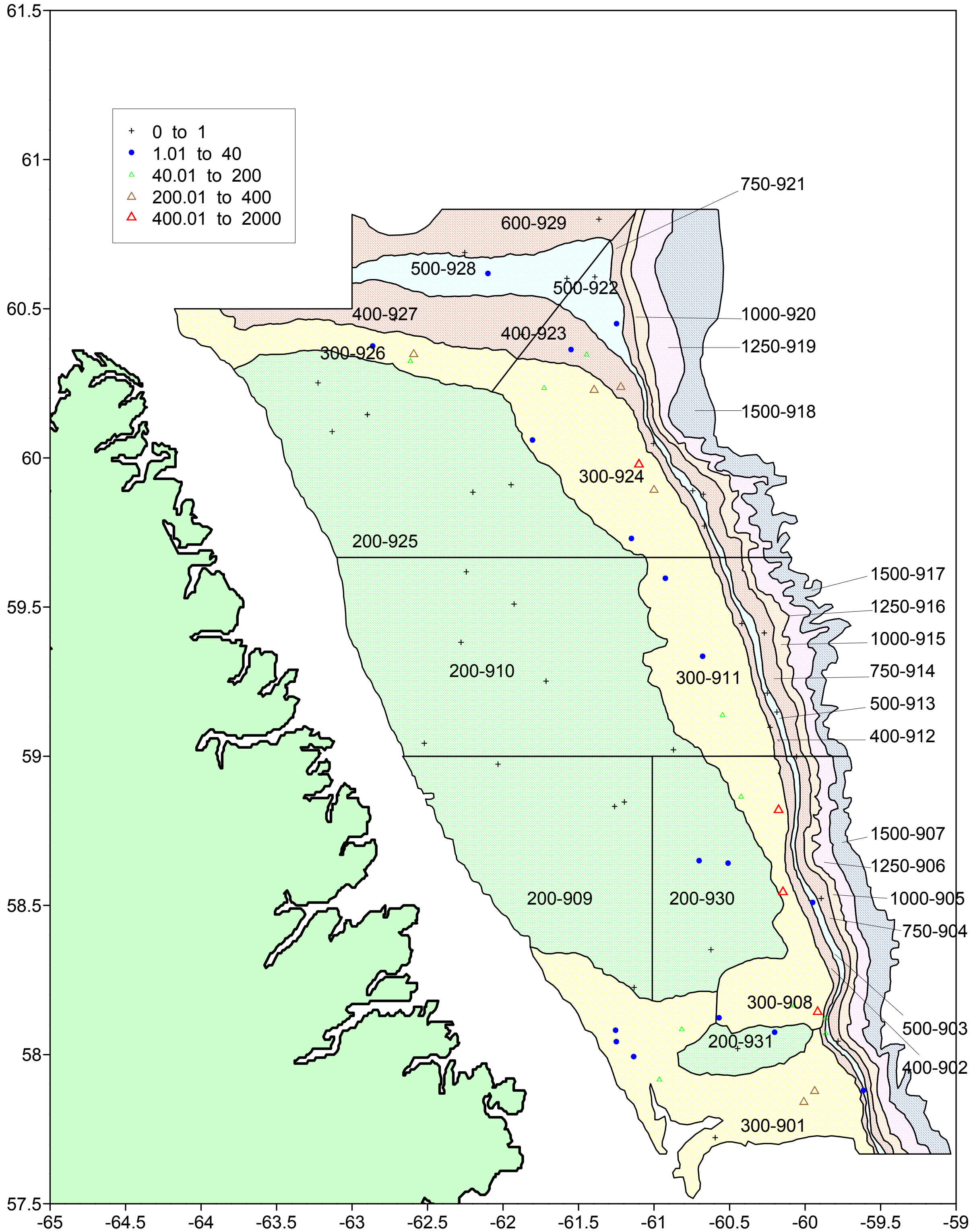
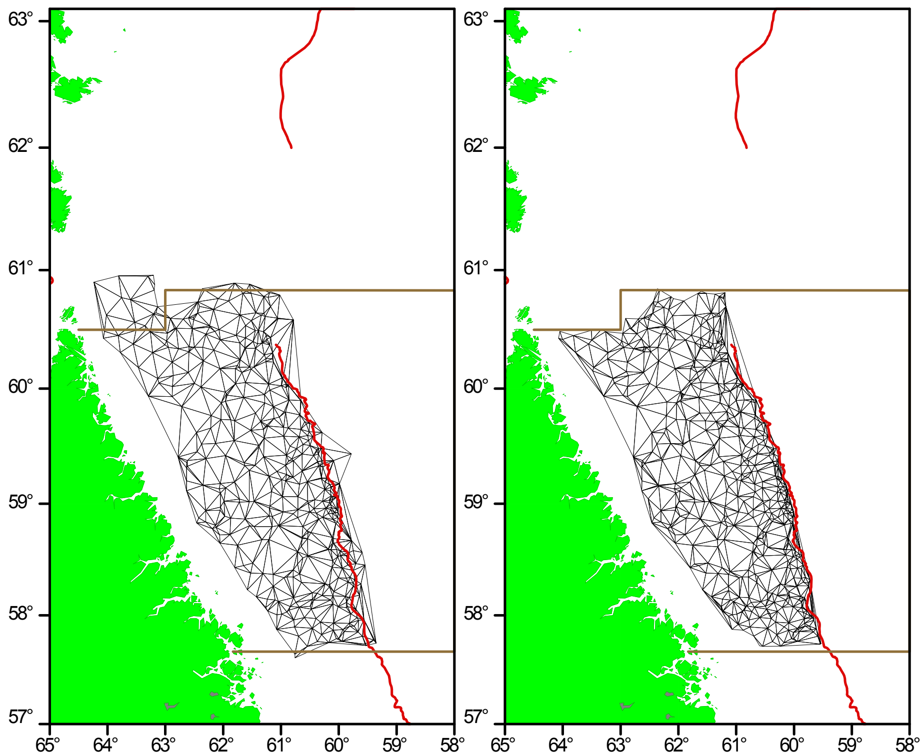


