# Standardized indices of abundance for Smooth Dogfish, *Mustelus canis*, from the Rhode Island Department of Environmental Management trawl surveys

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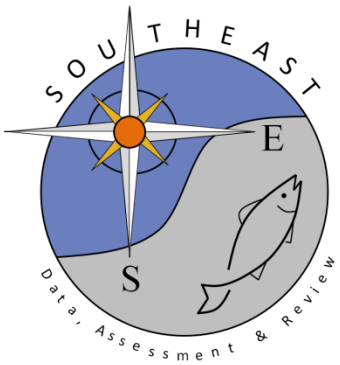

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# SEDAR 39 DATA WORKSHOP DOCUMENT

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***Summary***

This document details the smooth dogfish catch from the Rhode Island Department of Environmental Management monthly trawl survey in Narragansett Bay from 1990-2013 and seasonal trawl survey in Block Island Sound, Rhode Island Sound, and Narragansett Bay from 1979-2013. Catch per unit effort (CPUE) in number of sharks per 20 minute tow were examined by year. The CPUE was standardized using a two-step delta-lognormal approach that models the proportion of positive catch with a binomial error distribution separately from the positive catch, which is modeled using a lognormal distribution. Both time series show an overall increasing trend in relative abundance.

***Introduction***

The Rhode Island Department of Environmental Management (RIDEM) Division of Fish and Wildlife – Marine Fisheries Section, began monitoring finfish populations in Narragansett Bay in 1968, and continues through present day. The Rhode Island Coastal Trawl Surveys document recreationally important finfish species distribution, relative abundance and size composition. The seasonal trawl survey is conducted in the spring and fall of each year and covers Narragansett Bay, Rhode Island and Block Island Sounds. The monthly trawl survey primarily samples stations in Narragansett Bay. Data from these surveys are used to assess the status of finfish populations and ultimately improve fisheries regulations. In this document, the RIDEM trawl time series are modeled to create standardized indices of abundance for smooth dogfish, *Mustelus canis*.

***Methods***

**Sampling gear and survey design**

The RIDEM seasonal and monthly bottom trawl surveys are conducted using a standard otter trawl with an average wingspread of 6 m (20 ft), a 13.7 m headrope, 18.3 m (60 ft) footrope, 0.95 cm (0.375 inch) stretched mesh cod end and a 0.64 cm (0.25 inch) mesh liner. The net is towed for 20 minutes at 2.5 knots (4.63 km/hour) at each station. The seasonal survey is conducted during the spring (April/May) and fall (September/October) each year at 44 fixed and random stations in Narragansett Bay, Rhode Island Sound and Block Island Sound. The seasonal survey originally used a random stratified design based on depth strata. Based on the frequency of replicate stations selected by depth stratum since 1979, a fixed station allocation began in 1988 in Rhode Island and Block Island Sounds. Seasonal sampling began in 1968, but has been conducted continually since 1979. The monthly trawl survey began in 1990 and consists of 13 fixed stations and 14 randomly selected stations from a predefined grid of Narragansett Bay, which are also used during the seasonal survey. Data on wind direction and speed, sea condition, air temperature and cloud cover as well as surface and bottom water temperatures, are recorded at each station. Catch is sorted by species. Length (cm/mm) is recorded for all finfish, skates, squid, scallops, whelk, lobster, blue crabs and horseshoe crabs. Aggregate weights (gm/kg) and numbers are recorded by species as well.

**Data Analysis**

Catch per unit effort (CPUE) in number of sharks per 20 minute tow were used to examine the relative abundance of smooth dogfish caught during the RIDEM seasonal and monthly trawl surveys. The CPUE was standardized using the Lo et al. (2002) method which models the proportion of positive tows separately from the positive catch. Factors considered as potential influences on the CPUE for these analyses were: year, month and station for the monthly survey and year, season, and depth strata for the seasonal survey. The proportion of

tows with positive CPUE values was modeled assuming a binomial distribution with a logit link function and the positive CPUE tows were modeled assuming a lognormal distribution.

Models were fit in a stepwise forward manner adding one potential factor at a time after initially running a null model with no factors included (Gonzáles-Ania et al. 2001, Carlson 2002). Each potential factor was ranked from greatest to least reduction in deviance per degree of freedom when compared to the null model. The factor resulting in the greatest reduction in deviance was then incorporated into the model providing the deviance per degree freedom was reduced by at least 1% from the less complex model. This process was continued until no additional factors met the criteria for incorporation into the final model. The factor "year" was kept in all final models to allow for calculation of indices. All models in the stepwise approach were fitted using the SAS GENMOD procedure (SAS Institute, Inc.). The final models were then run through the SAS GLIMMIX macro to allow fitting of the generalized linear mixed models using the SAS MIXED procedure (Wolfinger, SAS Institute, Inc). The standardized indices of abundance were based on the year effect least square means determined from the combined binomial and lognormal components.

Available smooth dogfish lengths were converted from total length to fork length using the following formula (provided by the SEDAR 39 Life History Working Group Chair, William B. Driggers):

Sexes combined: TLcm = 3.43329 + 1.09539*FLcm

***Results***

**Monthly Survey**

A total of 703 smooth dogfish were caught during 3197 tows. The proportion of tows with positive catch (at least one smooth dogfish was caught) was 22%. Smooth dogfish ranged in length from 16 to 100 cm FL (Figure 1). The stepwise construction of each model and the resulting statistics are detailed in Table 1. Model diagnostic plots reveal that the model fit is acceptable (Figures 2a and 2b). The resulting indices of abundance based on the year effect least square means, associated statistics, and nominal indices are reported in Table 2 and are plotted by year in Figure 3. The standardized relative abundance for smooth dogfish shows an overall increasing trend in relative abundance with a large peak in abundance in 2003 (Figure 3). This peak in 2003 was also seen in the URI Trawl Survey conducted in Narragansett Bay (McCandless 2014)

**Seasonal Survey**

A total of 683 smooth dogfish were caught during 3155 tows. The proportion of tows with positive catch (at least one smooth dogfish was caught) was 6%. No smooth dogfish were caught in 1979 and 1988. Smooth dogfish ranged in length from 35 to 101 cm FL (Figure 4). The stepwise construction of each model and the resulting statistics are detailed in Table 3. Model diagnostic plots reveal that the model fit is acceptable

(Figures 5a and 5b). The resulting indices of abundance based on the year effect least square means, associated statistics, and nominal indices are reported in Table 4 and are plotted by year in Figure 6. The nominal and standardized relative abundance for smooth dogfish shows an overall increasing trend in relative abundance with a large peak in nominal abundance in 2003 that modeling accounted for in the standardized time series (Figure 6).

