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# Analysis of LFA 41 Lobster Catch Rates 1985 to 1999

# Analyse des taux de prise de homard dans la ZPH 41 de 1985 à 1999

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**Abstract**

Annual standardized lobster catch rates were estimated for five sub-areas of the Lobster Fishing Area (LFA) 41. The five sub-areas were: Crowells Basin (1), SW Browns Bank (2), Georges Basin (3), SE Browns Bank (4), and Georges Bank (5). The catch rates were estimated separately for Fall-Winter (October 16 to April 1) and Spring-Summer (April 2 to October 15) for 1985 to 1999 and from 1994 to 1999 separately due to recent changes in the fishery.

Catch rates from the 1985 to 1999 and the 1994 to 1999 analyses were significantly correlated. For the Fall-Winter portion of the seasons, catch rates in all areas were significantly higher in 1999-2000 than in 1998–1999. For areas 1 and 4 they were still below the peak levels achieved in 1994-1995, but for areas 2, 3, and 5 they were the highest estimated in recent years. For the Spring-Summer portion of the seasons, catch rates were higher in 1999-2000 than in 1998-1999 for areas 1, 3, and 5 but none of these were significantly different and in all areas catch rates were still below peak values. Catch rates were significantly correlated among adjacent areas. Interpretation of these associations requires consideration of migratory information from historical tagging studies.

**Resumé**

Les taux de prise annuels normalisés de homard ont été estimés pour cinq sous-zones de la zone de pêche du homard (ZPH) 41, à savoir : le bassin de Crowell (1), le sud-ouest du banc de Browns (2), le bassin du banc Georges (3), le sud-est du banc de Browns (4) et le banc Georges (5). Les taux de prise ont été estimés séparément pour l'automne-hiver (du 16 octobre au 1er avril) et le printemps-été (du 2 avril au 15 octobre) de 1985 à 1999, et séparément pour la période de 1994 à 1999 en raison de récents changements relatifs à la pêche.

Les taux de prise déterminés par les analyses de 1985 à 1999 et de 1994 à 1999 étaient étroitement corrélés. Dans le cas de la portion automne-hiver des saisons, les taux de prise dans toutes les sous-zones ont été significativement plus élevés en 1999-2000 qu'en 1998-1999. Dans les sous-zones 1 et 4, ils étaient encore inférieurs aux niveaux records de 1994-1995, mais, dans les sous-zones 2, 3 et 5, ils étaient les plus élevés des dernières années. Pour la portion printemps-été des saisons, les taux de prise ont été plus élevés en 1999-2000 qu'en 1998-1999 dans les sous-zones 1, 3 et 5, mais aucun de ceux-ci ne présentait de différence significative, et les taux de prise étaient encore inférieurs aux niveaux sans précédent dans toutes les sous-zones. Les taux de prise étaient étroitement corrélés entre les sous-zones adjacentes. Pour interpréter ces relations, il faut tenir compte de l'information sur les migrations fournie par les études historiques sur le marquage.

## Introduction

Annual trends in catch rates are often used as indices of population change in fisheries stock assessments. A number of factors may influence annual trends in catch rates. Among these factors are vessel type, gear type, captain, directed species, and for lobster, the temperature regime is an important aspect (Paloheimo 1963; Hilborn and Walters 1992). Therefore, understanding annual trends in catch rates is often the first step in assessing the impact of fishing on a population. The analysis presented in this paper represents an initial step in understanding the annual catch rate trends in the LFA 41 lobster fishery. It does this by partitioning the effects of captain changes, changes in directed fisheries from lobster to crab, and within season catchability changes from annual effects using analysis of variance techniques as described by Hilborn and Walters) 1992. We also make an initial attempt at examining temperature influences on these catch rates.

The LFA 41 lobster fishery harvests a relative small amount of lobsters compared to those in the Gulf of Maine / Bay of Fundy / South Shore Nova Scotia lobster fisheries. However, the majority of the lobsters harvested in this fishery are greater than the 50% size-at-maturity for these other lobster fisheries (DFO 2000). As a result, catch rate trends in this fishery may provide important insights into the spawning stock trends for these populations. Tags applied in the inshore Gulf of Maine/ Bay of Fundy/ South Shore Nova Scotia areas and recovered in the LFA 41 area indicate that these populations are linked in some manner. Although at the present time, quantification of the strength of these linkages has not been achieved (Campbell and Stasko 1985; Campbell 1986; Campbell and Stasko 1986; Pezzack and Duggan 1986; and Campbell 1989). As a result, interpretations of annual catch rate trends in LFA 41 may have implications for trends in spawning stock abundance for the areas described above and may affect the view of the stock status of these areas.

It is our hope that these analyses will serve as a template for more in depth analyses of catch rates required to make interpretations over a broader area and that they will serve as a methodological guide for investigating catch rate trends in this fishery.

## Materials and Methods

### Fishery Background

The lobster fishery in LFA 41 has been conducted since 1971 and daily catches reported in logbooks by area have been maintained since 1980. Catches are reported by fishing area defined as: Crowells Basin (1), SW Browns (2), Georges Basin (3), SE Browns (4), and Georges Bank (5) (Fig. 1).

From 1971 to 1985 the major change in the fishery was the replacement of the original small wooden vessels by larger steel vessels. Several changes have occurred in the fishery in 1985 and include: changing the season from one starting on Jan 1 and ending on Dec 31, to one which starts on Oct 16 and ends on Oct 15; each of the eight offshore licenses were given a quota of 90 tonnes; and American effort was removed from the fishery (Pezzack and Duggan 1991). More recently, in 1994, trap limits were removed. A directed fishery for Jonah crab began in 1995 (Figs. 2, 3).

Seasonal fluctuations are observed in catches and catch rates. They increase from the beginning of the season to mid-November and then decline until the end of March. Catches and catch rates then increase until the end of May or beginning of June and decline until the end of September (Fig. 3). Currently, eight vessels fish in the LFA 41 lobster fishery. A total of 20 vessels and 29 captains have fished in this fishery form 1980 to 1999 (Tables 1, 2).

In defining the analyses we have used the convention that the designated years are those that describe the year when the season began. For example, the 1985 to 1999 analyses described below refers to analyses for the seasons beginning in October 1985 and October 1999, even though the calendar year for the Spring-Summer fisheries the calendar year is 1986 and 2000 respectively. This convention maintains consistency with the definition of seasons for neighboring LFAs 33 to 38, and identifies fisheries that concentrate on groups of lobsters which molt from May to September. This designation is important because most of the fishery occurs during the intermolt period from October to May.

**Catch rate – Data**

Data for the catch rate analysis consisted of combined logbook and purchase slip weigh-out data collected for offshore catches from 1985 to1999. Only logbook data collected since the fall of 1985 has been used in this analysis. This date was chosen as the starting point for the analysis because of the changes that were made in the fishery during that year would likely have produced different fishing patterns than those between 1980, when the logbook program began, and 1985.

The logbook data used in the analysis consisted of daily records of number of hauls, daily estimates of lobster catch (pounds), and area of fishing. Crab catches (pounds) were indicated for total trips. Vessel and vessel captain were indicated for each trip. Final sales as recorded on purchase slips were recorded for each trip in pounds and a trip usually consisted of more than one day.

The sum of the daily estimates made by the captain would usually differ from the total recorded on the sales slips. This difference occurred because the captain would estimate the daily totals based on experience whereas the sales slip total for the trip would be based on the weight sold. The sales were assumed to be the most accurate catch data for the trip. Catch by area for the trip was assumed to be proportional to the catch reported by the captains in each area. As a result, the proportion of the total estimated catch in each area was multiplied by the total catches indicated on purchase slips to estimate the catch in each area for the trip.

Effort data were the number of hauls reported in each area by the vessel captains in the logbooks. These were not adjusted in any way.

Daily catch rates (CPUE) by area, vessel, and captain were estimated as catch/haul (kg/haul).

**Catch rate - Statistical analysis**

**Multiplicative model**

A number of factors may affect the comparison of annual trends in catch rates from the LFA 41 lobster fishery. These include area fished, the seasonal pattern of catches, the vessel or captain, the removal of trap limits in 1994, and directed fishing trips for Jonah crab which began in 1995. It is expected that the relative catchability may differ among areas as a result of different habitat types, temperature regimes, or other factors. Similarly, seasonal patterns of catchability may differ as a result of seasonal life history differences, such as molting, reproduction, feeding patterns, or responses to temperature (Paloheimo 1963). It has been hypothesized that removal of the trap restriction had the effect of improving the accuracy of reporting on the number of traps. The direction of fishing trips toward crab has been hypothesized to have had an effect on the distribution of effort and catch rates for lobster.

Ideally we would like to have indices of annual changes in catch rate that are independent of area, seasonal, and fishing practice factors. To achieve this objective we used an analysis of variance model that assumed that the catch rate of any factor was a fixed proportion of the catch rate associated with a fixed level of each of the factors we examined. Thus, we assumed that the factors affecting catch rates were multiplicative and log transformed the data, so that the effects would be additive and amenable to standard anova techniques. Reference levels for each analysis were chosen so that the maximum number of cells would be filled. The resulting annual catch rate indices are referred to as indices standardized to the reference level (Gavaris 1980, Kimura 1988).

**Analytical framework**

We analyzed each area separately and divided the analysis into separate Fall-Winter and Spring-Summer analyses. Fall–Winter is defined as fishing occurring from October 16 to April 1, and Spring–Summer is defined as fishing occurring from April 2 to October 15. Although these factors could have been included in one analysis, keeping them separate in this initial analysis allowed us to ignore possible area and seasonal interaction effects and simplified the initial interpretation of results. Seasonal patterns were considered within each of these analyses, by dividing each season into 14 day periods, designated as 14DayWeek.

**1985 to 1999 analysis**

Analyses were conducted to compare the entire time series from the 1985-1986 season to the 1999-2000 season using all trips. In this analysis, data from all trips, including those with crab catches in the most recent years were used. Data from all captains regardless of length of time spent in the fishery were used. These analyses were consistent with those conducted in the February 2000 LFA 41 assessment (DFO 2000). The 1985 to 1999 analyses examined two main effects: year and 14 day period.

**1994 to 1999 analysis**

The 1994 to 1999 analysis examined four main effects: year, 14 day period, percentage of crab in catch, and captain, by including trips made by the three most consistent captains. Each of the three captains participated in all of these years. These captains were those associated with boats 1, 5, and 19 (Table 2). The influence of the crab fishery was considered by dividing catches into those with 0% crab, 1 – 50% crab, and > 50% crab by weight in the catch for a trip. The reason for completing the 1994 to 1999 analysis in this manner was to contrast the previously used model (1985 to 1999) with one that would take into account principal changes in the fishery in recent years.

**Multiplicative model**

Taking the logarithms the model becomes )Quinn and Deriso 1999),

$$CPUE = B_0 + \sum_{1}^{k} B_i X_i + \varepsilon$$

$B_0$ is the coefficient associated with the reference level for each of the factors. $X_i$ refers to the year and 14 day periods for the 1985 to 1999 analyses. $X_i$ for the 1994 to 1999 analyses refers to year, 14 day period, percentage of trip with crab, and captain. The coefficients and variances were transformed to the arithmetic scale according to Gavaris (1980).

Confidence intervals (95%) were as arithmetic scaled coefficients +/- 1.96 x the arithmetic scaled standard error.

Residuals that were < -4 were eliminated. These were rare, but will be examined at some time to determine if they are the result of key punching errors or merely represent unusual catch rates.

A linear regression for each individual area by season was used to determine if the trends for 1994 to 1999 were similar for each of the two analyses (1985 to 1999 versus 1994 to 1999). These analyses were done using the arithmetic scaled annual catch rates as described above.

MATLAB anovan and regress functions were used to determine significant effects ($p<0.01$) and to estimate parameters for these analyses.

**Correlations among area catch rates**

Catch rates for 1985 to1999 and for 1994 to 1999 were compared among all areas using linear regression. This analysis was done to determine which areas had similar trends in catch rate for the complete time series and for the portion of the time series with the most reliable effort data. The analysis was done separately for the Fall–Winter and Spring–Summer time periods and used the arithmetic scaled annual catch rates. A p-value of 0.05 was considered significant for these analyses.

### Temperature effects

Temperature effects were examined only in a preliminary way by comparing the mean October and November temperatures associated with Area 1 catch rates at 30m and 100m depths. Linear regressions of these temperatures against the arithmetically scaled annual catch rates from the 1985 to 1999 and 1994 to 1999 analyses were used to examine the relationship between temperature and catch rates by area and season.

Mean monthly temperatures were obtained from designated areas that corresponded to fishing areas. Fishing Area 1 corresponded to Temperature Area 43 (Fig. 1b). Mean monthly temperatures were available for October for each year from 1985 – 1999. Mean monthly temperatures were available for November for 1985-1989, 1991, 1993-1995, and 1998-1999.

Mean monthly temperatures included temperatures at depths of 30, 50, 75 100, 125, 150, 175, and 200 metres. Correlations among depths were calculated using the MATLAB corrcoef function. The depths to be analyzed were organized into groups with correlation coefficients among them that were > 0.75. The level of 0.75, while arbitrary seemed to provide a reasonable level for depths with similar temperature trends, particularly in this preliminary analysis.

The relationship between mean monthly temperatures and catch rates was determined using linear regression with the following model:

$$CPUE = B_0 + B_1 X + \varepsilon$$

where the $B_l$s are the parameters of the regression model, and X is the mean monthly temperature.

## Results

### Catch rates – annual trends

All Fall-Winter models were significant for year and 14DayWeek effects for all areas (Appendix 1). For the shorter time series, captain effects were significant for all areas except Area 5 (Appendix 1). Percentage of crab in the catch was not significant in any area.

All Spring-Summer models were significant for year and 14DayWeek effects for all areas in the 1985-1999 time series (Appendix 1). Crab effects were not significant in any area for the short time series. Captain effects were significant only for Area 4 (Appendix 1). In Area 1 only one of the three major captains had fished during the Spring-Summer.

Residual patterns for some area - season combinations, for example, Area 1 Fall-Winter (Appendix T.1) and Areas 1,3, 4, and 5 Spring-Summer (Appendix T.11, 14, 15, and 17), show a tendency to be higher from 1994 to 1999 than from 1985 to 1993.

CPUEs from the1985 to 1999 analysis were significantly correlated with CPUE's from the 1994 to 1999 analysis (Figs. 5, 7, 9, 11, 14, 17).

For the Fall-Winter, catch rates in all areas were significantly higher in 1999-2000 than in 1998-1999 (Figs. 4, 6, 8, 10, 12). For Areas 1 and 4 they were still below the peak levels achieved in 1994-1995, but for Areas 2, 3, and 5 they were the highest estimated in recent years.

For the Spring-Summer, catch rates were higher in 1999-2000 than in 1998-1999 for Areas 1, 3, and 5 but these differences were not significant and in all areas catch rates were still below peak values. Catch rates between the short and long time series were significantly correlated for Areas 1 and 4. For the other areas neither crab nor captain effects were significant (Figs 13, 15, 16, 18).

### Catch rates – area correlations

For the 1985-1999 Fall-Winter time period analysis, Area 1 was significantly correlated only with Area 2. Area 2 was significantly correlated with all other areas. Area 3 was significantly correlated with all other areas, except Area 1. Area 4 was significantly correlated with Areas 2 and 3, as was Area 5 (Fig. 19).

For the 1994 to 1999 Fall-Winter period analysis, Area 1 was significantly correlated only with Area 4, Area 2 was significantly correlated with Areas 3 and 5, and Area 5 with Areas 2 and 3 (Fig. 20).

For the 1985 to 1999 Spring-Summer time period analysis, Area 1 was significantly correlated with Areas 2 and 3 (Fig. 21). Area 5 was significantly correlated with all areas except Area 1 (Fig. 19). For the 1994 to 1999 analysis, only Areas 1 and 3 were correlated (Fig. 22).

### Temperature effects

For October and November, temperatures at 30m did not have correlation coefficients that were above 0.75 with those at any other depth. In contrast, temperatures at 100m had correlation coefficients that were above 0.75 with all depths except 30m. As a result, mean monthly temperatures at 30m and 100m were compared to catch rates for the appropriate month.

Only the relationships between catch rate and temperature at 30m for the 1985 to 1999 October relationship was significant ($p<0.05$) (Figs. 23, 24).

## Discussion

### Catch rates

In general, Fall-Winter catch rates were higher than recent mean values but Spring-Summer catch rates were below mean values (Table 6). The addition of captain and crab effects had little effect on the analysis, with the exception of Area 2 in the Spring-Summer. Using the data from 1985 to 1994 for the future depends on the extent to which interpretation will be possible with respect to CPUE before 1994. If effort reporting was unreliable from 1984-1994 it makes interpretation of these earlier CPUE's with respect to current values uncertain. If they are not going to be used it makes little sense to continue to analyze these data. Therefore, future analyses should concentrate on the years from 1994 to the present.

The model examined here considered captain effects only by using the three captains that were consistent with the whole time series. These results should be compared to those obtained by using all captains over this time period. This comparison will be important to allow continuity in the analysis when these captains drop out of the fishery.