Figure 81. Distribution of NAFO Division 2G (SFA 4) northern shrimp (*Pandalus borealis*) catches (kg/tow) as obtained from the July 2009 Northern Shrimp Research Foundation–DFO joint northern shrimp bottom trawl survey. Tows were 15 minutes in duration and made use of a Campelen 1800 shrimp trawl.



A) Original version of SFA 4 triangulation B) Proposed version of SFA 4 triangulation

Figure 82. Original and proposed versions of the SFA 4 (NAFO Division 2G) Delauney triangulations. The red line is the 800 m depth contour while the brown lines are the SFA 4 boundaries with northern limit of the SFA limited by the southern bound of the voluntary coral closure.

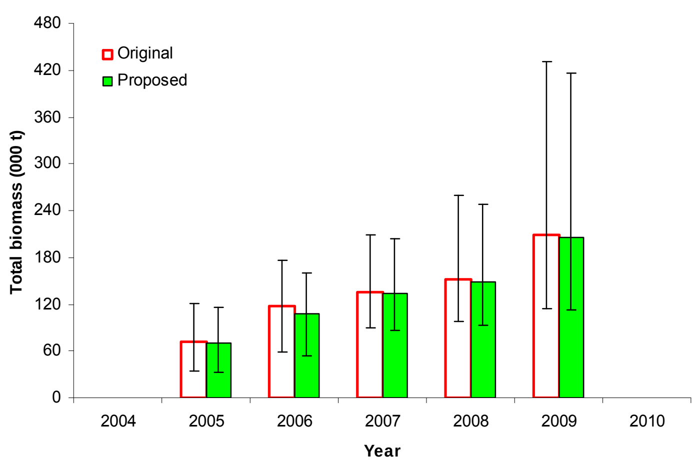


Figure 83. A comparison between the SFA 4 Northern Shrimp (*Pandalus borealis*) total biomass estimates using the old and new Delauney triangulation and parameter files used in Ogmap calculations. Data were obtained from annual NSRF-DFO multi species bottom trawl surveys using a Campelen 1800 shrimp trawl.