***References***

Carlson J.K. 2002. A fishery-independent assessment of shark stock abundance for large coastal species in the northeast Gulf of Mexico. Panama City Laboratory Contribution Series 02-08. 26pp.

González-Ania, L.V., C.A. Brown, and E. Cortés. 2001. Standardized catch rates for yellowfin tuna (*Thunnus albacares*) in the 1992-1999 Gulf of Mexico longline fishery based upon observer programs from Mexico and the United States. Col. Vol. Sci. Pap. ICCAT 52:222-237.

Lo, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

Table 1. Results of the stepwise procedure for development of the RIDEM monthly trawl survey catch rate model for smooth dogfish. DF is the degrees of freedom. %DIF is the percent difference in deviance/DF between each model and the null model. Delta% is the difference in deviance/DF between the newly included factor and the previous entered factor in the model.

**PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION**

| FACTOR | DF | DEVIANCE | DEVIANCE/DF | %DIFF | DELTA% |
|---|---|---|---|---|---|
| NULL | 892 | 697.3124 | 0.7817 | | |
| STATION | 981 | 684.6551 | 0.6979 | 10.7202 | 10.7202 |
| MONTH | 986 | 782.9205 | 0.7940 | | |
| YEAR | 974 | 773.8690 | 0.7945 | | |
| STATION + | | | | | |
| YEAR | 958 | 602.3051 | 0.6287 | 19.5727 | 8.8525 |
| MONTH | 970 | 643.5653 | 0.6635 | 15.1209 | 4.4007 |
| STATION + YEAR + | | | | | |
| MONTH | 947 | 563.0896 | 0.5946 | 23.9350 | 8.8141 |

| FINAL MODEL | AIC | BIC | (-2) Res Log Likelihood |
|---|---|---|---|
| STATION + YEAR + MONTH | 5909.3 | 5914.2 | 5907.3 |

**Type 3 Test of Fixed Effects**

| Significance (Pr>Chi) of Type 3 test of fixed effects for each factor | STATION | YEAR | MONTH |
|---|---|---|---|
| DF | 13 | 23 | 11 |
| CHI SQUARE | 98.13 | 69.67 | 33.88 |

**POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION**

| FACTOR | DF | DEVIANCE | DEVIANCE/DF | %DIFF | DELTA% |
|---|---|---|---|---|---|
| NULL | 147 | 147.0205 | 1.0001 | | |
| STATION | 133 | 128.0550 | 0.9628 | 3.7296 | 3.7296 |
| YEAR | 124 | 125.8731 | 1.0151 | -1.4999 | |
| MONTH | 136 | 139.4794 | 1.0256 | -2.5497 | |
| STATION + | | | | | |
| YEAR | 110 | 99.5764 | 0.9052 | 9.4891 | 5.7594 |

| FINAL MODEL | AIC | BIC | (-2) Res Log Likelihood |
|---|---|---|---|
| STATION + YEAR | 357.6 | 360.3 | 355.6 |

**Type 3 Test of Fixed Effects**

| Significance (Pr>Chi) of Type 3 test of fixed effects for each factor | STATION | YEAR |
|---|---|---|
| DF | 14 | 23 |
| CHI SQUARE | 29.05 | 31.46 |

Table 2. RIDEM monthly trawl survey smooth dogfish analysis number of tows (n tows), number of sharks (catch), number of model observations per year (n obs), number of positive model observations per year (obs pos), proportion of positive model observations per year (obs ppos), nominal cpue as sharks per 20 minute tow (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCL), the upper 95% confidence limit for the est cpue (UCL), and the coefficient of variation for the estimated cpue (CV).