Captain effects were small for this analysis because the three captains accounted for a high percentage of the catch in each area (Fig. 3). Crab catches were not important in the Fall-Winter. They have been an appreciable part of the catch only in the Spring-Summer and only from 1996 to 1998 (Fig. 2).

**Catch rates – Area correlations**

In general for the Fall-Winter data set (1985-1999) catch rates were significantly correlated with adjacent areas. For example, Areas 1 and 2, and Areas 2, 3, and 5, and Areas 2, 3, and 4 represented sets of significantly correlated areas (Fig. 19). In contrast, Areas 4 and 5 were not correlated (Fig. 19). An analysis of these associations with respect to migration routes determined from tagging may provide insight into the reason for these associations.

Spring-Summer associations seem to indicate a similarity in catch rate trends between Areas 1, 2, and 3, and a block of Areas consisting of 2, 3, 4, and 5 (Fig. 21). Interpretation of these associations requires the inclusion of migratory information.

**Temperature effects**

The analysis of temperature effects should be viewed as strictly preliminary and a more thorough investigation should be conducted to understand the relationship between temperature and catch rates in LFA 41. This analysis could be done by incorporating a parameter for temperature effects into the model.

**Recommendations**

The catch rates - area correlations analysis would be strengthened by using a profile analysis where the annual estimates are assumed to be repeated measurements indexed by year. Tests could then be conducted for parallelism, coincidence of curves, and interactions. Interactions between captains and years should be tested to determine if conclusions regarding this part of the analysis are misleading.

The catch rate analysis would be strengthened by comparing the catch rate from an aggregated model to the standardized catch rates to determine if there was an improvement in understanding by including factors for 14 day periods, captain, and percent of crab catches in the analysis. A posteriori multiple-comparisons tests (for example, Dunnet's test) should be used to determine which levels in each effect, for example, years, are significantly different from each other.

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Table 1. Captain and vessel codes for offshore lobster. For all captains and vessels that have participated in the fishery from 1980-2000.

| | Vessel Code | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Captain Code | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 1 | | | | | | X | | | | | | | | | | | | | | |
| 2 | X | | | | | | | | | | | | | | | | | | | |
| 3 | X | | | | | | | | | | | | | | | | | | | |
| 4 | | X | | | | | | | | X | | | | | | | | | | |
| 5 | | X | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | X | | | | | | | | | | |
| 7 | | | | | | | | | | X | | | | | | | | | | |
| 8 | | | X | | | | | | | | X | | | | | | | | | |
| 9 | | | | | | | | | | | X | | | | | | | | | |
| 10 | | | | | | | | | | | X | | | | | X | | | | |
| 11 | | | | | | | | | | | X | | | X | | | | X | | |
| 12 | | | | | X | | | X | | | | | | | X | | | | | |
| 13 | | | | | | | X | | | | | | | | | | | | | |
| 14 | | | | | | | | | X | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | X | | | |
| 16 | | | | | | | | | | | | | | | X | | X | | X | |
| 17 | | | | | | | | | | | | X | | X | X | | | | | |
| 18 | | | | X | | | | | | | | | X | | X | | | | | |
| 19 | | | | | | | | | | | | | X | | | | | | | |
| 20 | | | | | | | | | | | | | | | | X | | | | |
| 21 | | | | | | | | | | | | | | | | X | | | | |
| 22 | | | | | | | | | | | | | | | | X | | | | |
| 23 | | | | X | | | | | | | | | | | | | | | | |
| 24 | | | | | | | | X | | | | | | | | | | | | |
| 25 | | | X | | | | | | | | | | | | | | | | | |
| 26 | | | | | | | | | | | | | | | | | | X | | |
| 27 | | | | | | | | | | | | | | | | | | X | | |
| 28 | | | | | | | | | | | | | | | | | | | | X |
| 29 | | | | | | | | | | | | | | | | | | | | X |

Table 2. Captains for each boat that has fished in the offshore LFA 41 lobster fishery from 1980-2000. The numbers in each vessel code column are the captain codes from Table 1.

| | Vessel Code | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Season | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 80 | | | 25 | 23 | | | | 12,24 | | 6 | | 17 | | | 12 | 20 | 15 | | | |
| 81 | | | 25 | 23,18 | | | | 12 | | 6 | | 17 | | | 18,17 | 21 | 15 | | | |
| 82 | | | 25 | | | | | 12 | | 6 | | 17 | 18 | | 16 | 22 | 15 | | | |
| 83 | | | 25 | | | | | 12 | 14 | 6 | | 17 | 18 | | | 10 | 15 | | | |
| 84 | | | 8 | | | | | 12 | | 6 | | 17 | 18,19 | | | 10 | 16 | | | |
| 85 | | | | | 12 | | 13 | 12 | | 6 | 8 | 17 | | | | 10 | 16 | | | |
| 85-86 | | | | | 12 | | 13 | | | 6 | 8 | 17 | | | | 10 | | | 16 | |
| 86-87 | | | | | 12 | | | | | 6 | 8,9 | | | 17 | | 10 | | | 16 | |
| 87-88 | | | | | 12 | | | | | 6 | 10 | | | 17 | | 10 | | | 16 | |
| 88-89 | | | | | 12 | | | | | 6 | 10 | | | 17,11 | | | | | 16 | |
| 89-90 | | | | | 12 | | | | | 6 | 10 | | | 11 | | | | | 16 | |
| 90-91 | | | | | 12 | | | | | 6 | 10 | | | | | | | | 16 | |
| 91-92 | | | | | 12 | | | | | 6 | 10,11 | | | | | | | | 16 | |
| 92-93 | | | | | 12 | | | | | 6 | 10,11 | | | | | | | | 16 | |
| 93-94 | 2 | | | | 12 | | | | | 6 | 11 | | | | | | | 11 | 16 | |
| 94-95 | 2 | | | | 12 | | | | | 6 | | | | | | | | 11 | 16 | |
| 95-96 | 2 | | | | 12 | 1 | | | | 6 | | | | | | | | 11 | 16 | |
| 96-97 | 2 | | | | 12 | 1 | | | | 6 | | | | | | | | 11 | 16 | |
| 97-98 | 2,3 | | | | 12 | 1 | | | | 6,7 | | | | | | | | 11 | 16 | 28,29 |
| 98-99 | 2 | | | | 12 | 1 | | | | 7,4 | | | | | | | | 11,.26,27 | 16 | 29 |
| 99-00 | 2 | 4,5 | | | 12 | 1 | | | | 4 | | | | | | | | 26,27 | 16 | 29 |

Table 3. Reference levels for each model tested. Crab reference level for all 1994-2000 analyses was the 0% in the catch category.

| | Fall | | | Spring | | |
|---|---|---|---|---|---|---|
| Model | Year | 14DayWeek | Captain | Year | 14DayWeek | Captain |
| Crowell Basin (1) – 1985-2000 | 97-98 | 27-Nov | | 87-88 | 14-May | |
| Crowell Basin (1) – 1994 - 2000 | 97-98 | 13-Nov | 2 | 94-95 | 14-May | 2 |
| SW Browns (2) – 1985 -2000 | 98-99 | 27-Nov | | 89-90 | 14-May | |
| SW Browns (2) – 1994 - 2000 | 94-95 | 27-Nov | 12 | 95-96 | 06-Aug | 2 |
| Georges Basin (3) – 1985-2000 | 98-99 | 19-Feb | | 91-92 | 16-Apr | |
| Georges Basin (3) – 1994 - 2000 | 94-95 | 22-Jan | 12 | 95-96 | 06-Aug | 2 |
| SE Browns (4) – 1985 -2000 | 94-95 | 27-Nov | | 93-94 | 28_May | |
| SE Browns (4) – 1994 - 2000 | 95-96 | 13-Nov | 12 | 98-99 | 16-Apr | 2 |
| Georges Bank (5) – 1985 -2000 | 88-89 | 13-Nov | | 88-89 | 16-Apr | |
| Georges Bank (5) – 1994 - 2000 | 95-96 | 13-Nov | 2 | 98-99 | 16-Apr | 2 |

Table 4. Results of anova (p-values) for each Fall–Winter model tested.

| Fall – Winter | p-value | | | |
|---|---|---|---|---|
| Model | Year | Week | Crab | Captain |
| Crowell Basin (1) – 1985-2000 | <0.0001 | <0.0001 | | |
| Crowell Basin (1) – 1994-2000 | <0.0001 | <0.0001 | 0.1246 | 0.0002 |
| SW Browns Bank (2) – 1985-2000 | <0.0001 | <0.0001 | | |
| SW Browns Bank (2) – 1994-2000 | <0.0001 | <0.0001 | 0.0028 | <0.0001 |
| Georges Basin (3) – 1985-2000 | <0.0001 | <0.0001 | | |
| Georges Basin (3) – 1994-2000 | <0.0001 | <0.0001 | 0.1593 | <0.0001 |
| SE Browns Bank (4) – 1985-2000 | <0.0001 | <0.0001 | | |
| SE Browns Bank (4) – 1994-2000 | <0.0001 | <0.0001 | 0.0973 | <0.0001 |
| Georges Bank (5) – 1985-2000 | <0.0001 | <0.0001 | | |
| Georges Bank (5) – 1994-2000 | <0.0001 | <0.0001 | 0.026 | 0.2003 |

Table 5. Results of anova (p-values) for each Spring–Summer model tested. Ns = not significant. Na = model not applicable, for example only one captain was fishing in Crowell Basin 1994-2000.

| Spring - Summer | p-value | | | |
|---|---|---|---|---|
| Model | Year | Week | Crab | Captain |
| Crowell Basin (1) – 1985-2000 | <0.0001 | <0.0001 | | |
| Crowell Basin (1) – 1994-2000 | <0.0001 | <0.0001 | Ns | Na |
| SW Browns Bank (2) – 1985-2000 | <0.0001 | <0.0001 | | |
| SW Browns Bank (2) – 1994-2000 | <0.0001 | <0.0001 | Ns | Ns |
| Georges Basin (3) – 1985-2000 | <0.0001 | <0.0001 | | |
| Georges Basin (3) – 1994-2000 | <0.0001 | <0.0001 | Ns | Ns |
| SE Browns Bank (4) – 1985-2000 | <0.0001 | <0.0001 | | |
| SE Browns Bank (4) – 1994-2000 | <0.0001 | <0.0001 | Ns | <0.0001 |
| Georges Bank (5) – 1985-2000 | <0.0001 | <0.0001 | | |
| Georges Bank (5) – 1994-2000 | <0.0001 | <0.0001 | Ns | Ns |

Table 6. Average catch rates from 1994-1998 compared to catch rates for 1998-1999 and 1999-2000 Fall-Winter and Spring-Summer season. Means for 1994-1998 are from the analysis for the short time series (1994-2000). If the captain and crab effects were not significant for the short time series, then the catch rates estimated from the long time series (1985-2000) were used.

**(A) Fall catch rates in kilogram per trap haul (kg/th) of the five assessment areas.**

| Area | 1994-1998 | 1998-1999 | 1999-2000 |
|---|---|---|---|
| Crowell Basin | 8.20 | 3.09 | 5.99 |
| SW Browns Bank | 3.93 | 1.57 | 4.40 |
| Georges Basin | 2.12 | 1.46 | 2.66 |
| SE Browns Bank | 1.20 | 0.66 | 1.01 |
| Georges Bank | 7.12 | 4.43 | 9.50 |

**(B) Spring catch rates in kilogram per trap haul (kg/th) of the five assessment areas.**

| Area | 1994-1998 | 1998-1999 | 1999-2000 |
|---|---|---|---|
| Crowell Basin | 2.66 | 1.75 | 2.98 |
| SW Browns Bank | 2.15 | 1.74 | 1.63 |
| Georges Basin | 2.23 | 1.09 | 1.74 |
| SE Browns Bank | 2.11 | 1.78 | 1.73 |
| Georges Bank | 0.43 | 0.37 | 0.27 |

A)

B)

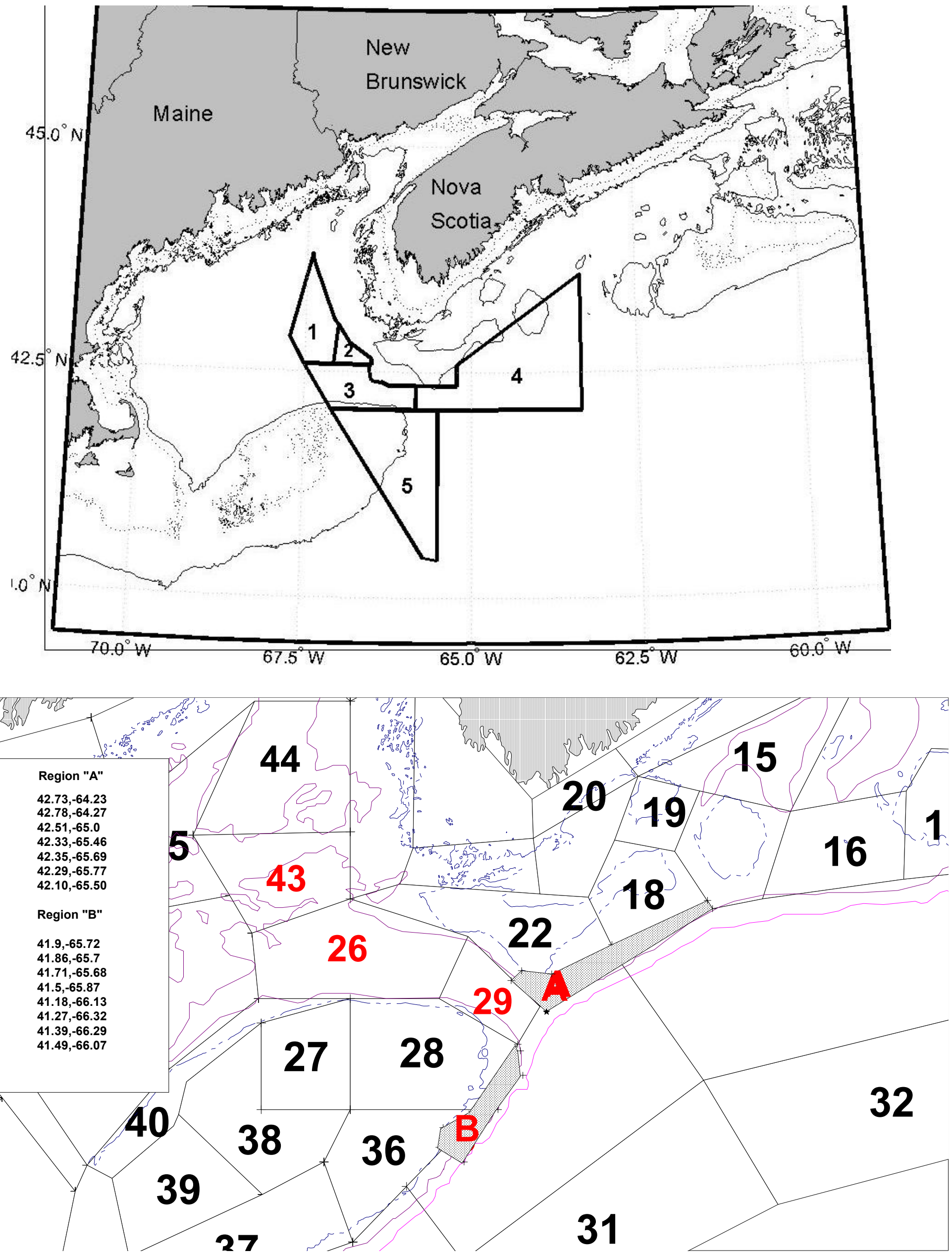



Fig. 1. (A) Map showing offshore areas defined as: Crowell Basin (1), SW Browns Bank (2), Georges Basin (3), SE Browns Bank (4), and Georges Bank (5). This solid line is 100 m depth contour, dotted line is 50 m depth contour. (B) Temperature areas that could be used to examine the relationship between temperature and catch rate in the LFA 41 fishery are areas, 43, 26, 29, A, and B.