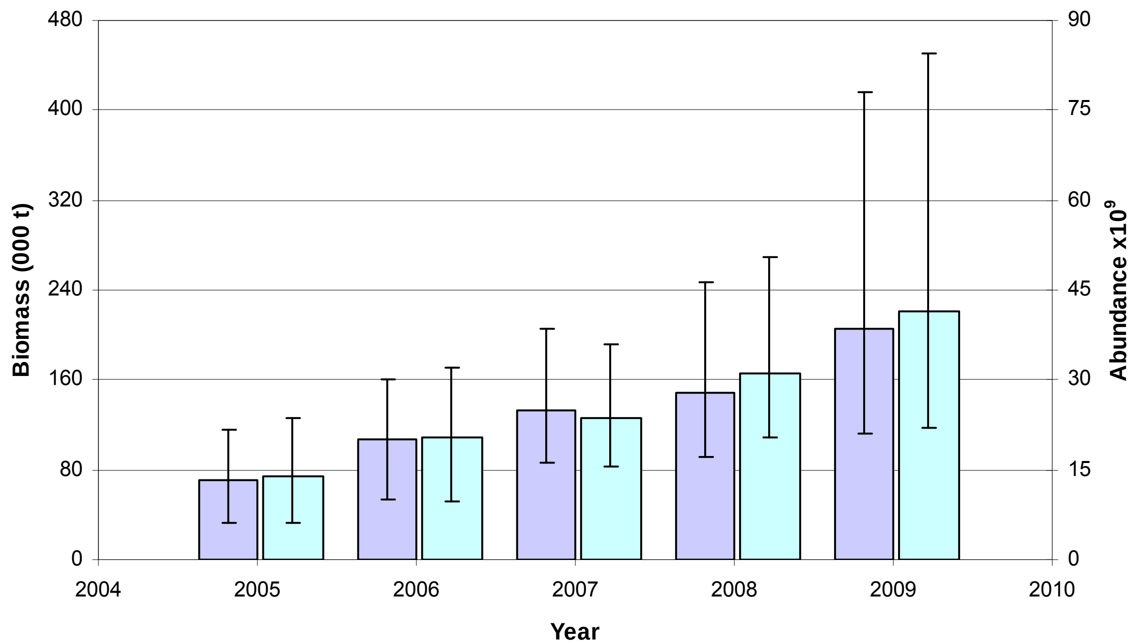


Figure 84. ***Proposed*** *SFA 4 abundance and biomass indices.*

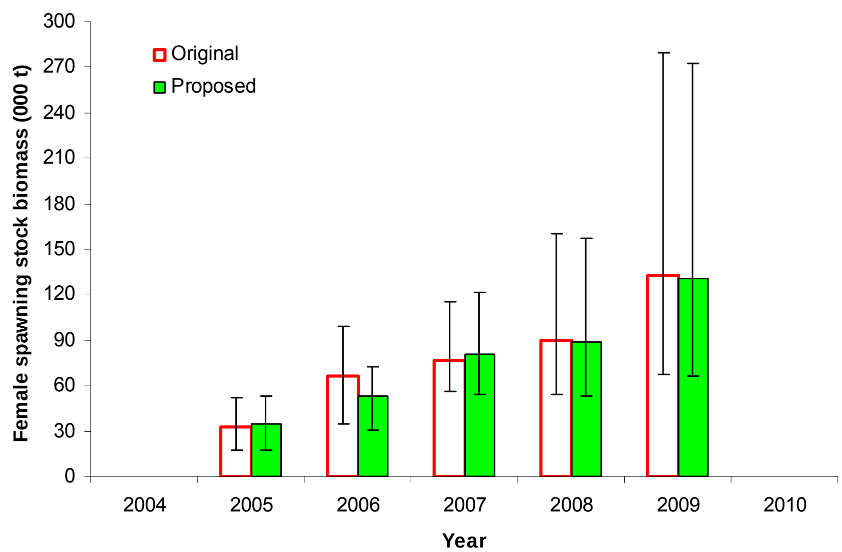


Figure 85. A comparison between the SFA 4 Northern Shrimp (*Pandalus borealis*) female spawning stock biomass (SSB) estimates using the old and new Delauney triangulation and parameter files used in Ogmap calculations. Data were obtained from annual NSRF-DFO multi species bottom trawl surveys using a Campelen 1800 shrimp trawl.