| year | n tows | catch | n obs | obs pos | obs ppos | obs cpue | est cpue | LCL | UCL | CV |
|---|---|---|---|---|---|---|---|---|---|---|
| 1990 | 137 | 78 | 32 | 4 | 0.1250 | 2.4375 | 1.5488 | 0.4469 | 5.3679 | 0.6866 |
| 1991 | 89 | 1 | 25 | 1 | 0.0400 | 0.0400 | 0.0529 | 0.0071 | 0.3939 | 1.3182 |
| 1992 | 131 | 5 | 35 | 4 | 0.1143 | 0.1429 | 0.1675 | 0.0485 | 0.5789 | 0.6847 |
| 1993 | 100 | 17 | 32 | 10 | 0.3125 | 0.5313 | 1.2646 | 0.5886 | 2.7170 | 0.3968 |
| 1994 | 143 | 21 | 33 | 5 | 0.1515 | 0.6364 | 0.4685 | 0.1497 | 1.4661 | 0.6201 |
| 1995 | 149 | 1 | 34 | 1 | 0.0294 | 0.0294 | 0.0452 | 0.0062 | 0.3279 | 1.2920 |
| 1996 | 139 | 26 | 34 | 8 | 0.2353 | 0.7647 | 1.5143 | 0.6162 | 3.7213 | 0.4733 |
| 1997 | 137 | 5 | 31 | 4 | 0.1290 | 0.1613 | 0.3183 | 0.0921 | 1.0995 | 0.6844 |
| 1998 | 153 | 9 | 34 | 4 | 0.1176 | 0.2647 | 0.3030 | 0.0889 | 1.0335 | 0.6759 |
| 1999 | 136 | 1 | 32 | 1 | 0.0313 | 0.0313 | 0.0226 | 0.0031 | 0.1639 | 1.2896 |
| 2000 | 107 | 22 | 34 | 7 | 0.2059 | 0.6471 | 1.1236 | 0.4402 | 2.8677 | 0.4954 |
| 2001 | 111 | 69 | 31 | 10 | 0.3226 | 2.2258 | 2.3756 | 1.1336 | 4.9782 | 0.3829 |
| 2002 | 125 | 13 | 34 | 2 | 0.0588 | 0.3824 | 0.3909 | 0.0786 | 1.9438 | 0.9500 |
| 2003 | 119 | 127 | 34 | 16 | 0.4706 | 3.7353 | 4.6631 | 2.7186 | 7.9983 | 0.2748 |
| 2004 | 119 | 11 | 38 | 7 | 0.1842 | 0.2895 | 0.5254 | 0.1947 | 1.4178 | 0.5286 |
| 2005 | 133 | 15 | 38 | 5 | 0.1316 | 0.3947 | 0.7358 | 0.2338 | 2.3151 | 0.6236 |
| 2006 | 114 | 4 | 35 | 3 | 0.0857 | 0.1143 | 0.1425 | 0.0356 | 0.5707 | 0.7860 |
| 2007 | 140 | 16 | 36 | 6 | 0.1667 | 0.4444 | 0.6844 | 0.2449 | 1.9129 | 0.5498 |
| 2008 | 155 | 16 | 24 | 2 | 0.0833 | 0.6667 | 0.8983 | 0.1826 | 4.4179 | 0.9412 |
| 2009 | 150 | 19 | 23 | 5 | 0.2174 | 0.8261 | 1.1066 | 0.3737 | 3.2769 | 0.5853 |
| 2010 | 152 | 61 | 23 | 6 | 0.2609 | 2.6522 | 1.6253 | 0.6057 | 4.3608 | 0.5251 |
| 2011 | 155 | 38 | 23 | 6 | 0.2609 | 1.6522 | 1.4660 | 0.5469 | 3.9296 | 0.5245 |
| 2012 | 147 | 58 | 147 | 14 | 0.0952 | 0.3946 | 0.5886 | 0.2774 | 1.2486 | 0.3897 |
| 2013 | 156 | 70 | 156 | 17 | 0.1090 | 0.4487 | 0.5500 | 0.2800 | 1.0807 | 0.3476 |

Table 3. Results of the stepwise procedure for development of the RIDEM seasonal trawl survey catch rate model for smooth dogfish. DF is the degrees of freedom. %DIF is the percent difference in deviance/DF between each model and the null model. Delta% is the difference in deviance/DF between the newly included factor and the previous entered factor in the model.

**PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION**

| FACTOR | DF | DEVIANCE | DEVIANCE/DF | %DIFF | DELTA% |
|---|---|---|---|---|---|
| NULL | 704 | 603.7695 | 0.8576 | | |
| STRATUM | 694 | 530.6742 | 0.7647 | 10.8326 | 10.8326 |
| SEASON | 703 | 559.9424 | 0.7965 | | |
| YEAR | 670 | 548.8115 | 0.8191 | | |
| STRATUM + | | | | | |
| SEASON | 693 | 479.8365 | 0.6924 | 19.2631 | 8.4305 |
| YEAR | 660 | 472.6842 | 0.7162 | 16.4879 | 5.6553 |
| STRATUM + SEASON + | | | | | |
| YEAR | 659 | 419.0152 | 0.6358 | 25.8629 | 6.5998 |

| FINAL MODEL | AIC | BIC | (-2) Res Log Likelihood |
|---|---|---|---|
| STRATUM + SEASON + YEAR | 3784.6 | 3789.1 | 3782.6 |

**Type 3 Test of Fixed Effects**

| Significance (Pr>Chi) of Type 3 test of fixed effects for each factor | STRATUM | SEASON | YEAR |
|---|---|---|---|
| DF | 10 | 1 | 32 |
| CHI SQUARE | 67.36 | 43.41 | 1.17 |

**POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION**

| FACTOR | DF | DEVIANCE | DEVIANCE/DF | %DIFF | DELTA% |
|---|---|---|---|---|---|
| NULL | 107 | 131.7810 | 1.2316 | | |
| STRATUM | 97 | 88.7043 | 0.9145 | 25.7470 | 25.7470 |
| SEASON | 106 | 114.2255 | 1.0776 | 12.5041 | |
| YEAR | 75 | 84.2528 | 1.1234 | 8.7853 | |
| STRATUM + | | | | | |
| YEAR | 65 | 48.6674 | 0.7487 | 39.2092 | 13.4622 |
| SEASON | 96 | 79.7851 | 0.8311 | 32.5187 | 6.7717 |
| STRATUM + YEAR + | | | | | |
| SEASON | 64 | 45.8986 | 0.7172 | 41.7668 | 2.5576 |

| FINAL MODEL | AIC | BIC | (-2) Res Log Likelihood |
|---|---|---|---|
| STRATUM + YEAR + SEASON | 210.8 | 213.0 | 214.0 |

**Type 3 Test of Fixed Effects**

| Significance (Pr>Chi) of Type 3 test of fixed effects for each factor | STRATUM | YEAR | SEASON |
|---|---|---|---|
| DF | 10 | 32 | 1 |
| CHI SQUARE | 44.94 | 47.25 | 3.86 |

Table 4. RIDEM seasonal trawl survey smooth dogfish analysis number of tows (n tows), number of sharks (catch), number of model observations per year (n obs), number of positive model observations per year (obs pos), proportion of positive model observations per year (obs ppos), nominal cpue as sharks per 20 minute tow (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCL), the upper 95% confidence limit for the est cpue (UCL), and the coefficient of variation for the estimated cpue (CV).