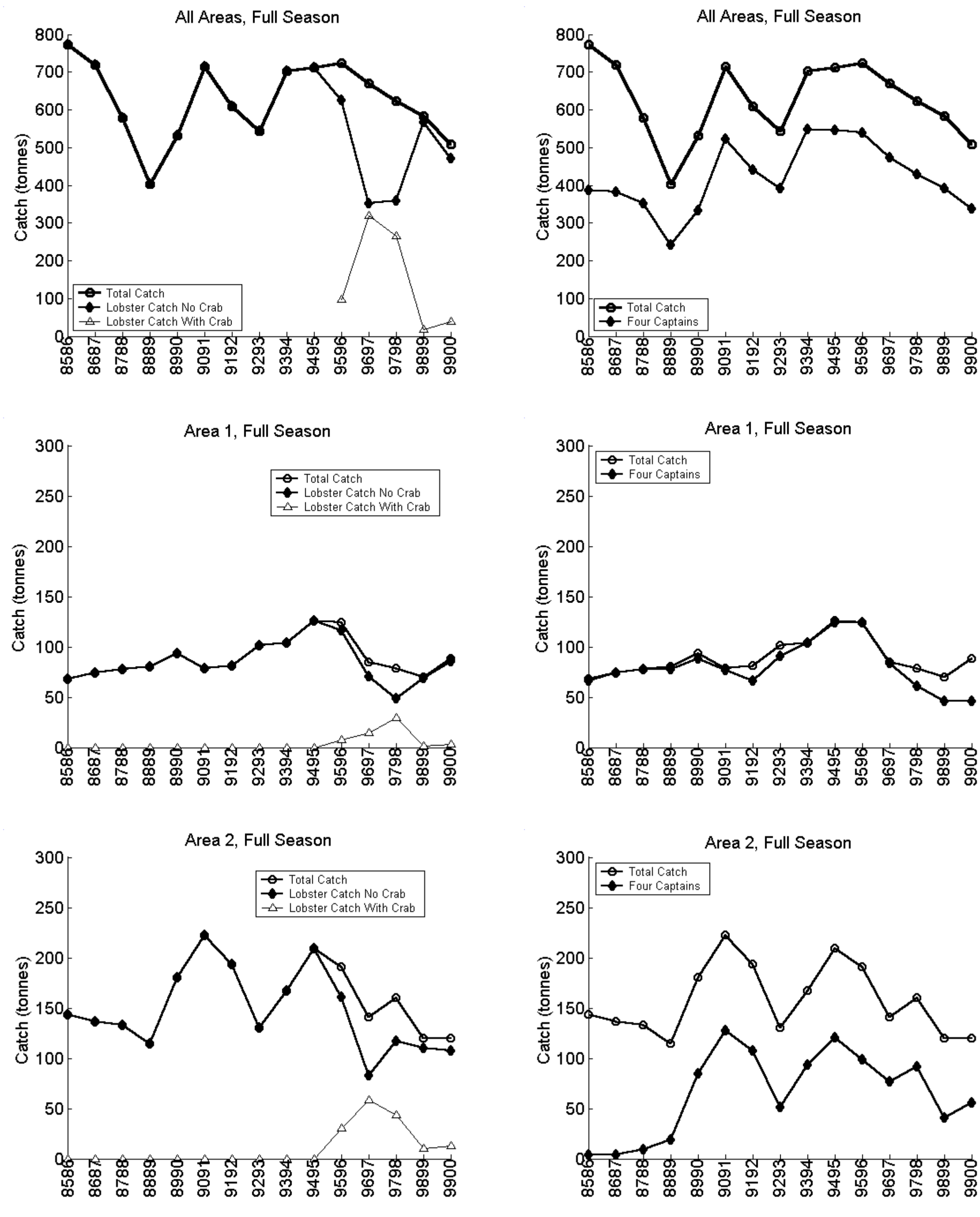
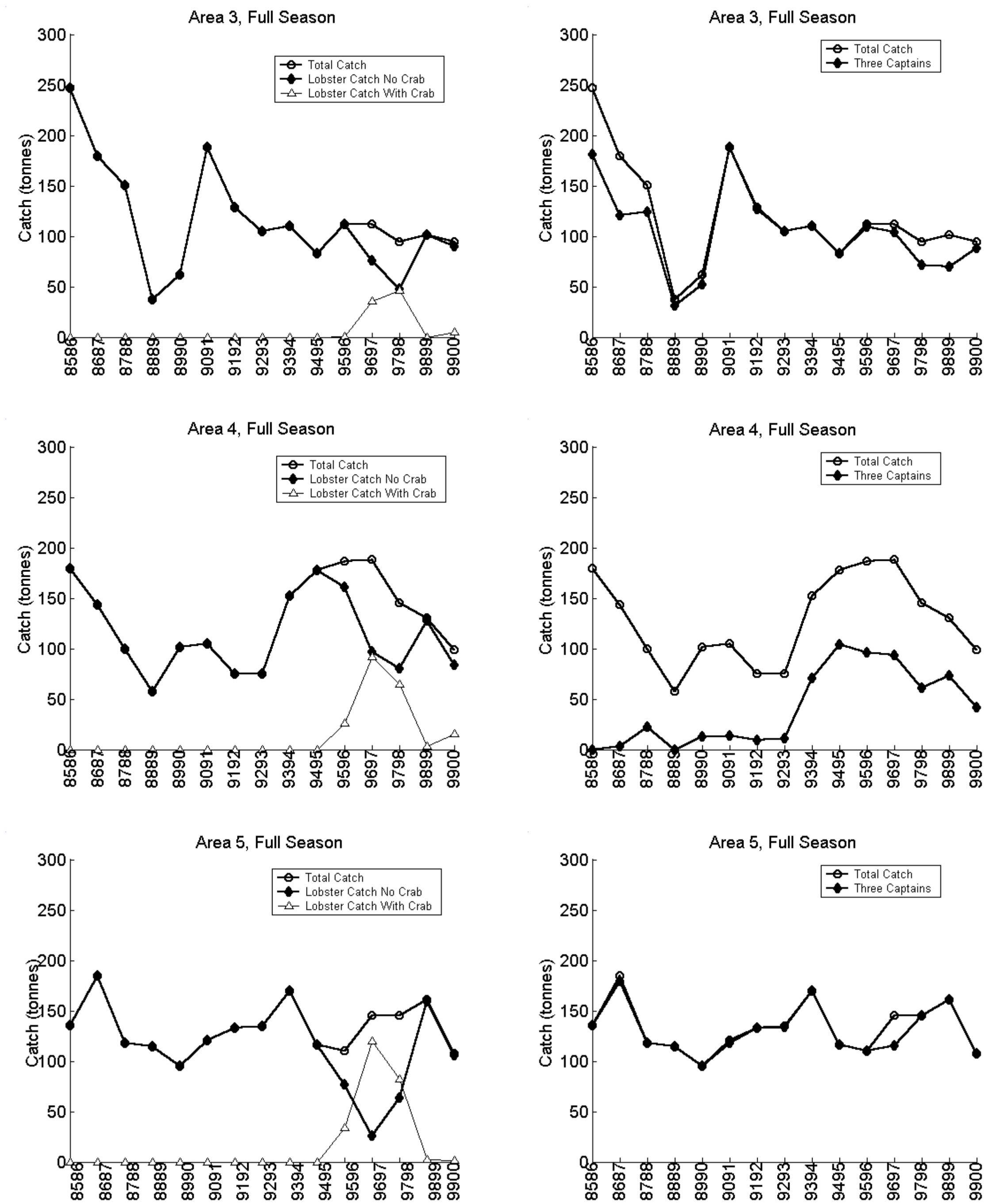



Fig. 2. Annual catch (tonnes) for the LFA 41 fishery by area and all areas. Total Catch for all trips are compared to trips with no crab catches and trips with crab catches.



Area 3, Full Season
Catch (tonnes)
Total Catch
Lobster Catch No Crab
Lobster Catch With Crab
Area 3, Full Season
Catch (tonnes)
Total Catch
Three Captains
Area 4, Full Season
Catch (tonnes)
Total Catch
Lobster Catch No Crab
Lobster Catch With Crab
Area 4, Full Season
Catch (tonnes)
Total Catch
Three Captains
Area 5, Full Season
Catch (tonnes)
Total Catch
Lobster Catch No Crab
Lobster Catch With Crab
Area 5, Full Season
Catch (tonnes)
Total Catch
Three Captains
0
50
100
150
200
250
300
8586
8687
8788
8889
8990
9091
9192
9293
9394
9495
9596
9697
9798
9899
9900


Fig. 2 (cont.).

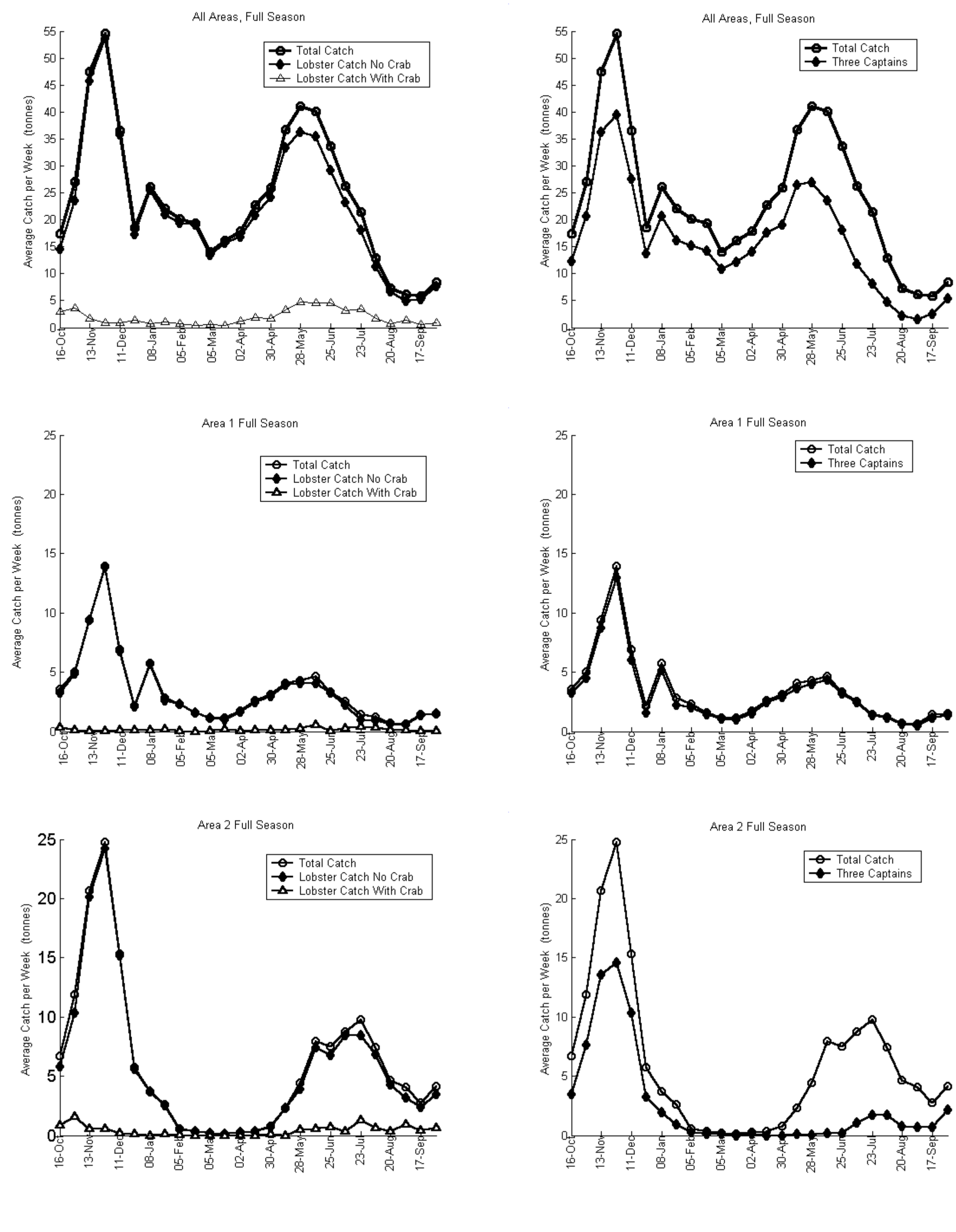



Fig. 3. Timing of catches in the LFA 41 fishery (tonnes), for all areas combined and each area separately. Catches for all trips are compared to those with and without crab landings.

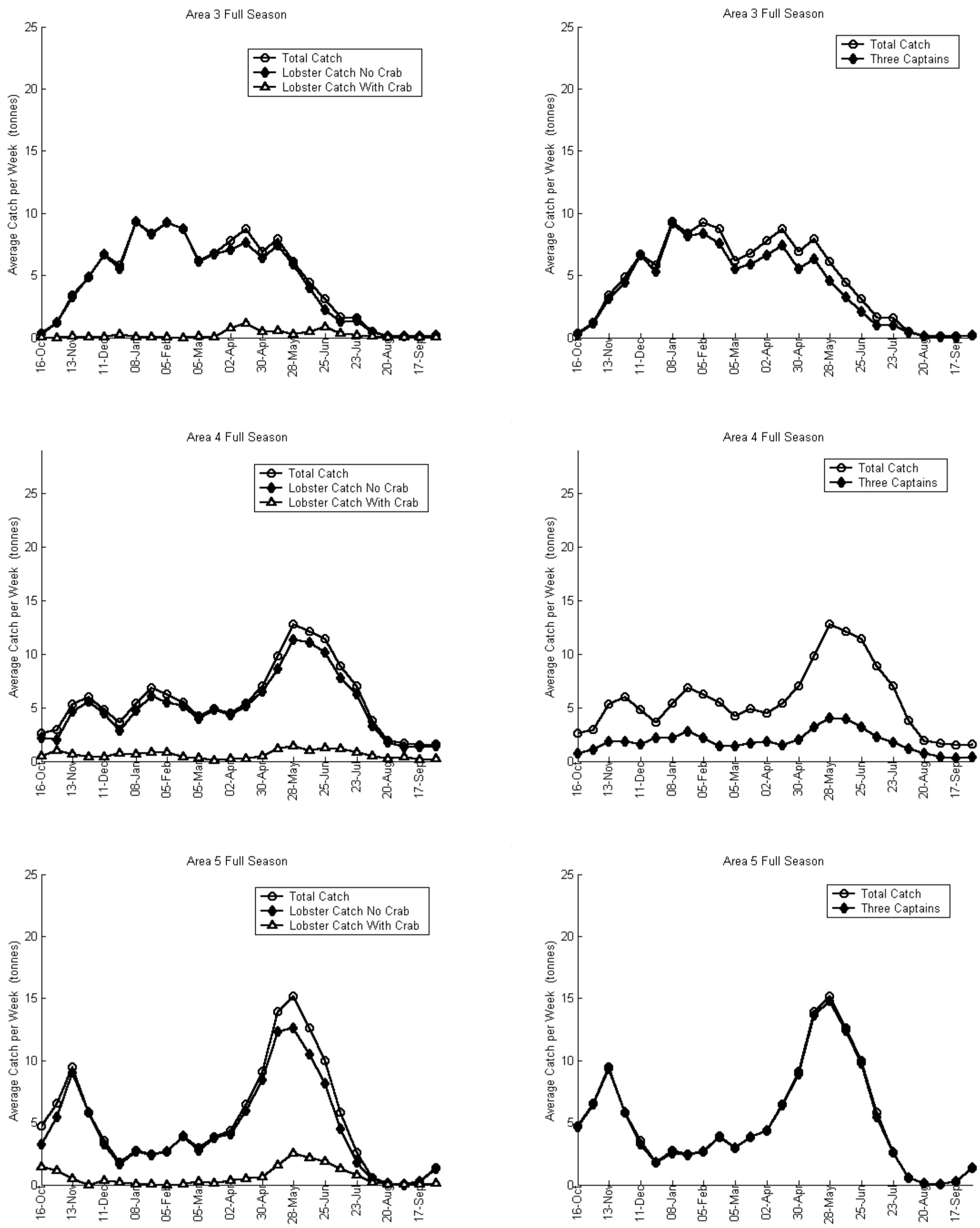

Area 3 Full Season
Total Catch
Lobster Catch No Crab
Lobster Catch With Crab
Average Catch per Week (tonnes)
Area 3 Full Season
Total Catch
Three Captains
Average Catch per Week (tonnes)
Area 4 Full Season
Total Catch
Lobster Catch No Crab
Lobster Catch With Crab
Average Catch per Week (tonnes)
Area 4 Full Season
Total Catch
Three Captains
Average Catch per Week (tonnes)
Area 5 Full Season
Total Catch
Lobster Catch No Crab
Lobster Catch With Crab
Average Catch per Week (tonnes)
Area 5 Full Season
Total Catch
Three Captains
Average Catch per Week (tonnes)
16-Oct
13-Nov
11-Dec
08-Jan
05-Feb
05-Mar
02-Apr
30-Apr
28-May
25-Jun
23-Jul
20-Aug
17-Sep

Fig. 3 (cont.)