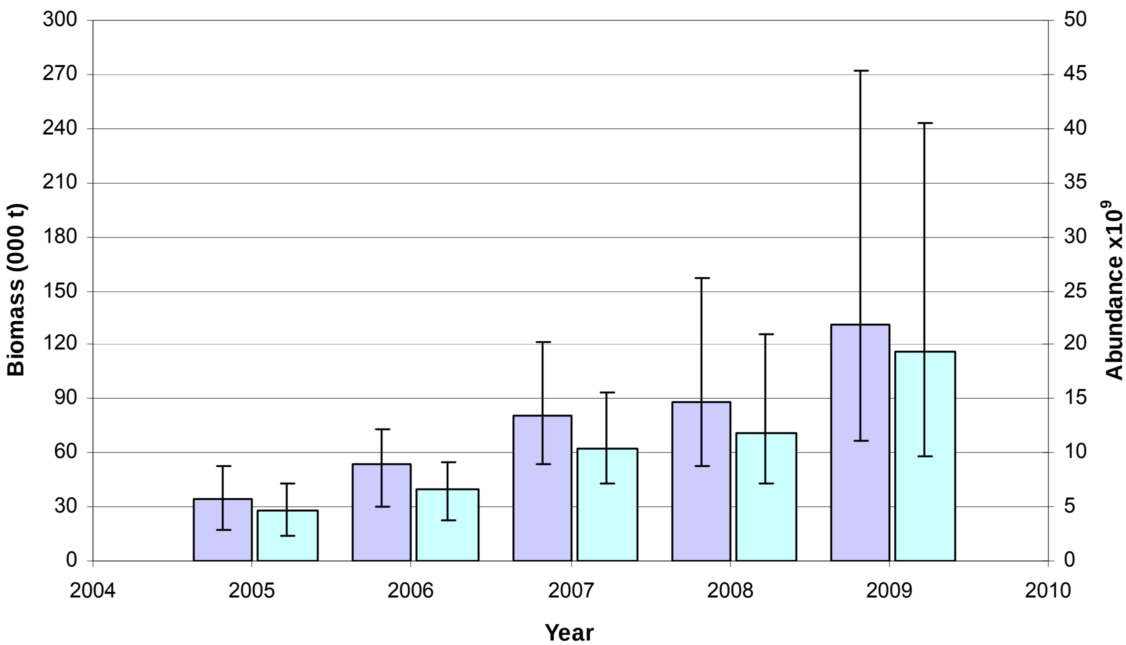


Figure 86. Proposed Northern shrimp female spawning stock biomass and abundance indices within SFA 4 (NAFO Division 2G), as determined using OGive MAPped calculations. The data were obtained from the annual NSRF–DFO joint shrimp bottom trawl survey.

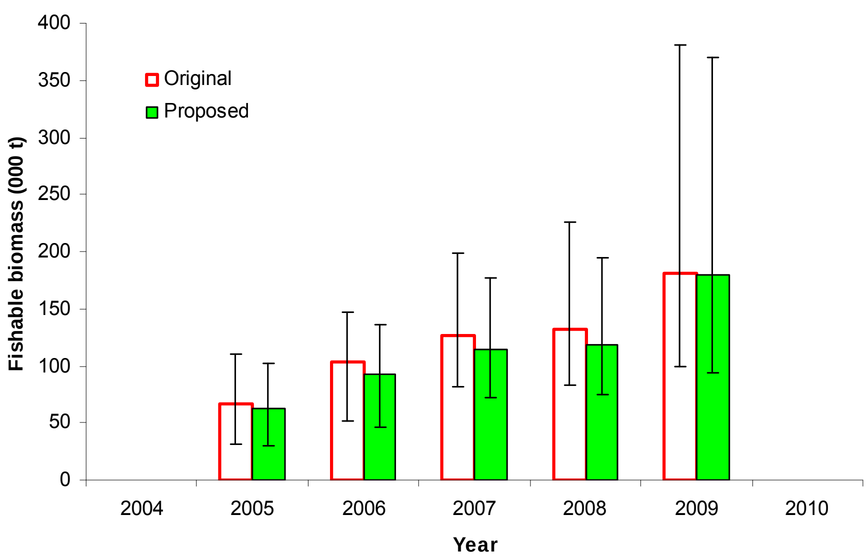


Figure 87. A comparison between the SFA 4 Northern Shrimp (*Pandalus borealis*) fishable biomass estimates using the old and new Delauney triangulation and parameter files used in Ogmap calculations. Data were obtained from annual NSRF-DFO multi species bottom trawl surveys using a Campelen 1800 shrimp trawl.