| year | n tows | catch | n obs | obs pos | obs ppos | obs cpue | est cpue | LCL | UCL | CV |
|---|---|---|---|---|---|---|---|---|---|---|
| 1979 | 70 | 0 | 13 | 0 | 0 | 0 | . | . | . | . |
| 1980 | 74 | 13 | 10 | 5 | 0.5000 | 1.3000 | 1.5990 | 0.6544 | 3.9070 | 0.4699 |
| 1981 | 136 | 36 | 22 | 5 | 0.2273 | 1.6364 | 1.8017 | 0.7281 | 4.4585 | 0.4773 |
| 1982 | 139 | 27 | 21 | 4 | 0.1905 | 1.2857 | 1.2573 | 0.4285 | 3.6895 | 0.5797 |
| 1983 | 139 | 14 | 22 | 1 | 0.0455 | 0.6364 | 0.2804 | 0.0468 | 1.6796 | 1.1082 |
| 1984 | 132 | 16 | 22 | 7 | 0.3182 | 0.7273 | 1.7845 | 0.8544 | 3.7273 | 0.3811 |
| 1985 | 123 | 41 | 21 | 4 | 0.1905 | 1.9524 | 1.3046 | 0.4654 | 3.6574 | 0.5516 |
| 1986 | 108 | 7 | 22 | 3 | 0.1364 | 0.3182 | 0.4598 | 0.1412 | 1.4977 | 0.6458 |
| 1987 | 103 | 2 | 21 | 1 | 0.0476 | 0.0952 | 0.0698 | 0.0113 | 0.4333 | 1.1401 |
| 1988 | 85 | 0 | 22 | 0 | 0 | 0 | . | . | . | . |
| 1989 | 84 | 2 | 22 | 1 | 0.0455 | 0.0909 | 0.0401 | 0.0067 | 0.2399 | 1.1082 |
| 1990 | 87 | 66 | 22 | 1 | 0.0455 | 3.0000 | 1.3219 | 0.2207 | 7.9183 | 1.1082 |
| 1991 | 81 | 2 | 22 | 2 | 0.0909 | 0.0909 | 0.1227 | 0.0299 | 0.5028 | 0.8026 |
| 1992 | 77 | 2 | 21 | 2 | 0.0952 | 0.0952 | 0.0516 | 0.0112 | 0.2368 | 0.8869 |
| 1993 | 60 | 8 | 14 | 3 | 0.2143 | 0.5714 | 0.5116 | 0.1549 | 1.6899 | 0.6549 |
| 1994 | 82 | 2 | 22 | 2 | 0.0909 | 0.0909 | 0.1008 | 0.0247 | 0.4119 | 0.8007 |
| 1995 | 84 | 11 | 22 | 1 | 0.0455 | 0.5000 | 0.2203 | 0.0368 | 1.3197 | 1.1082 |
| 1996 | 75 | 10 | 22 | 5 | 0.2273 | 0.4545 | 0.9222 | 0.3756 | 2.2642 | 0.4727 |
| 1997 | 82 | 16 | 21 | 1 | 0.0476 | 0.7619 | 0.3256 | 0.0543 | 1.9533 | 1.1096 |
| 1998 | 83 | 3 | 22 | 1 | 0.0455 | 0.1364 | 0.0601 | 0.0100 | 0.3599 | 1.1082 |
| 1999 | 83 | 4 | 22 | 4 | 0.1818 | 0.1818 | 0.3483 | 0.1249 | 0.9710 | 0.5483 |
| 2000 | 81 | 5 | 22 | 2 | 0.0909 | 0.2273 | 0.3263 | 0.0792 | 1.3445 | 0.8066 |
| 2001 | 79 | 15 | 19 | 3 | 0.1579 | 0.7895 | 0.8522 | 0.2610 | 2.7826 | 0.6475 |
| 2002 | 81 | 40 | 20 | 4 | 0.2000 | 2.0000 | 1.2881 | 0.4646 | 3.5715 | 0.5449 |
| 2003 | 83 | 125 | 20 | 6 | 0.3000 | 6.2500 | 1.8441 | 0.8330 | 4.0825 | 0.4136 |
| 2004 | 79 | 9 | 20 | 5 | 0.2500 | 0.4500 | 1.5505 | 0.6149 | 3.9094 | 0.4883 |
| 2005 | 83 | 17 | 19 | 2 | 0.1053 | 0.8947 | 0.8933 | 0.2191 | 3.6422 | 0.7991 |
| 2006 | 85 | 11 | 20 | 5 | 0.2500 | 0.5500 | 0.9043 | 0.3679 | 2.2229 | 0.4734 |
| 2007 | 82 | 23 | 19 | 4 | 0.2105 | 1.2105 | 1.3812 | 0.4999 | 3.8159 | 0.5428 |
| 2008 | 84 | 15 | 20 | 3 | 0.1500 | 0.7500 | 0.7032 | 0.2161 | 2.2883 | 0.6452 |
| 2009 | 84 | 43 | 18 | 4 | 0.2222 | 2.3889 | 1.6507 | 0.5956 | 4.5755 | 0.5447 |
| 2010 | 85 | 20 | 20 | 4 | 0.2000 | 1.0000 | 1.3148 | 0.4759 | 3.6321 | 0.5427 |
| 2011 | 86 | 12 | 20 | 5 | 0.2500 | 0.6000 | 0.8794 | 0.3594 | 2.1518 | 0.4707 |
| 2012 | 88 | 49 | 20 | 5 | 0.2500 | 2.4500 | 3.7454 | 1.5339 | 9.1455 | 0.4695 |
| 2013 | 88 | 17 | 20 | 3 | 0.1500 | 0.8500 | 0.8740 | 0.2693 | 2.8364 | 0.6435 |

Figure 1. Fork lengths (cm) of smooth dogfish caught during the RIDEM monthly trawl survey.