Area 1  (Fall – Winter)

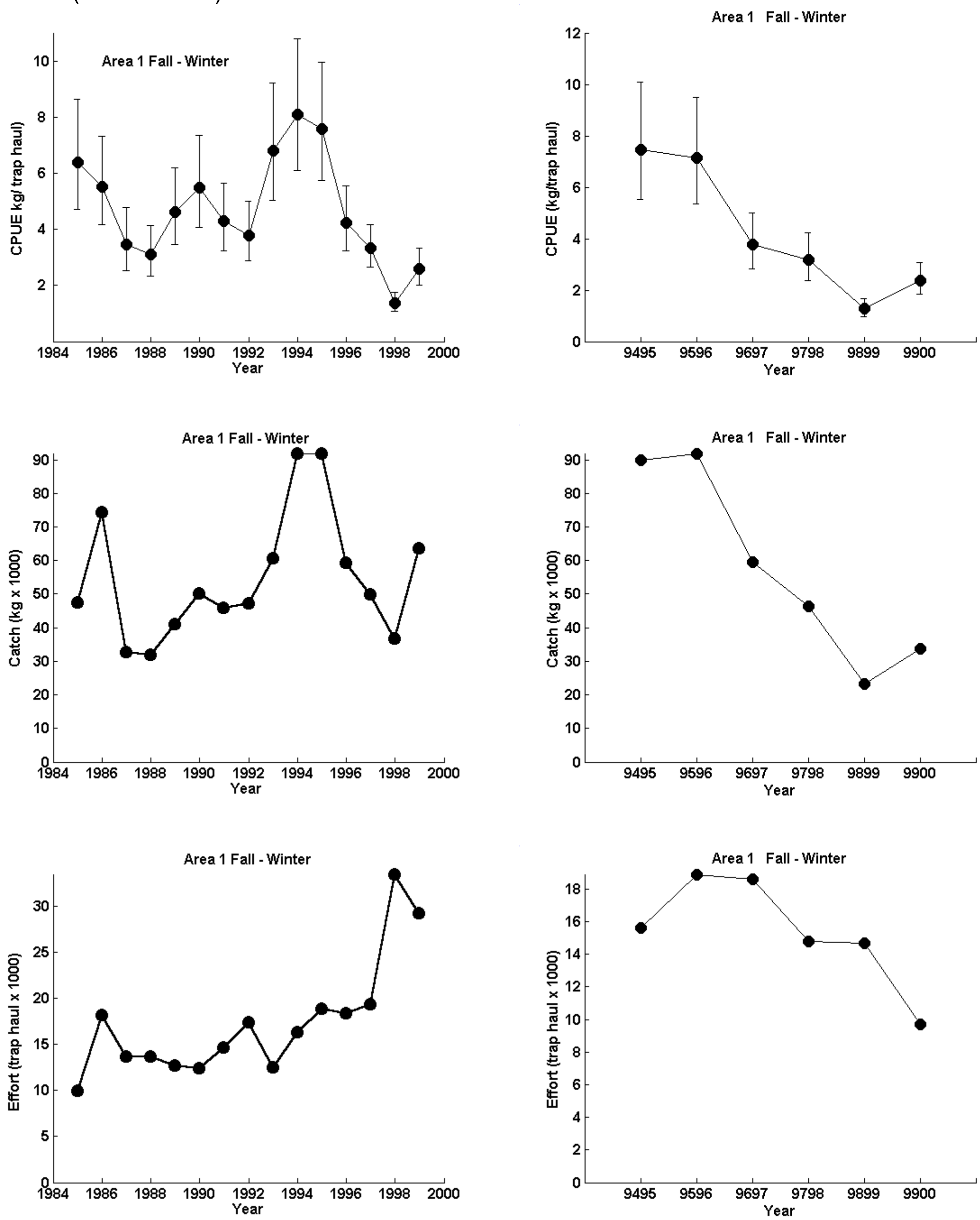



Fig. 4.  Catch rate (kg/ haul) (CPUE) for Area 1, Fall – Winter anova models.  Left column is the analysis for 1985-2000 and right column is for 1994-2000 with crab and captain effects. Year axis for the left hand column indicates year when fall season began.

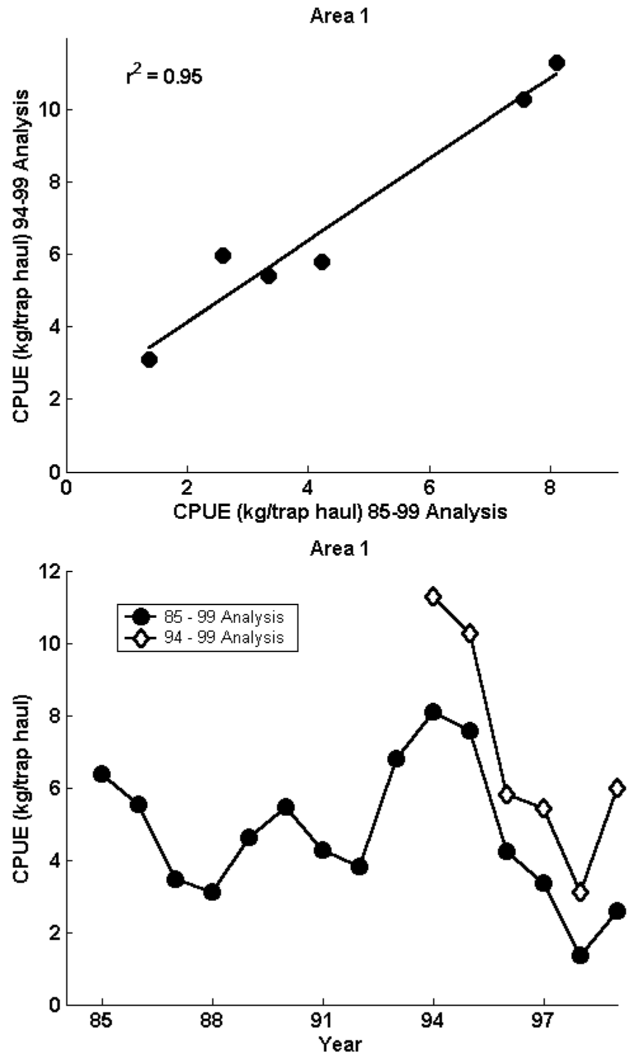



Fig. 5. Comparison of CPUE for 1985-2000 and 1994-2000 model for Area 1, Fall – Winter. Top panel is correlation with r2 between the CPUE for each model, and bottom panel is the CPUE over time for each model. Year is the year the Fall-Winter portion of the season began, see text.

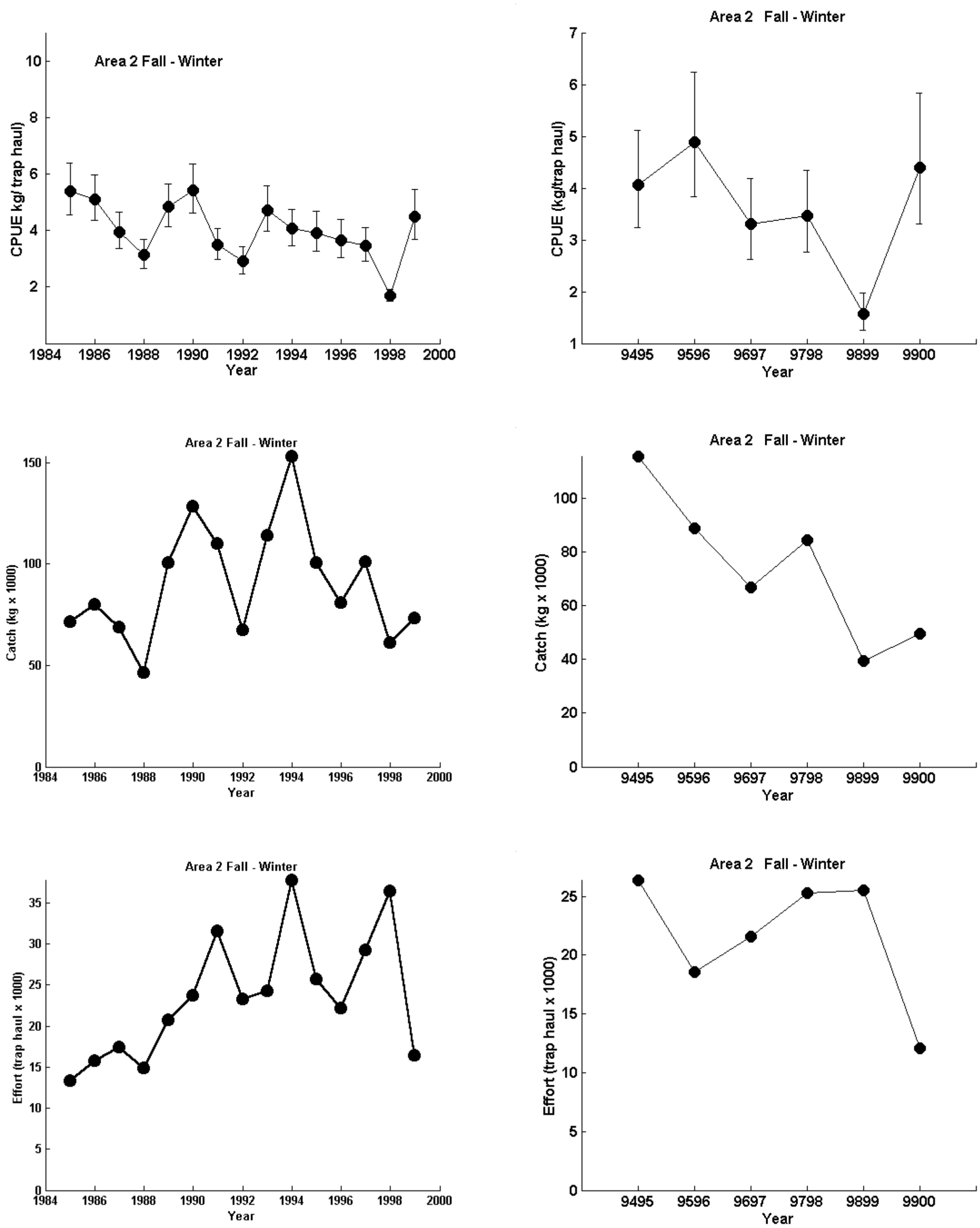



Fig. 6. Catch rate (kg/ haul) (CPUE) for Area 2, Fall – Winter anova models. Left column is the analysis for 1985-2000 and right column is for 1994-2000 with crab and captain effects. Year axis for the left hand column indicates year when Fall-Winter season began, see text.

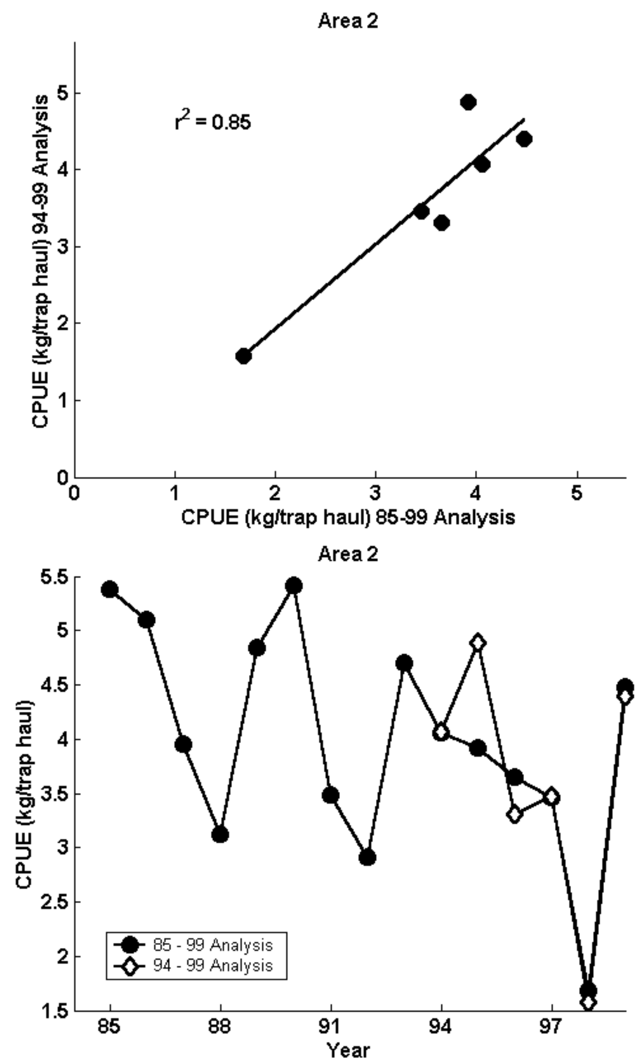



Fig. 7. Comparison of CPUE for 1985-2000 and 1994-2000 model for Area 2, Fall – Winter. Top panel is correlation with r2 between the CPUE for each model, and bottom panel is the CPUE over time for each model. Year is the year the Fall-Winter portion of the season began, see text.

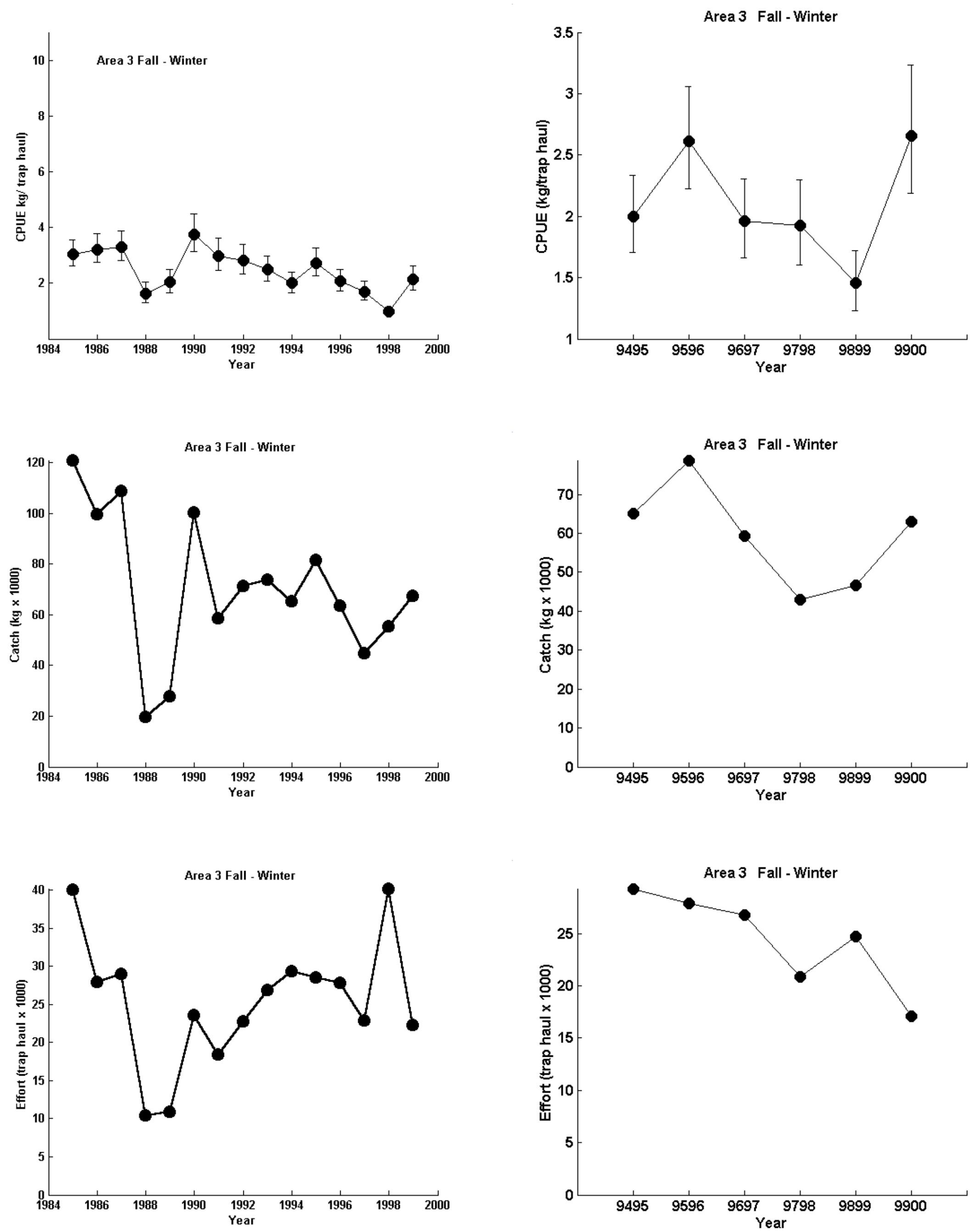
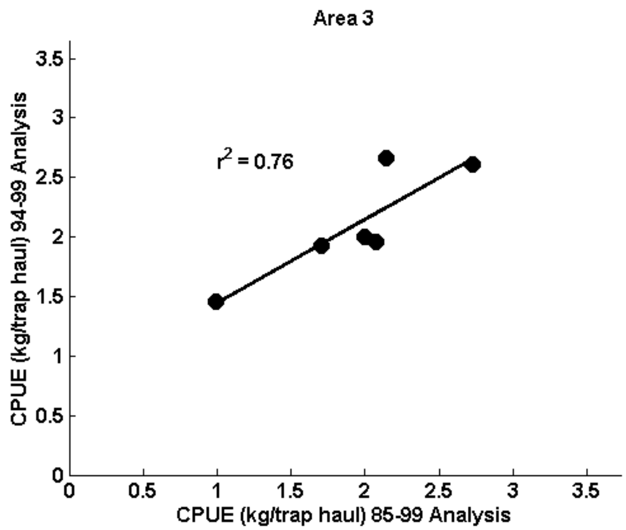



Fig. 8. Catch rate (kg/ haul) (CPUE) for Area 3, Fall – Winter anova models. Left column is the analysis for 1985-2000 and right column is for 1994-2000 with crab and captain effects. Year axis for the left hand column indicates year when Fall-Winter season began, see text.