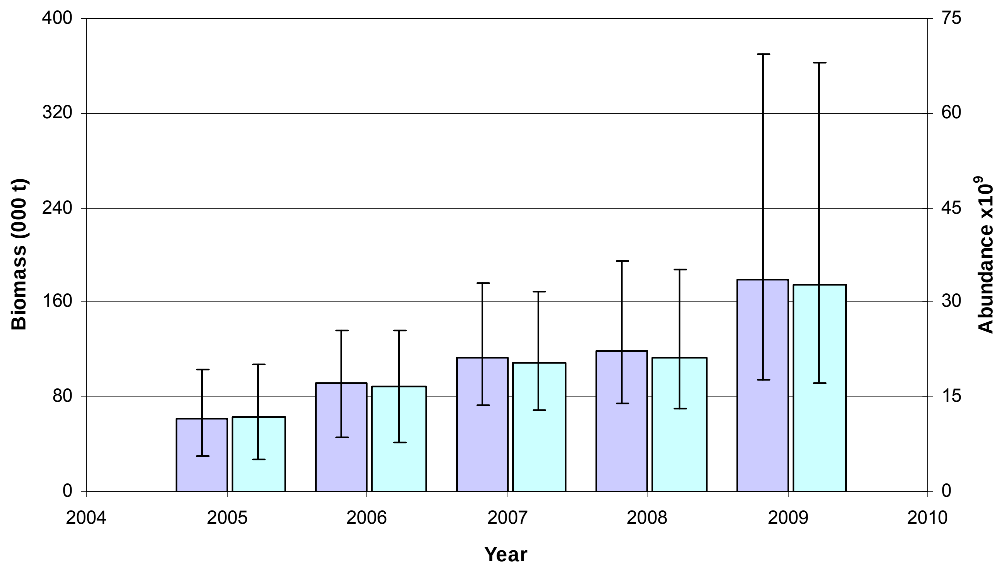


Figure 88. Proposed Northern shrimp fishable biomass and abundance indices within SFA 4 (NAFO Division 2G), as determined using OGive MAPped calculations. The data were obtained from the annual NSRF–DFO joint shrimp bottom trawl survey.

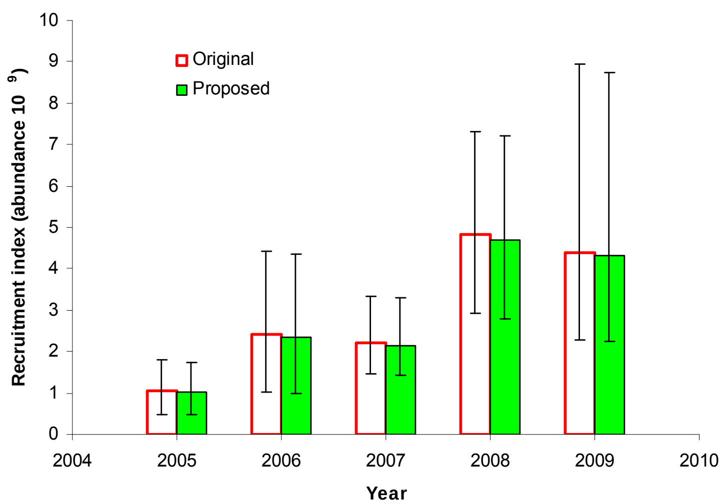


Figure 89. NAFO Division 2G (SFA 4) Northern shrimp recruitment indices using the original definition (abundance of all males and unidentified Pandalus 11.5-16 mm carapace lf), Delauney triangulation compared with the new estimates using the new definitions (abundances of all males + females with 11.5–16 mm carapace lf) and new Delauney triangulation file used in Ogmap calculations. These estimates were calculated from 2005 - 09 NSRF–DFO joint northern shrimp bottom trawl research surveys (standard tows = 15 min at 3.0 Nmi/hr).