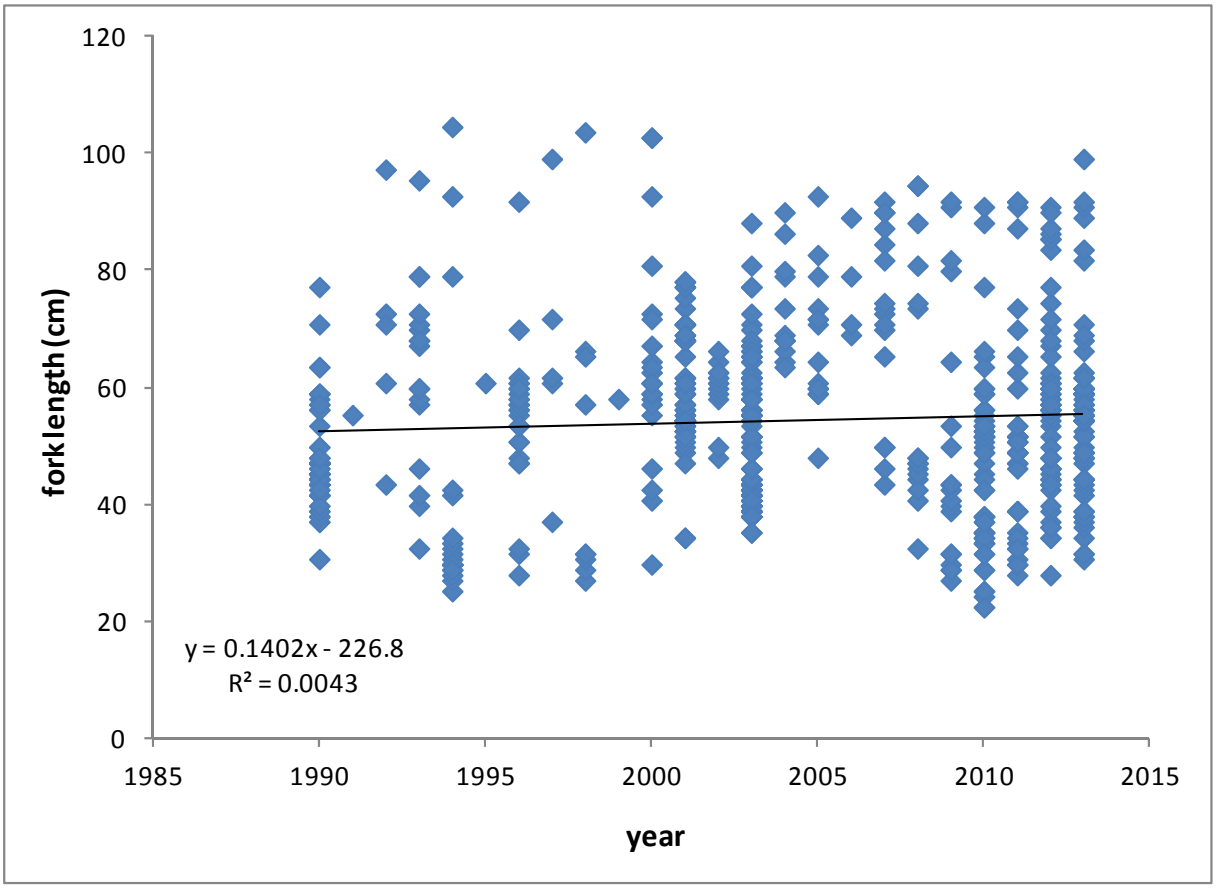
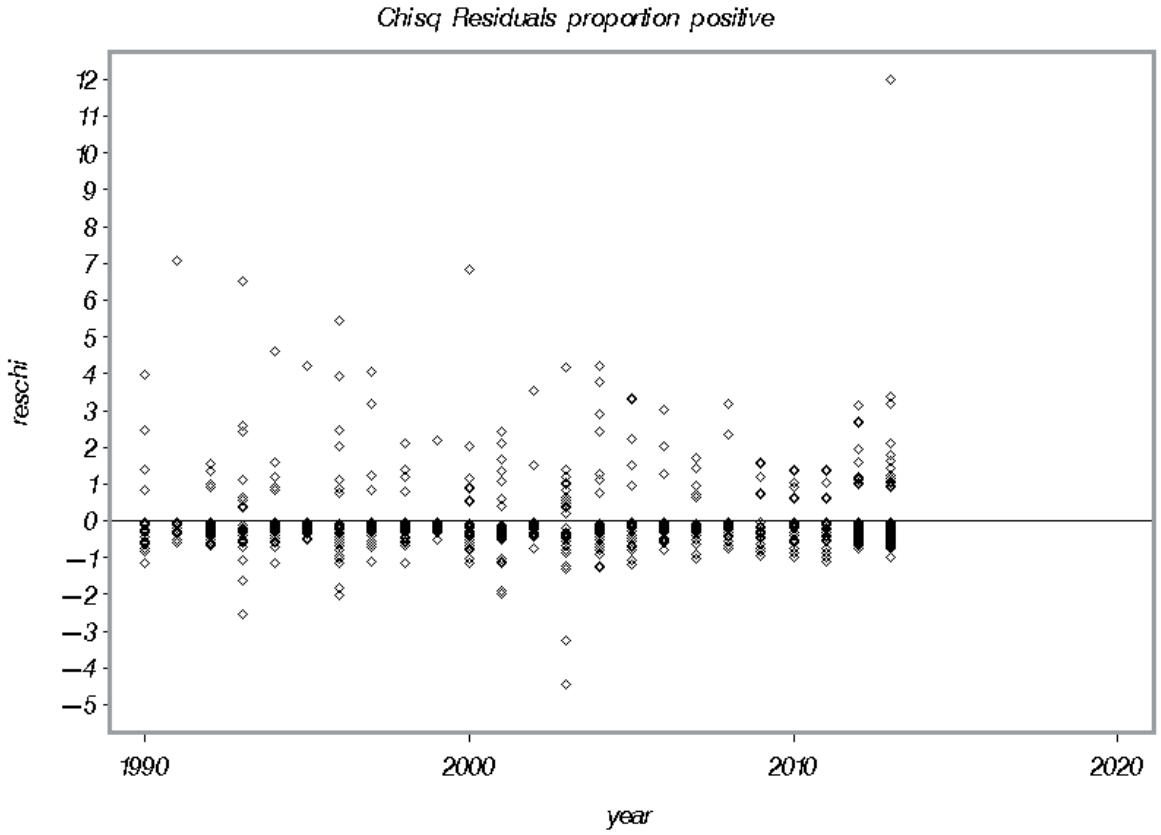


Figure 2a. RIDEM monthly trawl survey smooth dogfish model diagnostic plots for the binomial component.