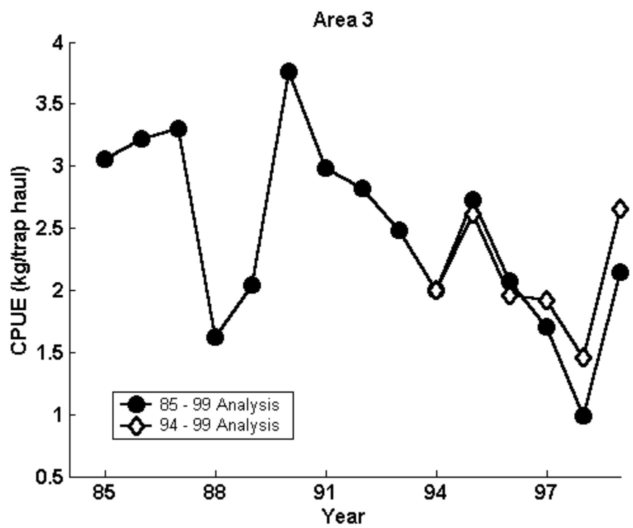




Fig. 9. Comparison of CPUE for 1985-2000 and 1994-2000 model for Area 3, Fall – Winter. Top panel is correlation with r2 between the CPUE for each model, and bottom panel is the CPUE over time for each model. Year is the year the Fall-Winter portion of the season began, see text.

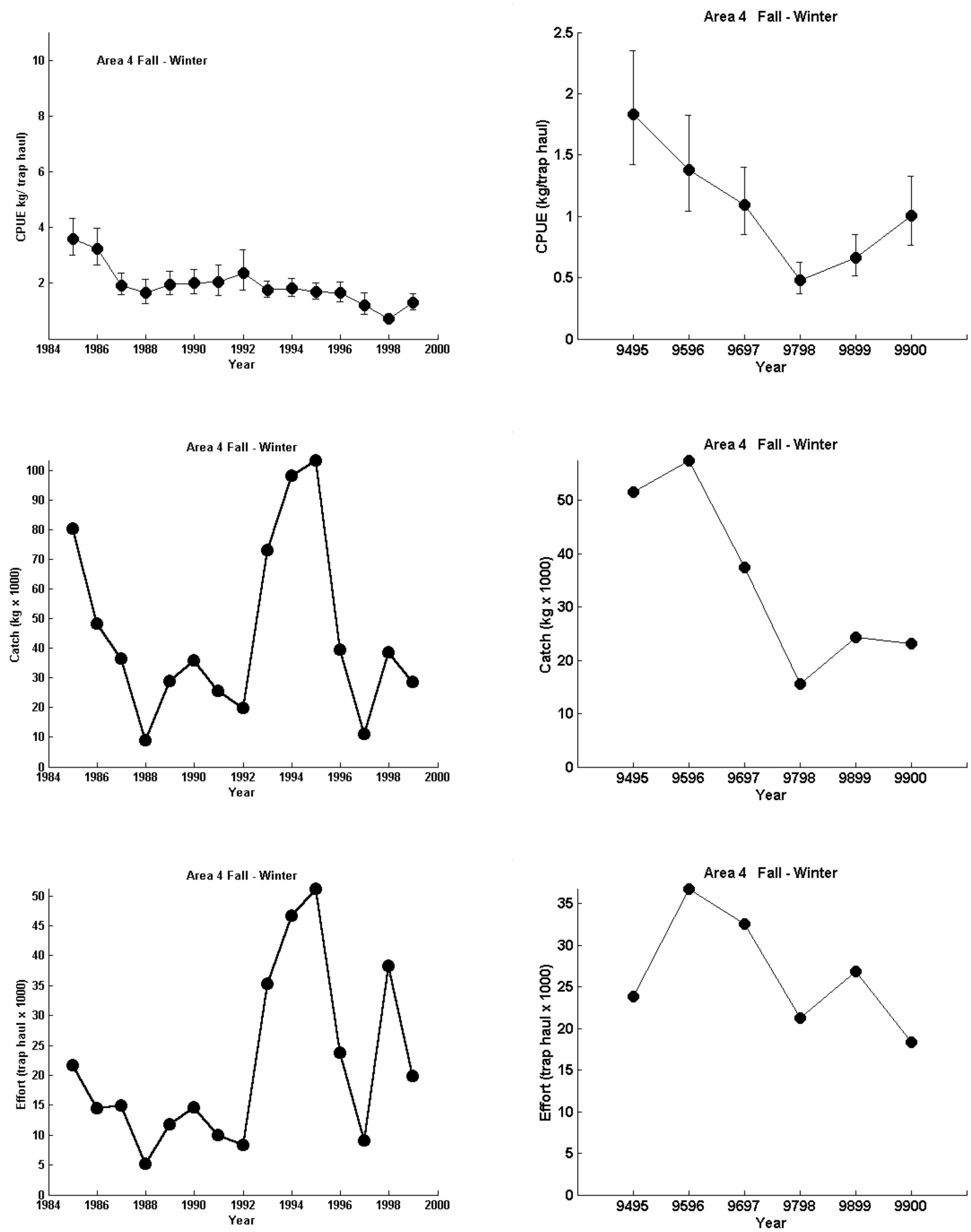



Fig. 10. Catch rate (kg/ haul) (CPUE) for Area 4, Fall – Winter anova models. Left column is the analysis for 1985-2000 and right column is for 1994-2000 with crab and captain effects. Year axis for the left hand column indicates year when Fall-Winter season began, see text.

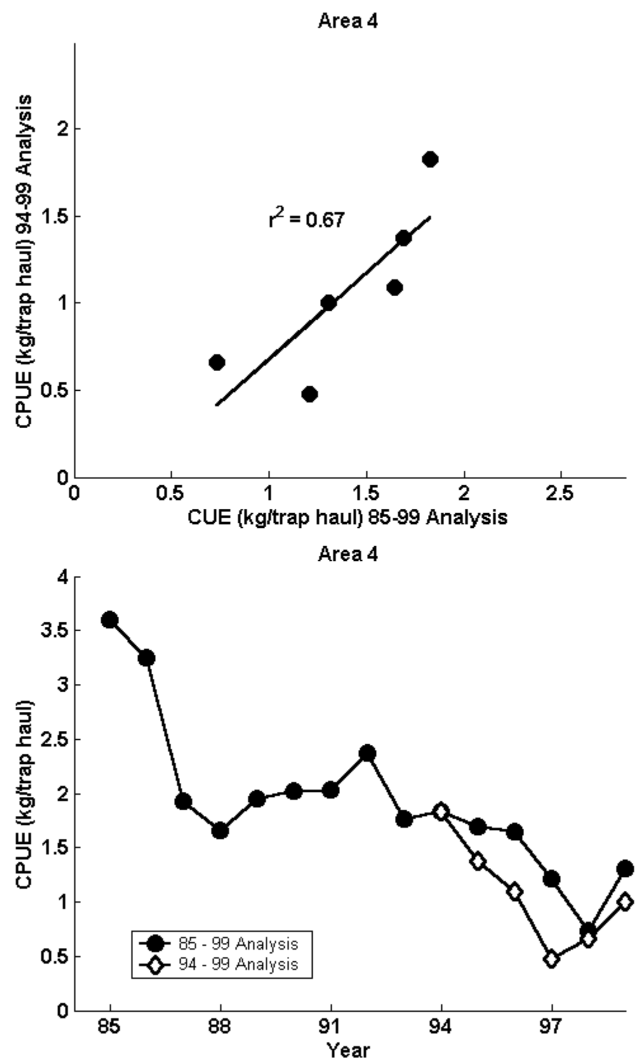
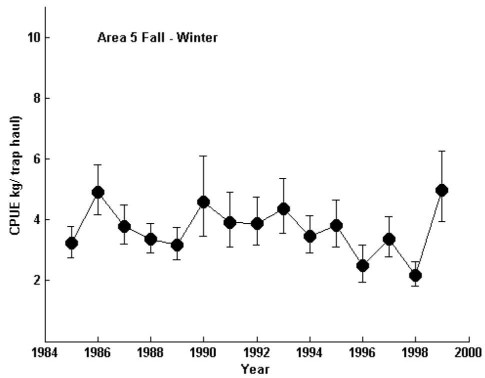
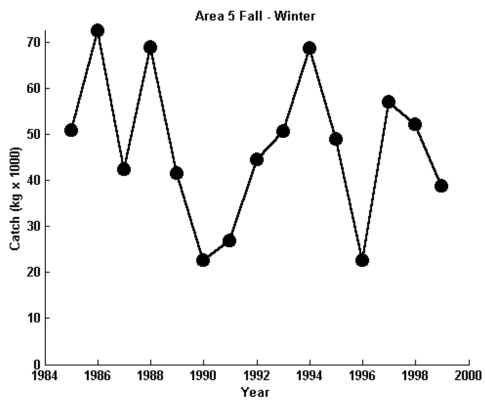



Fig. 11. Comparison of CPUE for 1985-2000 and 1994-2000 model for Area 4, Fall – Winter. Top panel is correlation with r2 between the CPUE for each model, and bottom panel is the CPUE over time for each model. Year is the year the Fall-Winter portion of the season began, see text.




Crab and Captain effects
were not significant



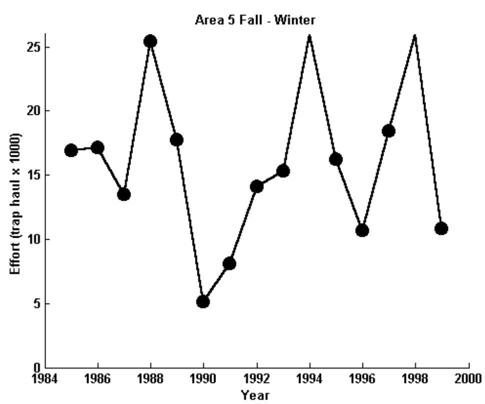




Fig. 12. Catch rate (kg/ haul) (CPUE) for Area 5, Fall – Winter anova models. Left column is the analysis for 1985-2000 and right column is for 1994-2000 with crab and captain effects. Year axis for the left hand column indicates year when Fall-Winter portion of the season began, see text.

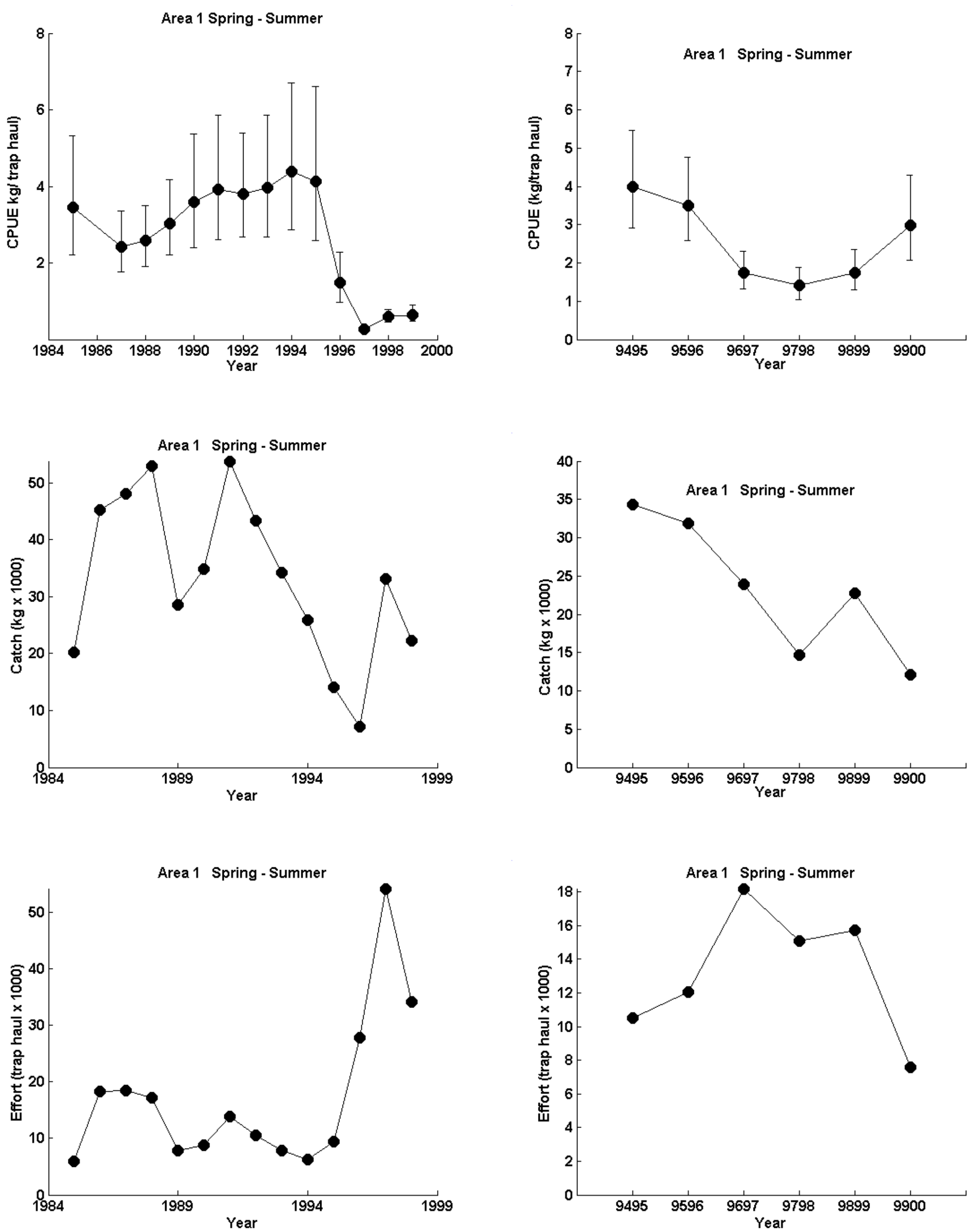



Fig. 13. Catch rate (kg/ haul) (CPUE) for Area 1, Spring - Summer anova models. Left column is the analysis for 1985-2000 and right column is for 1994-2000 with crab and captain effects. Year for left-hand column is the year the Fall-Winter portion of the season began, see text.

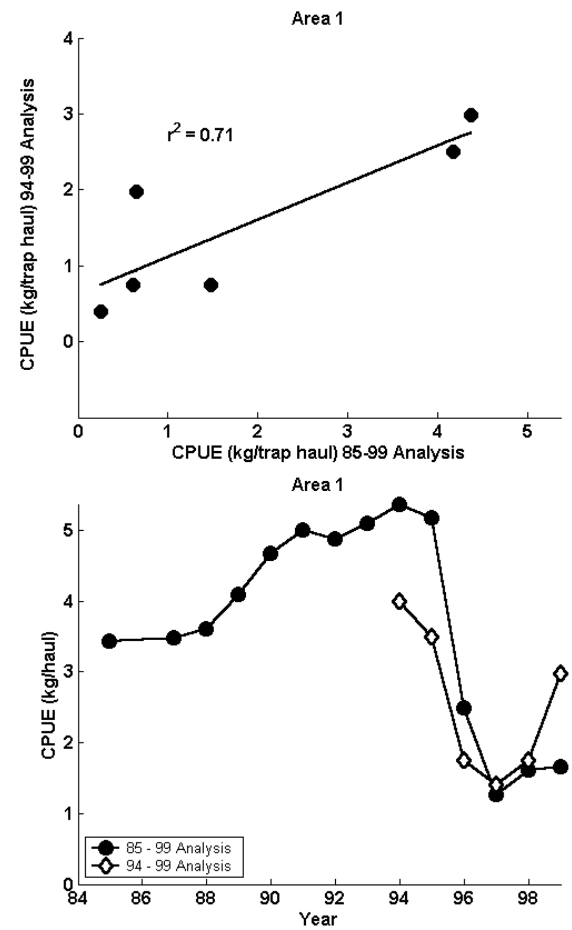



Fig. 14. Comparison of CPUE for 1985-2000 and 1994-2000 model for Area 1, Spring - Summer. Top panel is correlation with r2 between the CPUE for each model, and bottom panel is the CPUE over time for each model. Year is the year the Fall-Winter portion of the season began, see text.