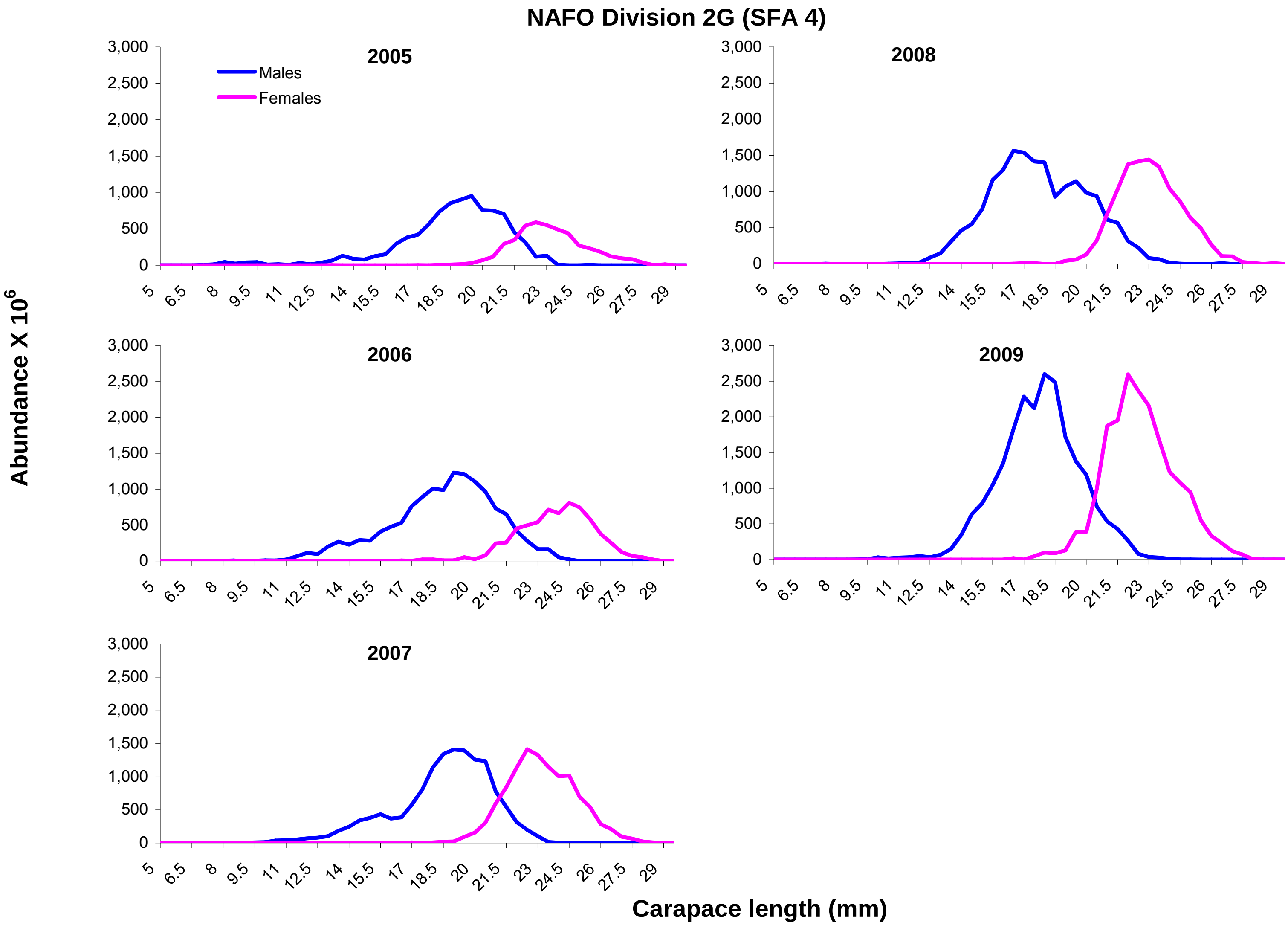


Figure 90. Abundance at length for NAFO Division 2G (SFA 4) Northern Shrimp (*Pandalus borealis*) estimated from OGive MAPped calculations of NSRF–DFO joint shrimp survey data, 2005–09.