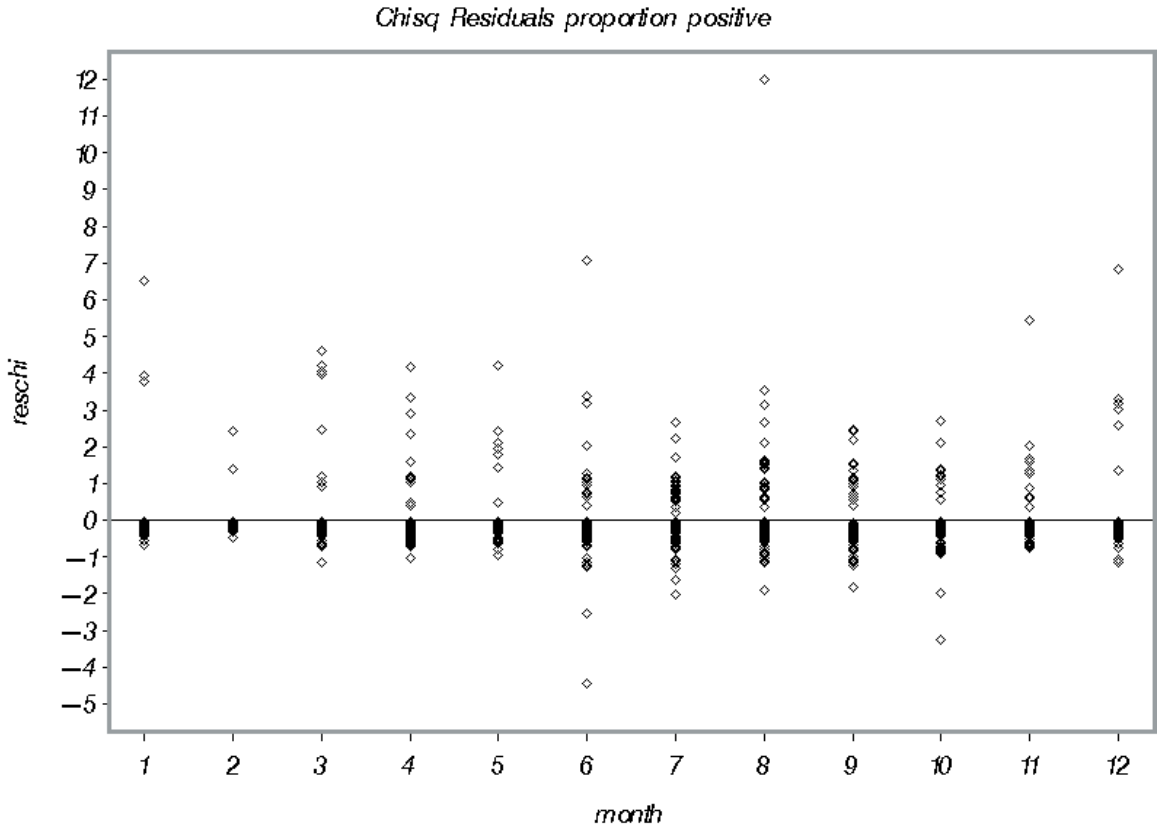
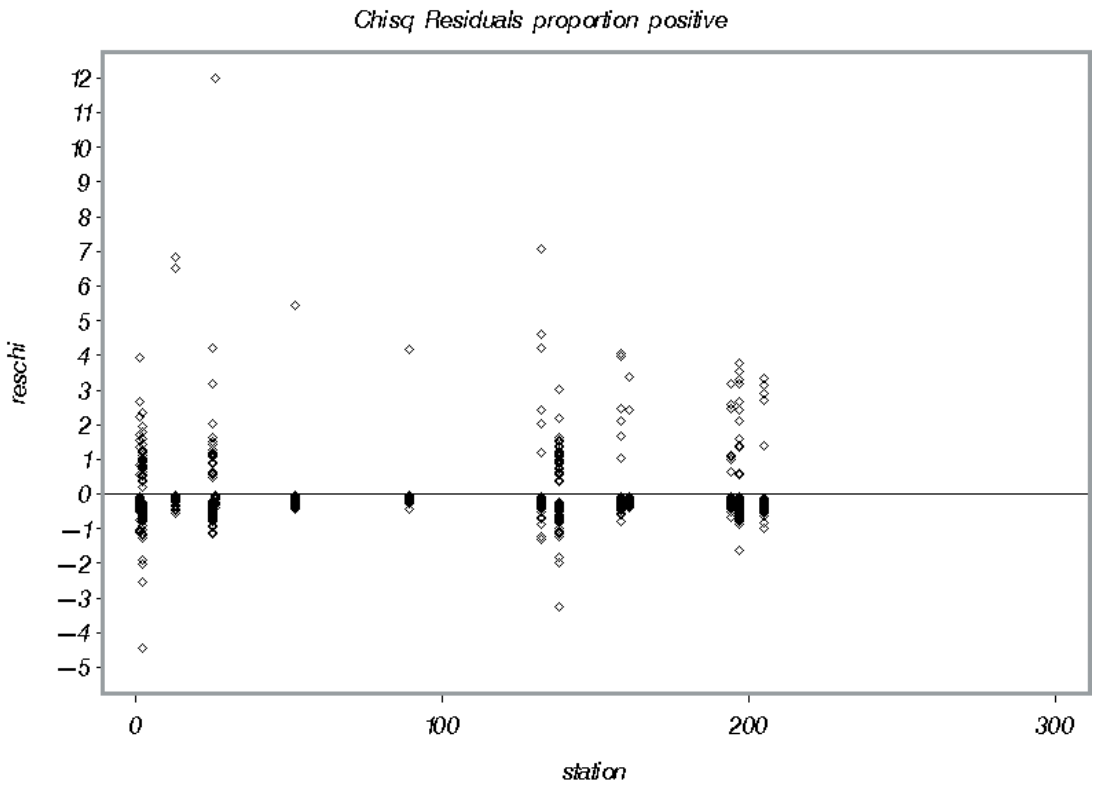



Figure 2a continued. RIDEM monthly trawl survey smooth dogfish model diagnostic plots for the binomial component.