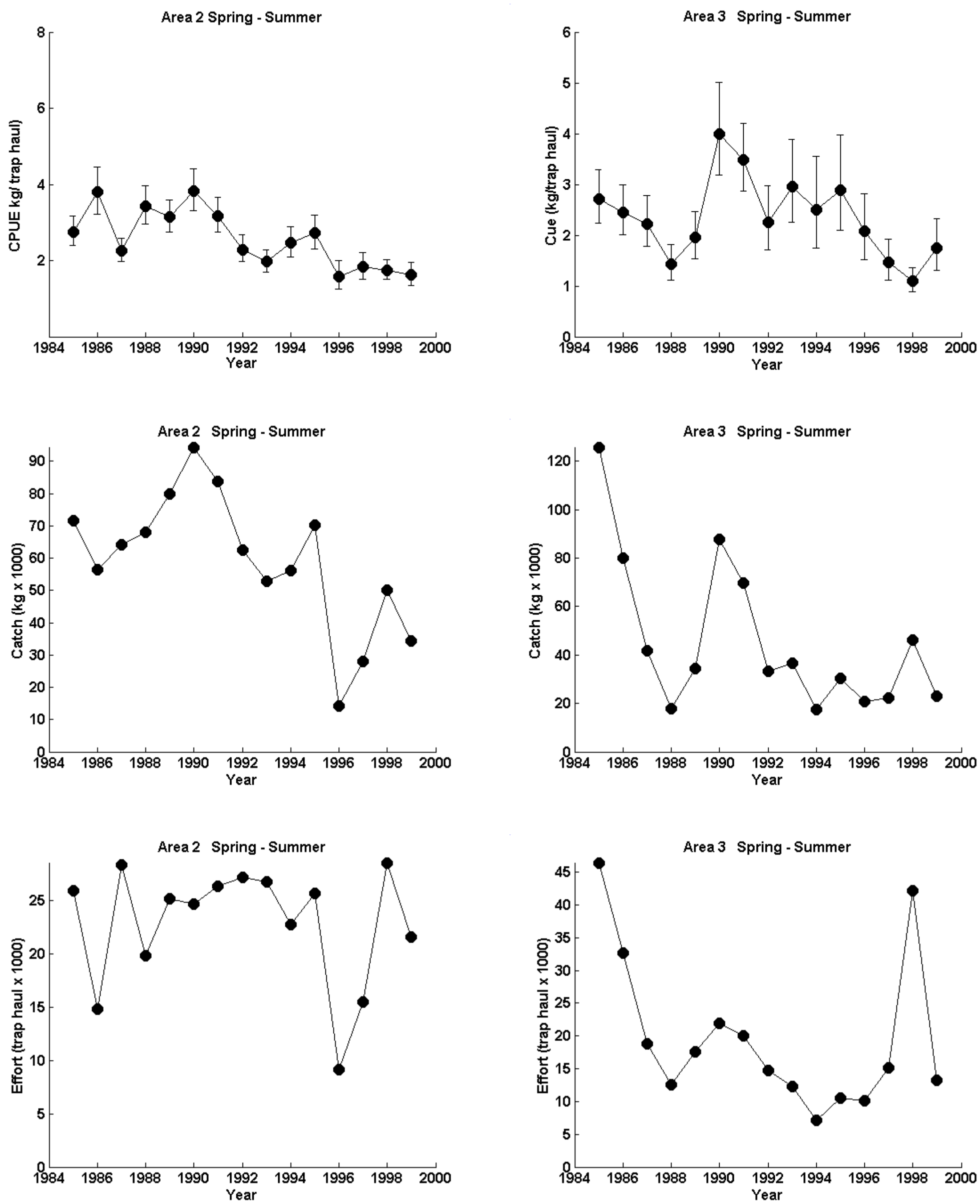



Fig. 15. Catch rate (kg/ haul) (CPUE) for Areas 2 and 3, Spring - Summer anova models. Left column is the analysis for 1985-2000 and right column is for 1994-2000 with crab and captain effects. Year is the year the Fall-Winter portion of the season began, see text.

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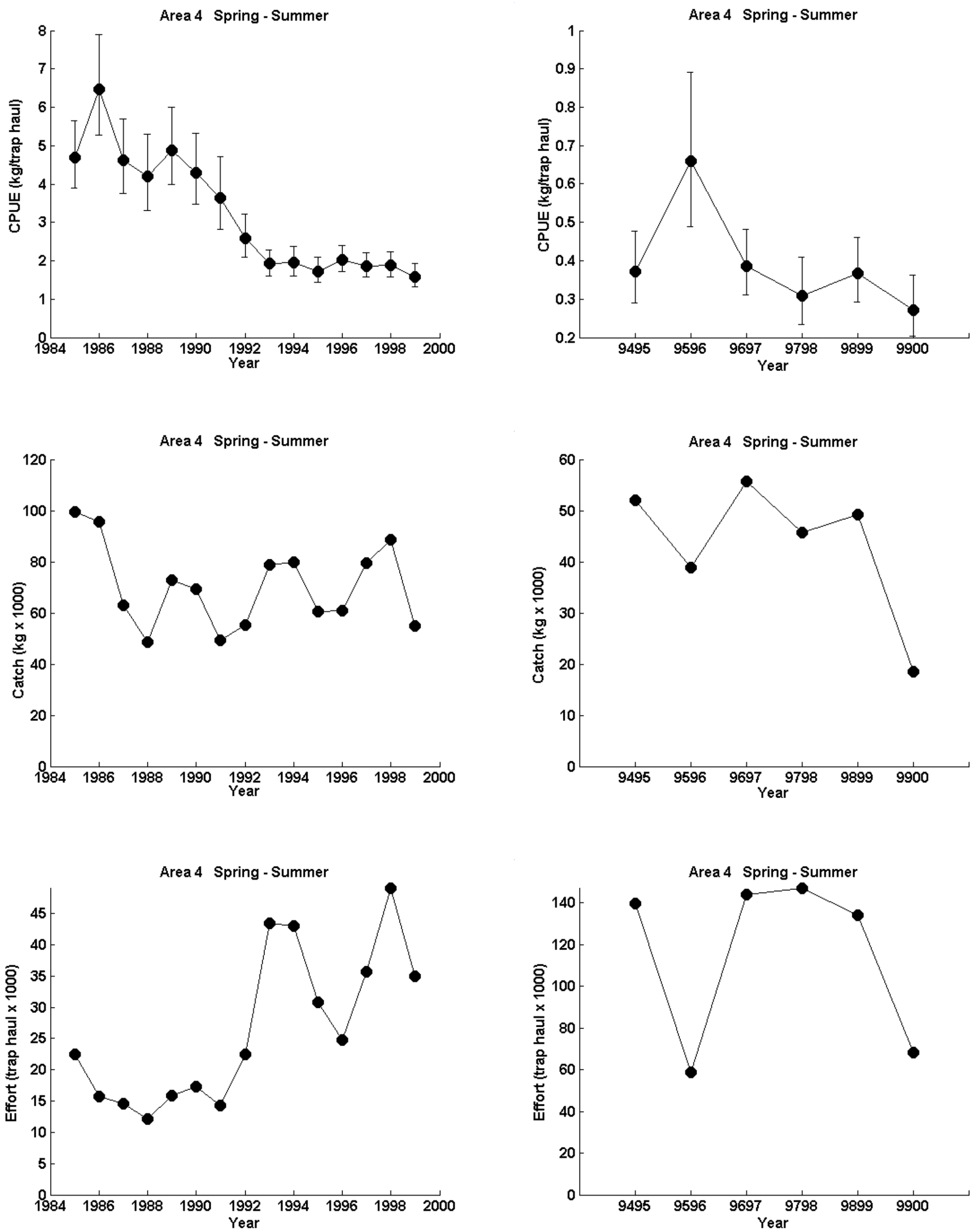



Fig. 16. Catch rate (kg/ haul) (CPUE) for Area 4, Spring - Summer anova models. Left column is the analysis for 1985-2000 and right column is for 1994-2000 with crab and captain effects. Year axis for the left hand column indicates year when Fall-Winter portion of the season began, see text.

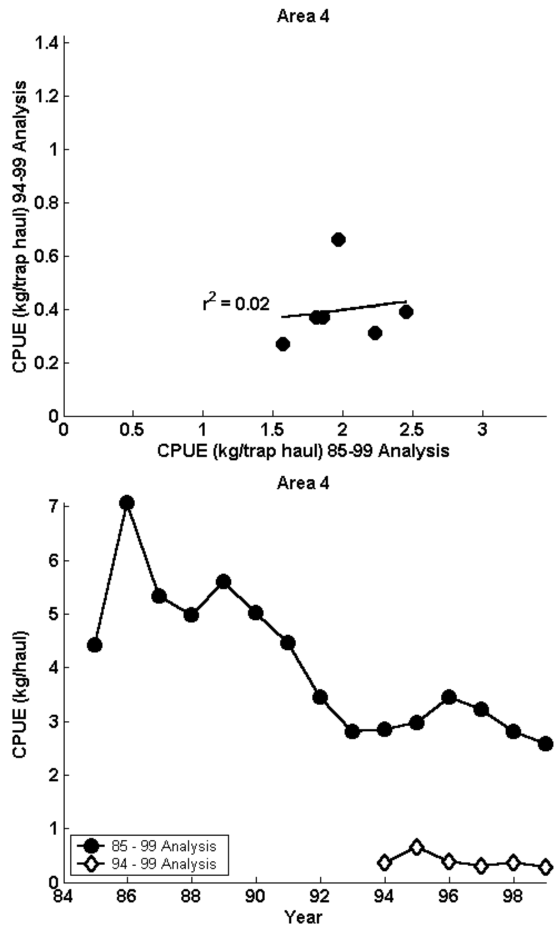



Fig. 17. Comparison of CPUE for 1985-2000 and 1994-2000 model for Area 4, Spring - Summer. Top panel is correlation with r2 between the CPUE for each model, and bottom panel is the CPUE over time for each model. Year is the year the Fall-Winter portion of the season began, see text.

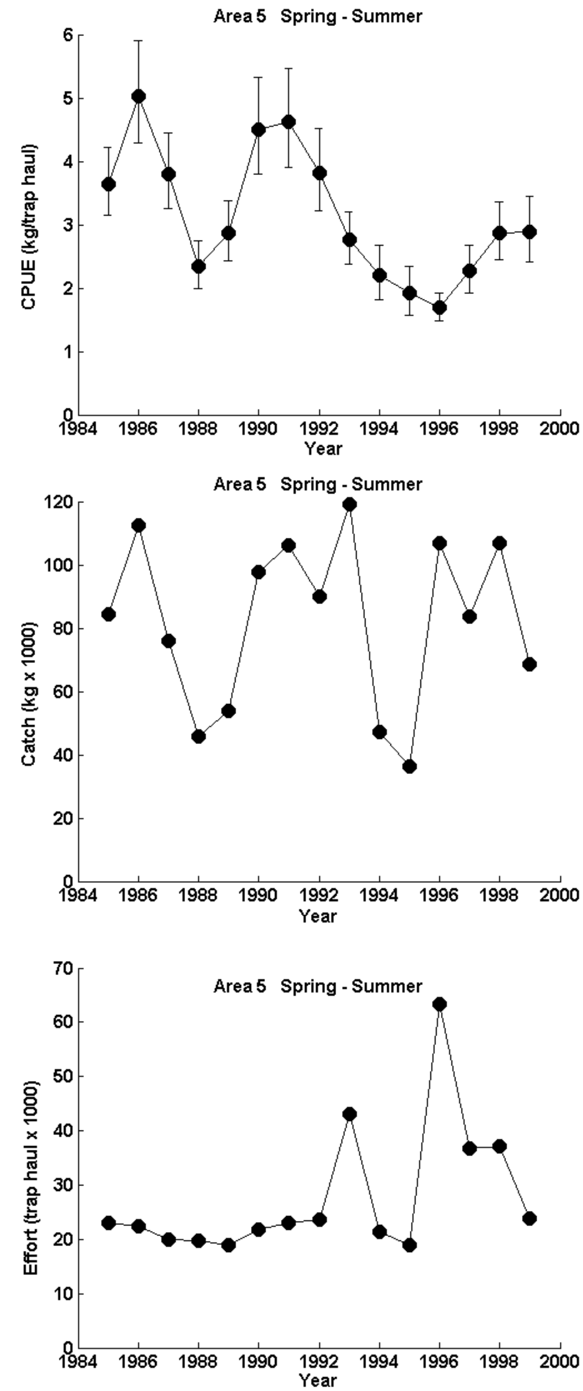



Fig. 18. Catch rate (kg/ haul) (CPUE) for Area 5, Spring - Summer anova models. Left column is the analysis for 1985-2000 and right column is for 1994-2000 with crab and captain effects. Year axis for the left hand column indicates year when Fall-Winter season began, see text.

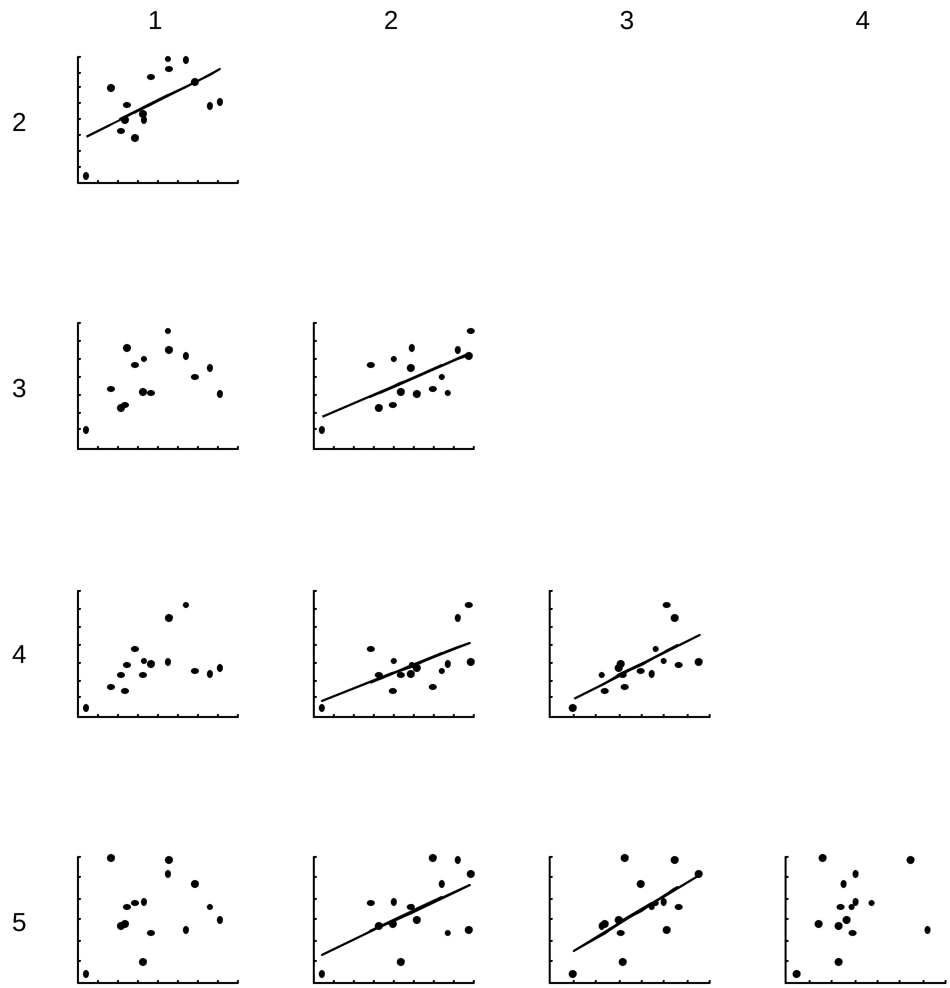



Fig. 19. Regression analyses between LFA 41 Fall-Winter fishing areas for CPUE. Regressions with p-values < 0.05 are shown with prediction linear regression line. Analyses are for 1985-2000. X–axis for each figure is the CPUE (kg/haul) for the area indicated along the top row, and the y-axis is the CPUE for the area indicated in the left hand column.

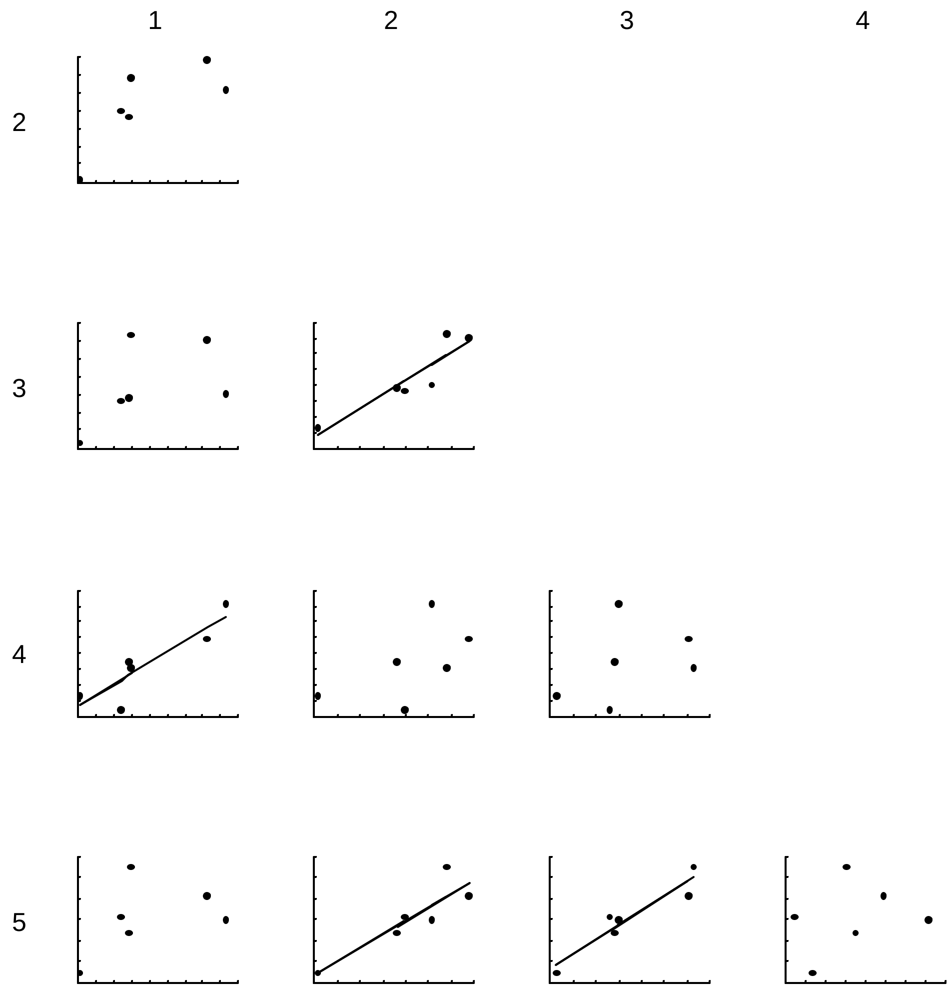



Fig. 20. Regression analyses between LFA 41 Fall-Winter fishing areas for CPUE. Regressions with p-values < 0.05 are shown with prediction linear regression line. Analyses are for 1994-2000. X–axis for each figure is the CPUE (kg/haul) for the area indicated along the top row, and the y-axis is the CPUE for the area indicated in the left hand column.