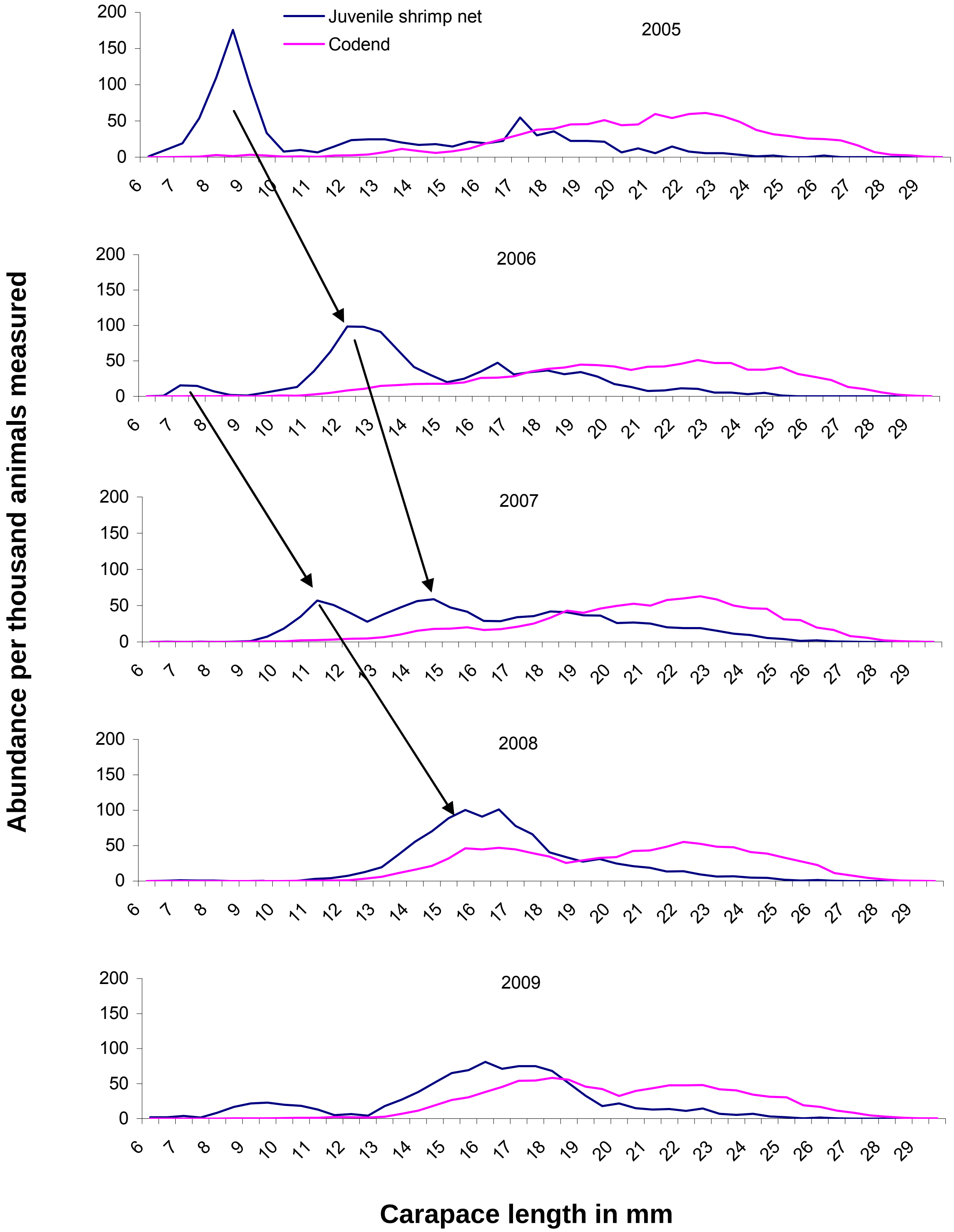


Figure 91. Northern Shrimp length frequencies from the juvenile shrimp net overlain upon length frequencies from the Campelen codend. The shrimp were taken in the Northern Shrimp Research Foundation–DFO Northern shrimp survey in SFA 4 over the period 2005–09. The length frequencies were scaled to number per thousand. Arrows indicate the growth of cohorts from one year to the next.