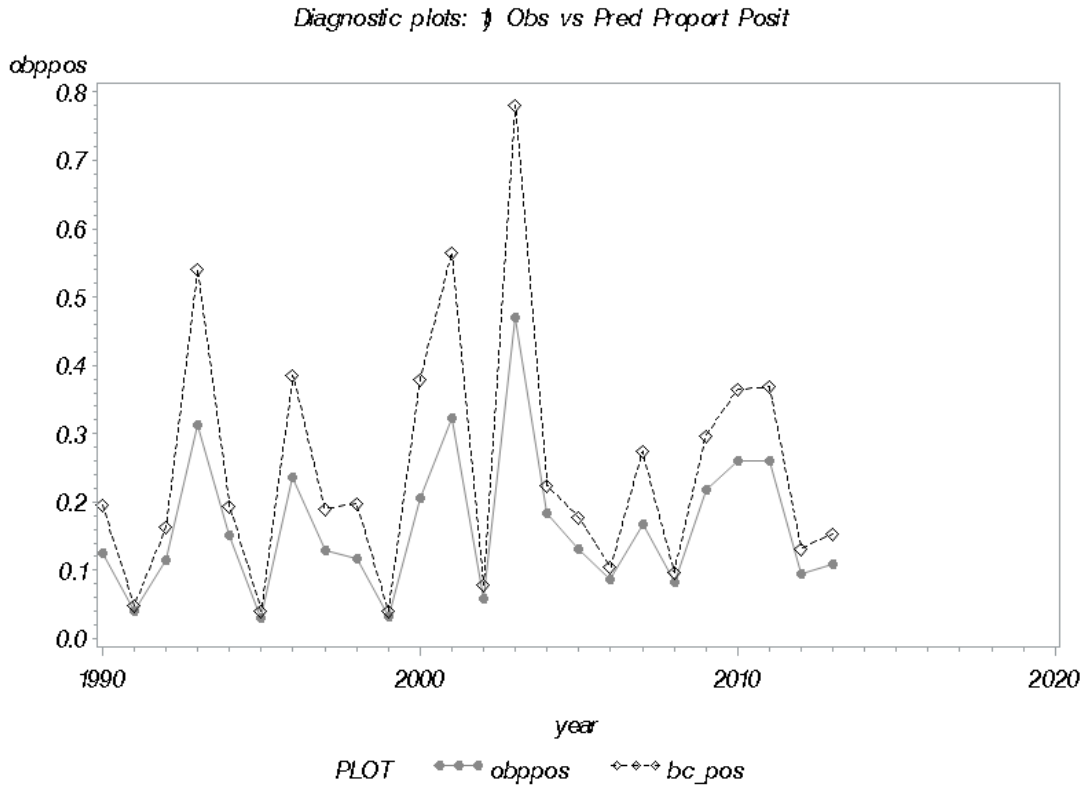
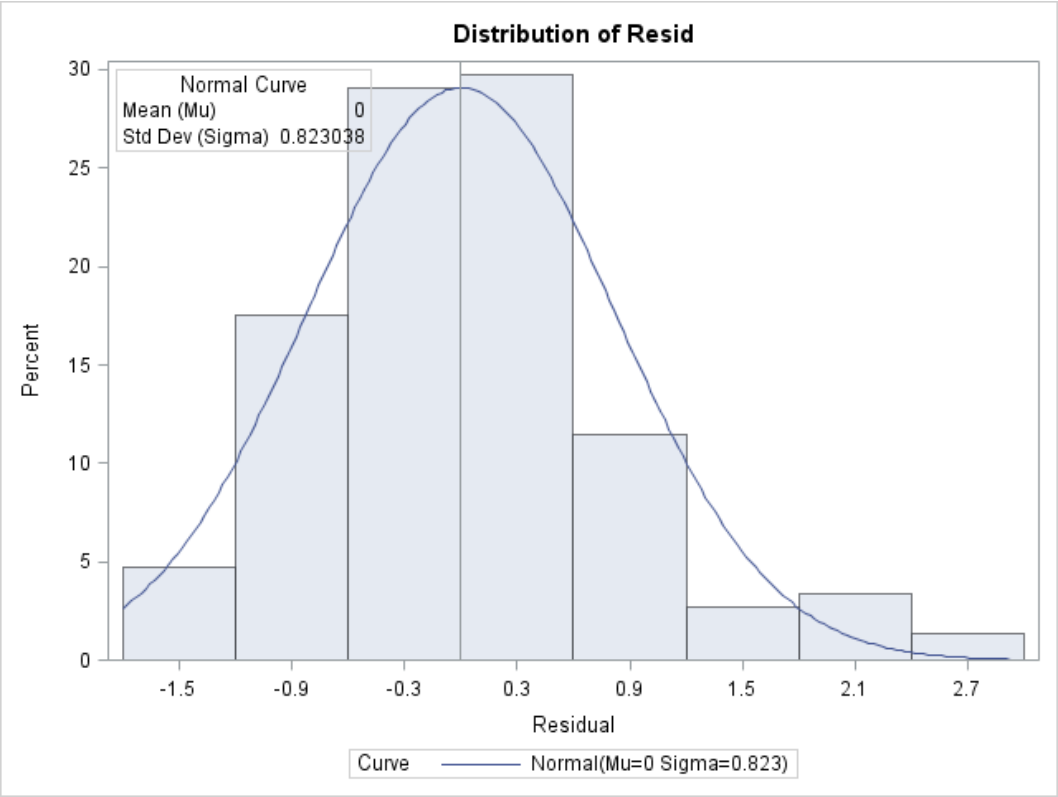



Figure 2b. RIDEM monthly trawl survey smooth dogfish model diagnostic plots for lognormal component.