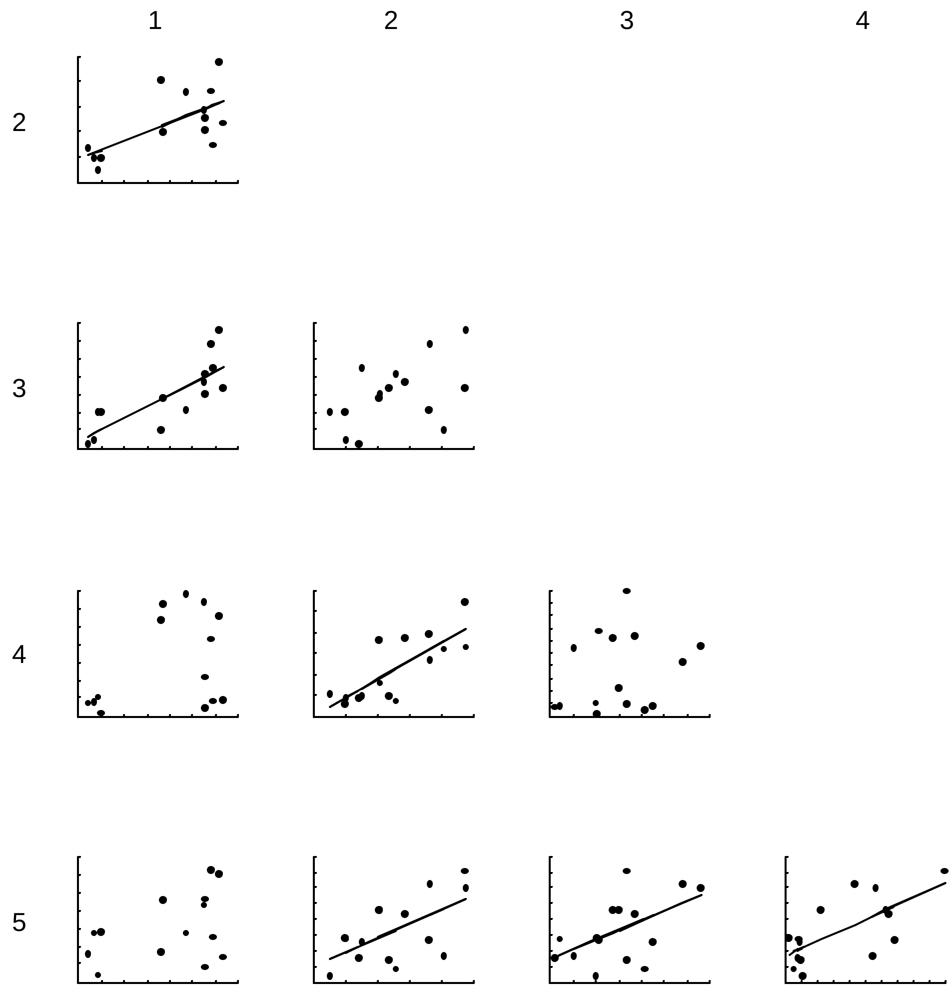



Fig. 21. Regression analyses between LFA 41 Spring-Summer fishing areas for CPUE. Regressions with p-values < 0.05 are shown with prediction linear regression line. Analyses are for 1985-2000. X–axis for each figure is the CPUE (kg/haul) for the area indicated along the top row, and the y-axis is the CPUE for the area indicated in the left hand column.

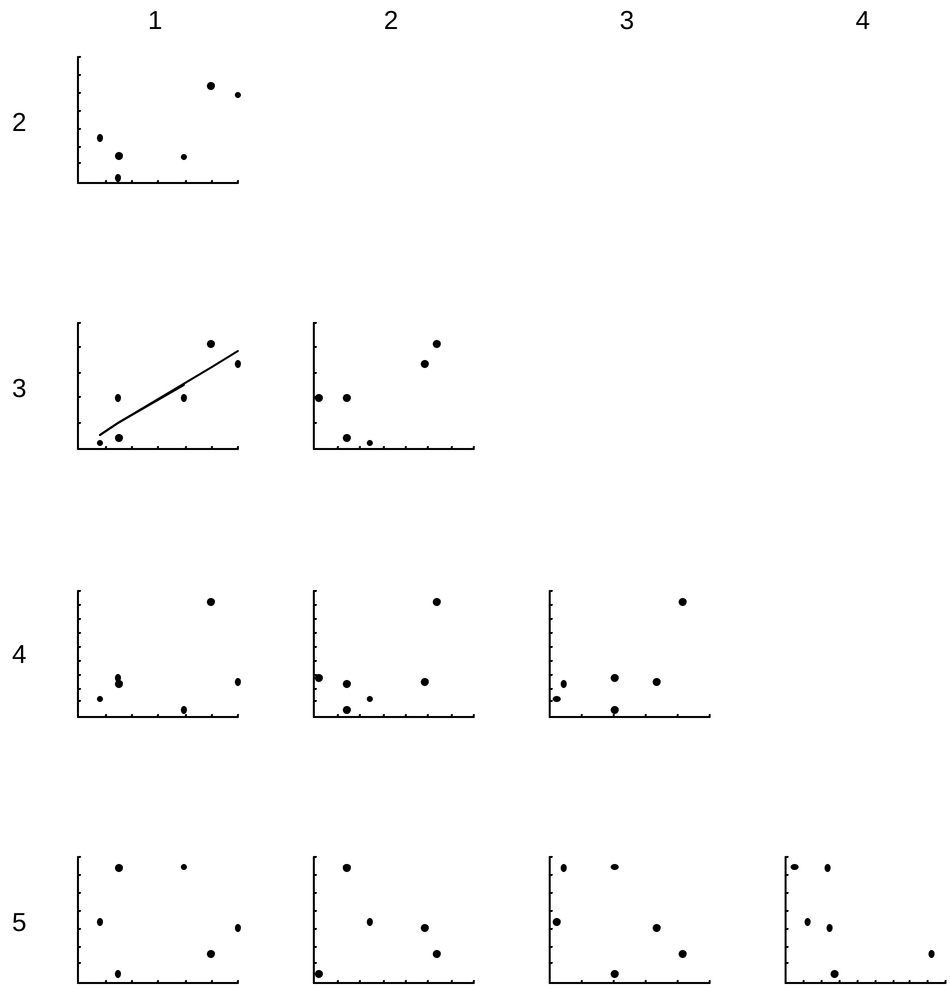



Fig. 22. Regression analyses between LFA 41 Spring-Summer fishing areas for CPUE. Regressions with p-values < 0.05 are shown with prediction linear regression line. Analyses are for 1994-2000. X–axis for each figure is the CPUE (kg/haul) for the area indicated along the top row, and the y-axis is the CPUE for the area indicated in the left hand column.

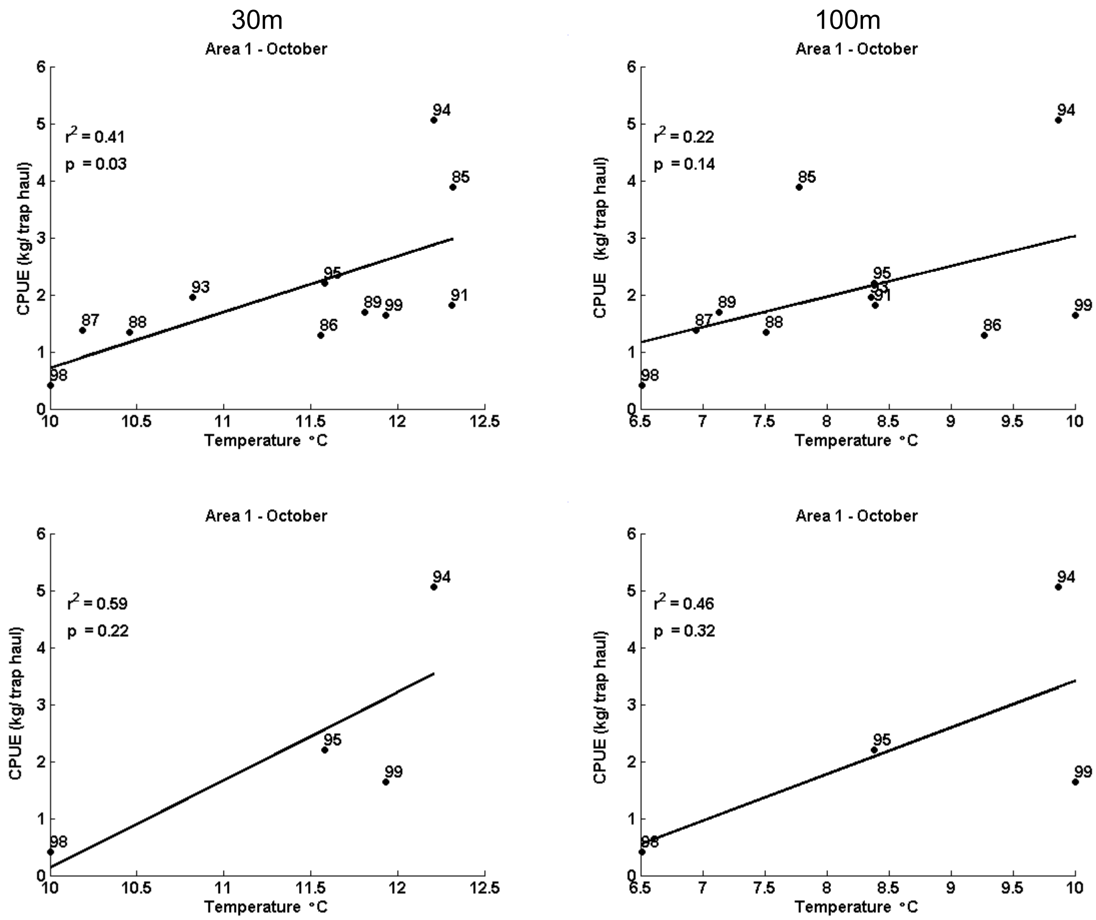



Fig. 23. Results of regression analysis between mean monthly temperature and catch rates for fishing Area 1 and temperature Area 43 at 30m and 100m during October for all possible years. Top row is 1985-2000 data and bottom row is 1994-2000 data. Year is the year the Fall-Winter portion of the season began, see text.

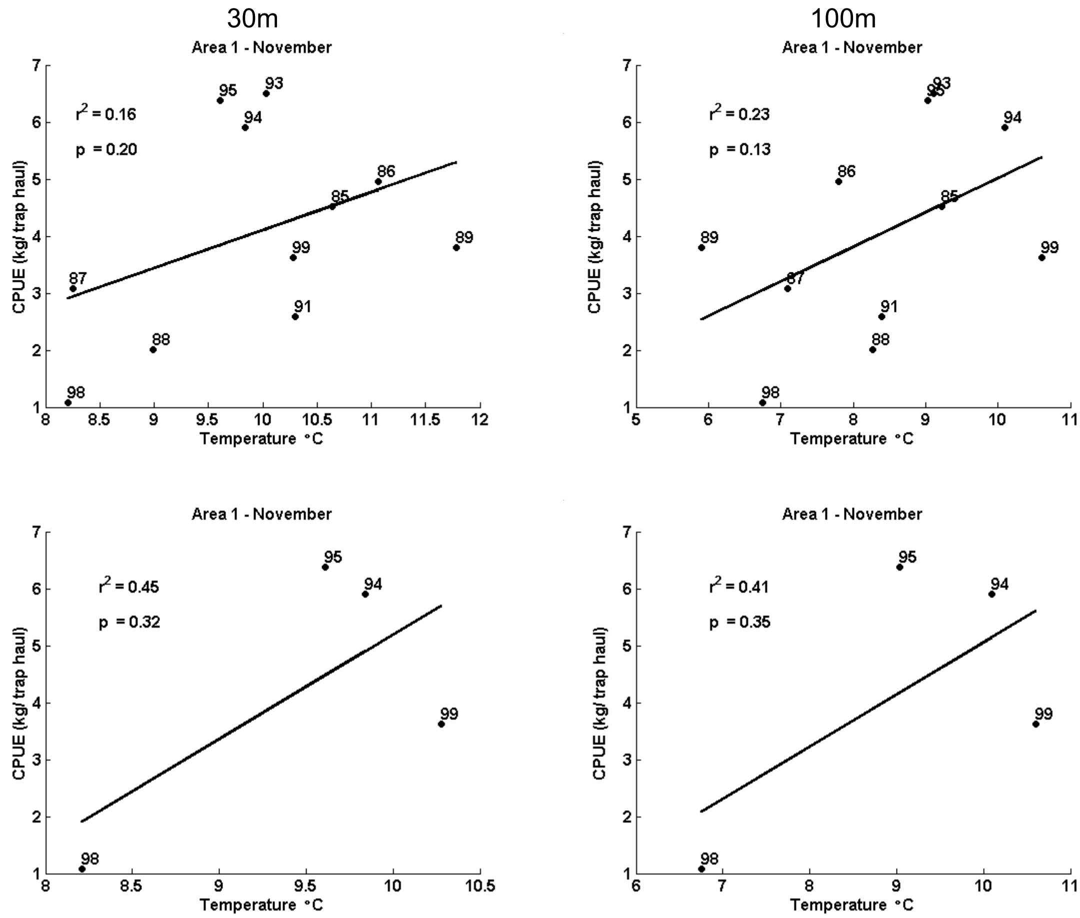


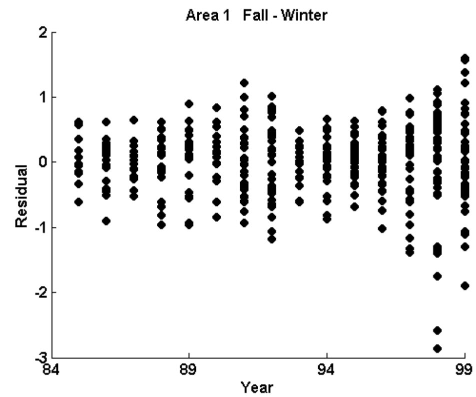

Fig. 24. Results of regression analysis between mean monthly temperature and catch rates for fishing Area 1 and temperature Area 43 at 30m and 100m during November for all possible years. Top row is 1985-2000 data and bottom row is 1994-2000 data. Year is the year the Fall-Winter portion of the season began, see text.

Appendix T.1. Anova results for LFA 41 Area 1, Fall – Winter 1985-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 108.72 | 14 | 7.76571 | 25.95 | 0 |
| 14DayWeek | 52.395 | 11 | 4.76314 | 15.92 | 0 |
| Error | 128.96 | 431 | 0.29921 | | |
| Total | 321.2 | 456 | | | |

Constrained (Type III) sums of squares.

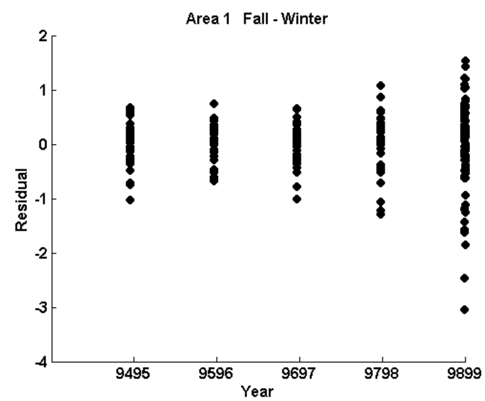



Appendix T.2. Anova results for LFA 41 Area 1, Fall – Winter 1994-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 23.9076 | 5 | 4.78152 | 29.64 | 0 |
| 14DayWeek | 30.7009 | 11 | 2.79099 | 17.3 | 0 |
| CrabPercent | 0.5708 | 1 | 0.57083 | 3.54 | 0.0621 |
| Captain | 2.9615 | 2 | 1.48077 | 9.18 | 0.0002 |
| Error | 22.0999 | 137 | 0.16131 | | |
| Total | 85.7801 | 156 | | | |

Constrained (Type III) sums of squares.