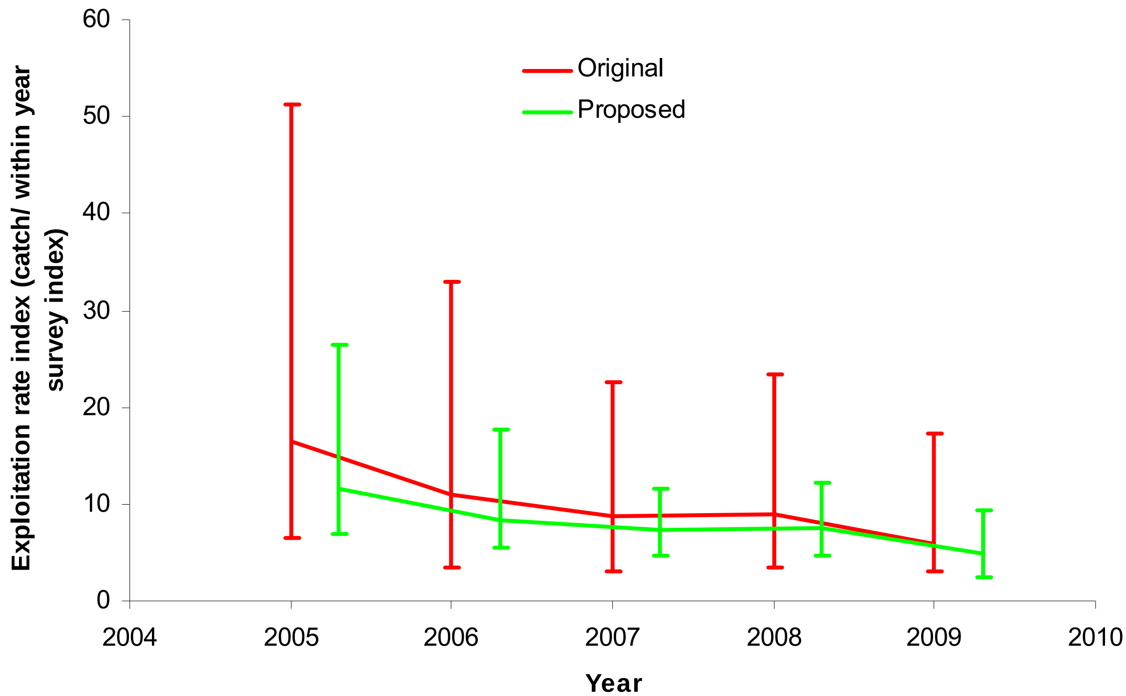


Figure 92. Original formulation of SFA 4 exploitation rate indices (total catch/ fishable biomass index from the within year expressed as percent) and proposed formulation (abundance of shrimp removed by the fishery/ abundance from the fishable portion of the resource). Both indices are expressed as percent while error bars indicate 95% confidence intervals.

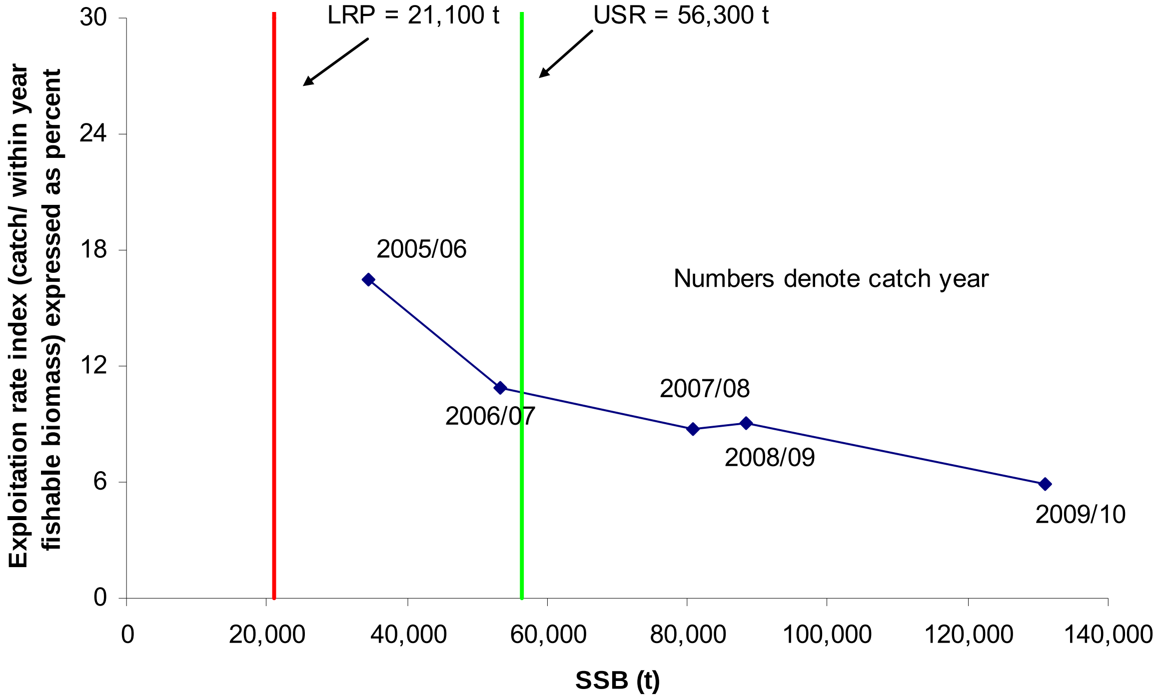


Figure 93. SFA 4 precautionary approach using an Upper Stock Reference (USR = 80% of the geometric mean of SSB over a productive period (2005–09)) and a Lower Reference Point (LRP = 30% of the geometric mean of SSB over a productive period (2005–09)) superimposed with the exploitation rate trajectory over time.