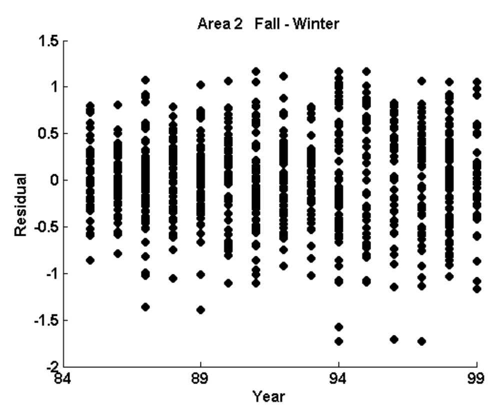



Appendix T.3. Anova results for LFA 41 Area 2, Fall – Winter 1985-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 88.513 | 14 | 6.3224 | 26.2 | 0 |
| 14DayWeek | 114.776 | 11 | 10.4342 | 43.24 | 0 |
| Error | 221.512 | 918 | 0.2413 | | |
| Total | 431.141 | 943 | | | |

Constrained (Type III) sums of squares.

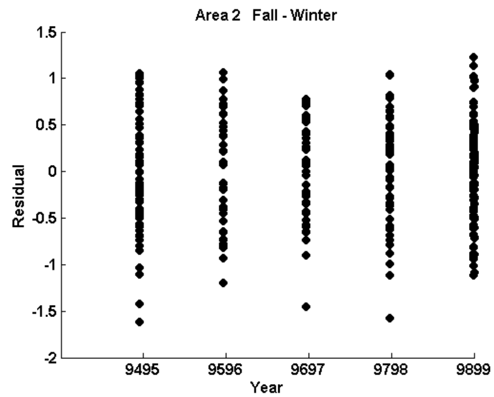


Appendix T.4. Anova results for LFA 41 Area 2, Fall – Winter 1994-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

**Analysis of Variance**

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 26.2986 | 5 | 5.25972 | 24.11 | 0 |
| 14DayWeek | 18.9862 | 9 | 2.10958 | 9.67 | 0 |
| CrabPercent | 0.7559 | 1 | 0.75589 | 3.46 | 0.0645 |
| Captain | 7.7927 | 2 | 3.89636 | 17.86 | 0 |
| Error | 36.2163 | 166 | 0.21817 | | |
| Total | 98.4456 | 183 | | | |

Constrained (Type III) sums of squares.

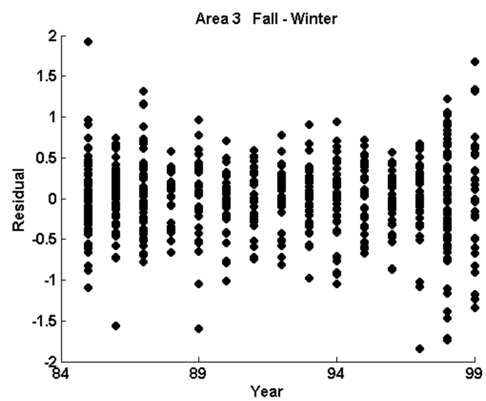



Appendix T.5. Anova results for LFA 41 Area 3, Fall – Winter 1985-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

**Analysis of Variance**

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 92.438 | 14 | 6.60271 | 30.04 | 0 |
| 14DayWeek | 67.59 | 11 | 6.14451 | 27.96 | 0 |
| Error | 162.196 | 738 | 0.21978 | | |
| Total | 336.972 | 763 | | | |

Constrained (Type III) sums of squares.

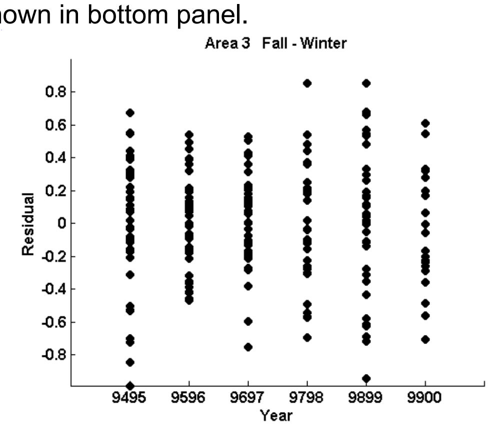



Appendix T.6. Anova results for LFA 41 Area 3, Fall – Winter 1994-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

**Analysis of Variance**

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 8.5373 | 5 | 1.70745 | 12.49 | 0 |
| # 14DayWeek | 8.7642 | 10 | 0.87642 | 6.41 | 0 |
| # CrabPercent | 0.3733 | 1 | 0.37332 | 2.73 | 0.0999 |
| Captain | 3.8929 | 2 | 1.94645 | 14.24 | 0 |
| Error | 27.7462 | 203 | 0.13668 | | |
| Total | 49.7144 | 222 | | | |

Constrained (Type III) sums of squares. Terms marked with # are not full rank.

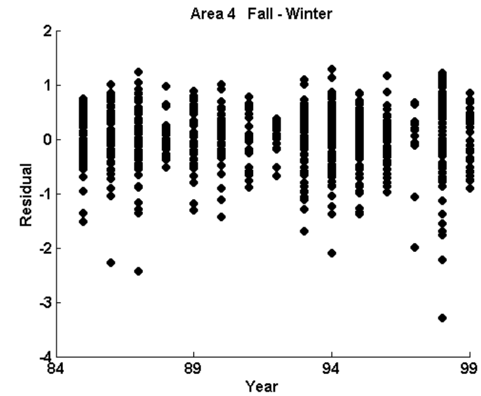


Appendix T.7. Anova results for LFA 41 Area 4, Fall – Winter 1985-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 117.907 | 14 | 8.42196 | 25.1 | 0 |
| 14DayWeek | 71.891 | 11 | 6.53552 | 19.48 | 0 |
| Error | 247.303 | 737 | 0.33555 | | |
| Total | 445.632 | 762 | | | |

Constrained (Type III) sums of squares.

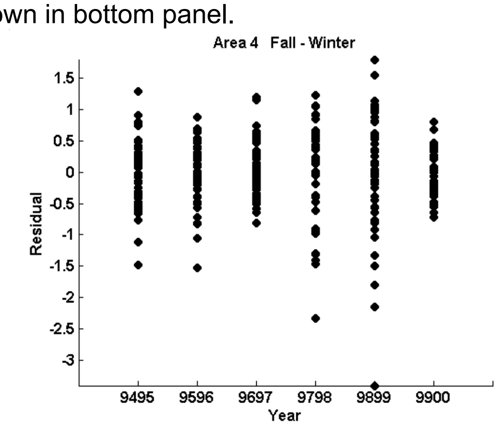



Appendix T.8. Anova results for LFA 41 Area 4, Fall – Winter 1994-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 37.52 | 5 | 7.504 | 17.63 | 0 |
| 14DayWeek | 47.032 | 11 | 4.27562 | 10.04 | 0 |
| CrabPercent | 1.045 | 2 | 0.52229 | 1.23 | 0.2948 |
| Captain | 10.768 | 2 | 5.38412 | 12.65 | 0 |
| Error | 114.511 | 269 | 0.42569 | | |
| Total | 231.858 | 289 | | | |

Constrained (Type III) sums of squares.

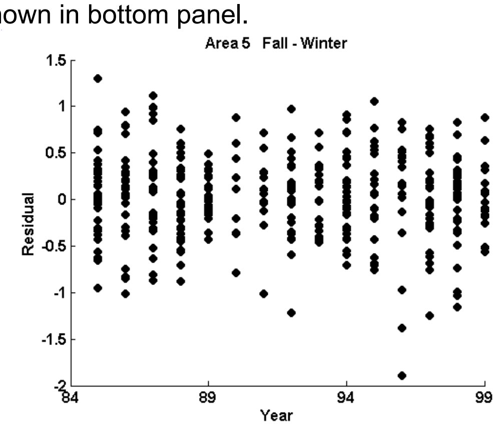



Appendix T.9. Anova results for LFA 41 Area 5, Fall – Winter 1985-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 19.838 | 14 | 1.41703 | 7.48 | 0 |
| 14DayWeek | 43.708 | 11 | 3.97347 | 20.96 | 0 |
| Error | 89.846 | 474 | 0.18955 | | |
| Total | 154.049 | 499 | | | |

Constrained (Type III) sums of squares.

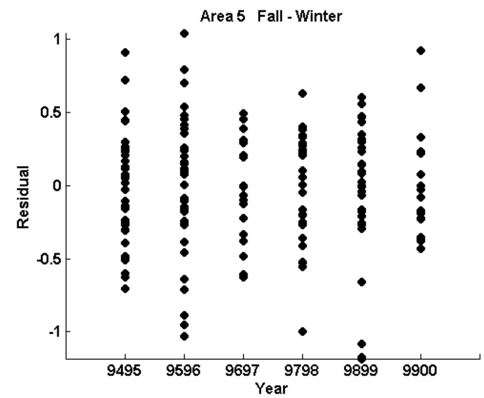


Appendix T.10. Anova results for LFA 41 Area 5, Fall – Winter 1994-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 7.8897 | 5 | 1.57793 | 8.76 | 0 |
| 14DayWeek | 18.3117 | 11 | 1.6647 | 9.24 | 0 |
| CrabPercent | 1.4581 | 2 | 0.72907 | 4.05 | 0.0194 |
| Captain | 0.5854 | 2 | 0.29269 | 1.62 | 0.2003 |
| Error | 27.7401 | 154 | 0.18013 | | |
| Total | 53.9466 | 174 | | | |

Constrained (Type III) sums of squares.

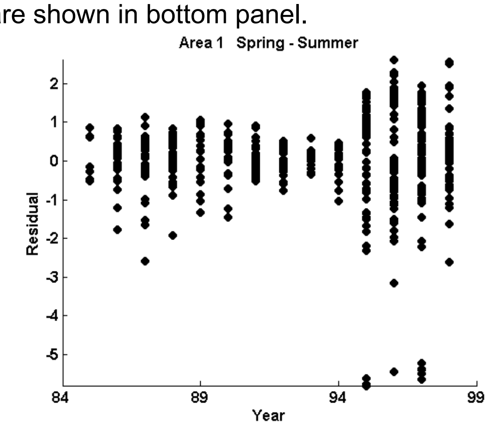



Appendix T.11. Anova results for LFA 41 Area 1, Spring - Summer 1985-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 364.667 | 13 | 28.0513 | 46.84 | 0 |
| 14DayWeek | 28.947 | 13 | 2.2267 | 3.72 | 0 |
| Error | 261.707 | 437 | 0.5989 | | |
| Total | 663.864 | 463 | | | |

Constrained (Type III) sums of squares.

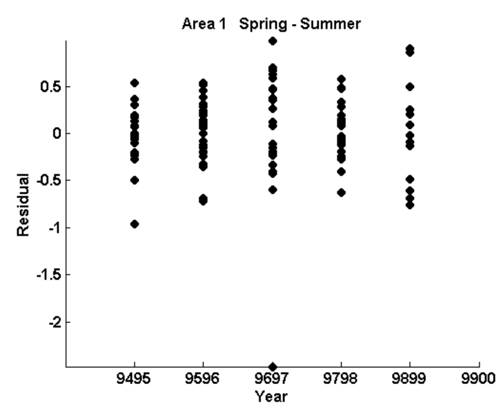



Appendix T.12. Anova results for LFA 41 Area 1, Spring - Summer 1994-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 6.4388 | 4 | 1.6097 | 6.96 | 0.0001 |
| 14DayWeek | 14.1346 | 13 | 1.08728 | 4.7 | 0 |
| CrabPercent | 0.6332 | 2 | 0.3166 | 1.37 | 0.2593 |
| Error | 21.9672 | 95 | 0.23123 | | |
| Total | 50.9348 | 114 | | | |

Constrained (Type III) sums of squares.

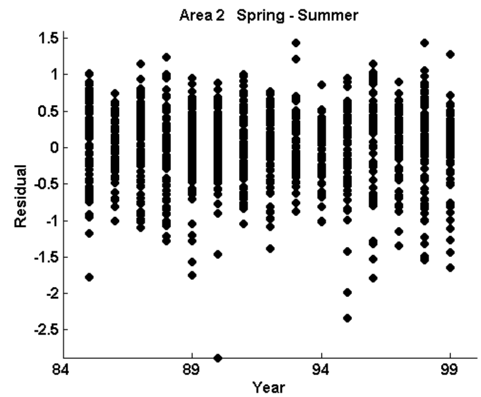


Appendix T.13. Anova results for LFA 41 Area 2, Spring - Summer 1985-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 76.772 | 14 | 5.4837 | 21.28 | 0 |
| 14DayWeek | 80.54 | 13 | 6.19537 | 24.04 | 0 |
| Error | 279.612 | 1085 | 0.25771 | | |
| Total | 450.056 | 1112 | | | |

Constrained (Type III) sums of squares.

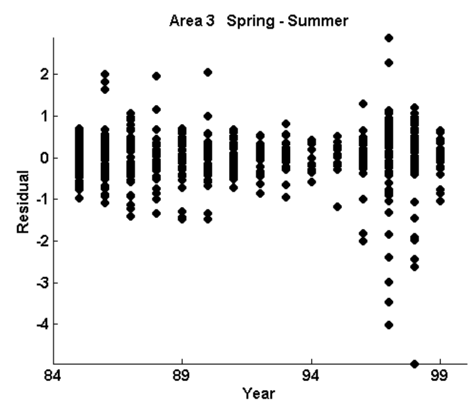



Appendix T.14. Anova results for LFA 41 Area 3, Spring - Summer 1985-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 76.228 | 14 | 5.44486 | 17.6 | 0 |
| 14DayWeek | 52.893 | 13 | 4.06868 | 13.15 | 0 |
| Error | 196.749 | 636 | 0.30935 | | |
| Total | 346.948 | 663 | | | |

Constrained (Type III) sums of squares.

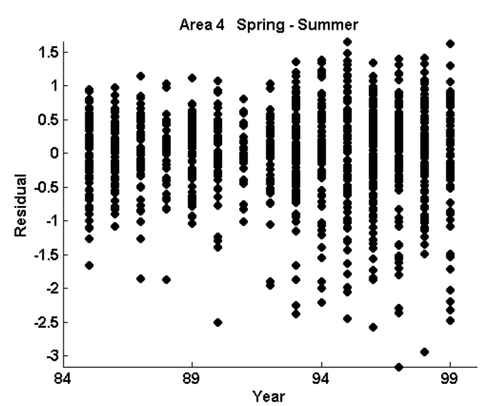



Appendix T.15. Anova results for LFA 41 Area 4, Spring - Summer 1985-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 176.562 | 14 | 12.6116 | 29.18 | 0 |
| 14DayWeek | 108.361 | 13 | 8.3355 | 19.29 | 0 |
| Error | 418.823 | 969 | 0.4322 | | |
| Total | 709.733 | 996 | | | |

Constrained (Type III) sums of squares.

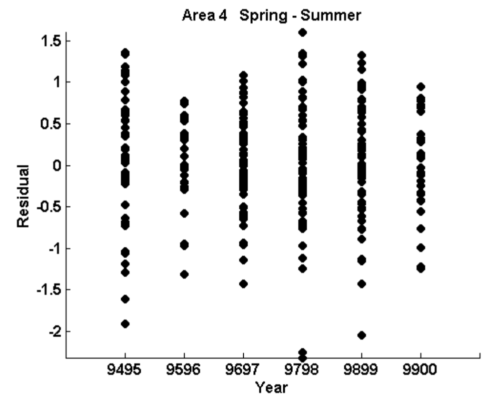


Appendix T.16. Anova results for LFA 41 Area 4, Spring - Summer 1994-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 13.105 | 5 | 2.62094 | 5.92 | 0 |
| 14DayWeek | 117.354 | 13 | 9.02721 | 20.38 | 0 |
| Captain | 16.85 | 2 | 8.42501 | 19.02 | 0 |
| Error | 135.532 | 306 | 0.44292 | | |
| Total | 287.229 | 326 | | | |

Constrained (Type III) sums of squares.




Appendix T.17. Anova results for LFA 41 Area 5, Spring - Summer 1985-2000 analysis showing Type 3 sum of squares (top). Residuals for model are shown in bottom panel.

Analysis of Variance

| Source | Sum Sq. | d.f. | Mean Sq. | F | Prob>F |
|---|---|---|---|---|---|
| Year | 80.783 | 14 | 5.7702 | 22.49 | 0 |
| 14DayWeek | 184.111 | 13 | 14.1624 | 55.2 | 0 |
| Error | 224.751 | 876 | 0.2566 | | |
| Total | 603.461 | 903 | | | |

Constrained (Type III) sums of squares.