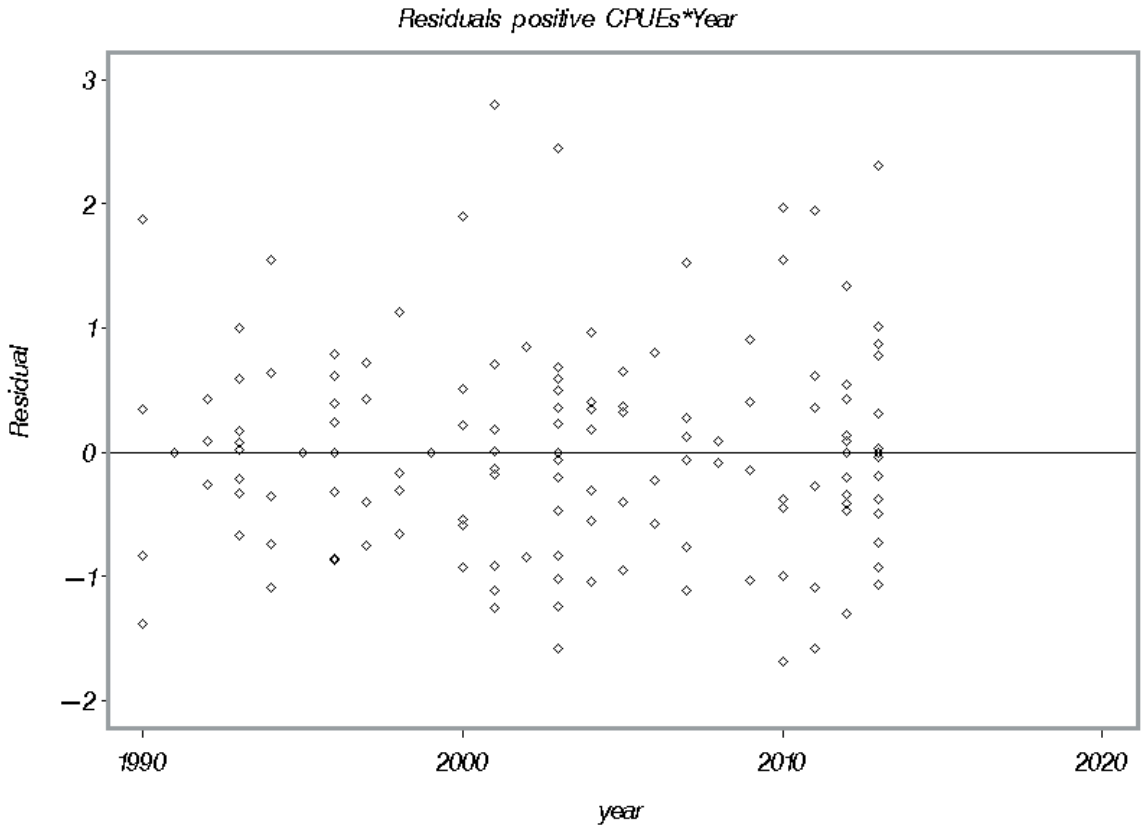
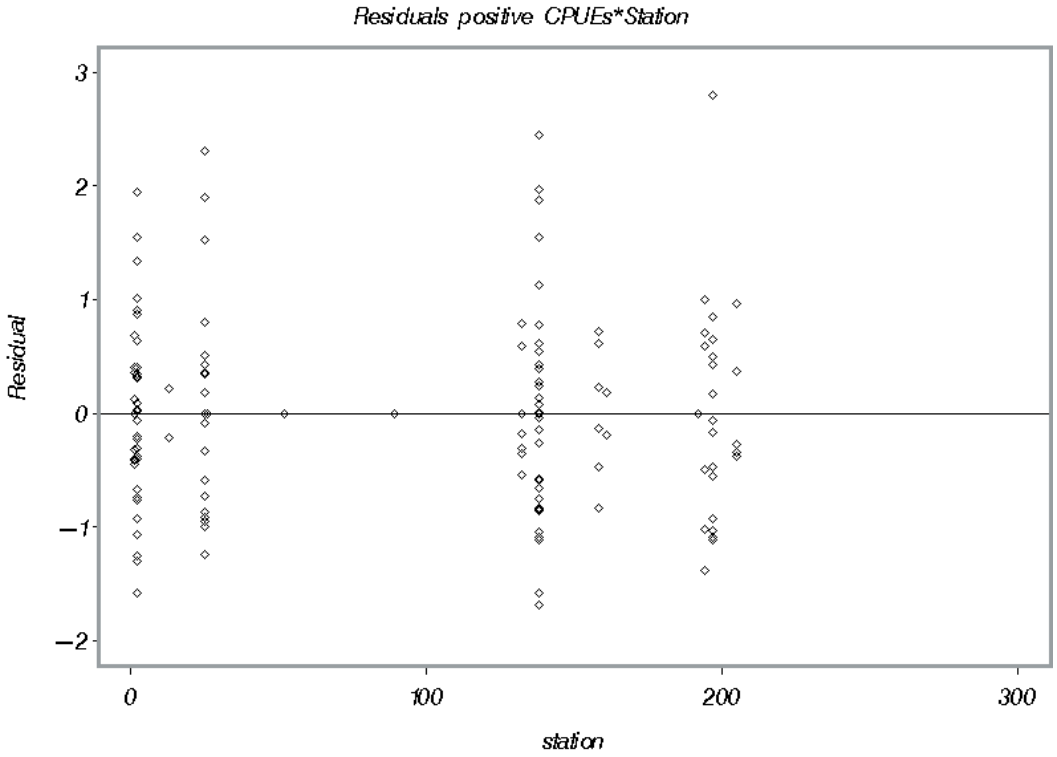



Figure 2b continued. RIDEM monthly survey smooth dogfish model diagnostic plots for lognormal component.



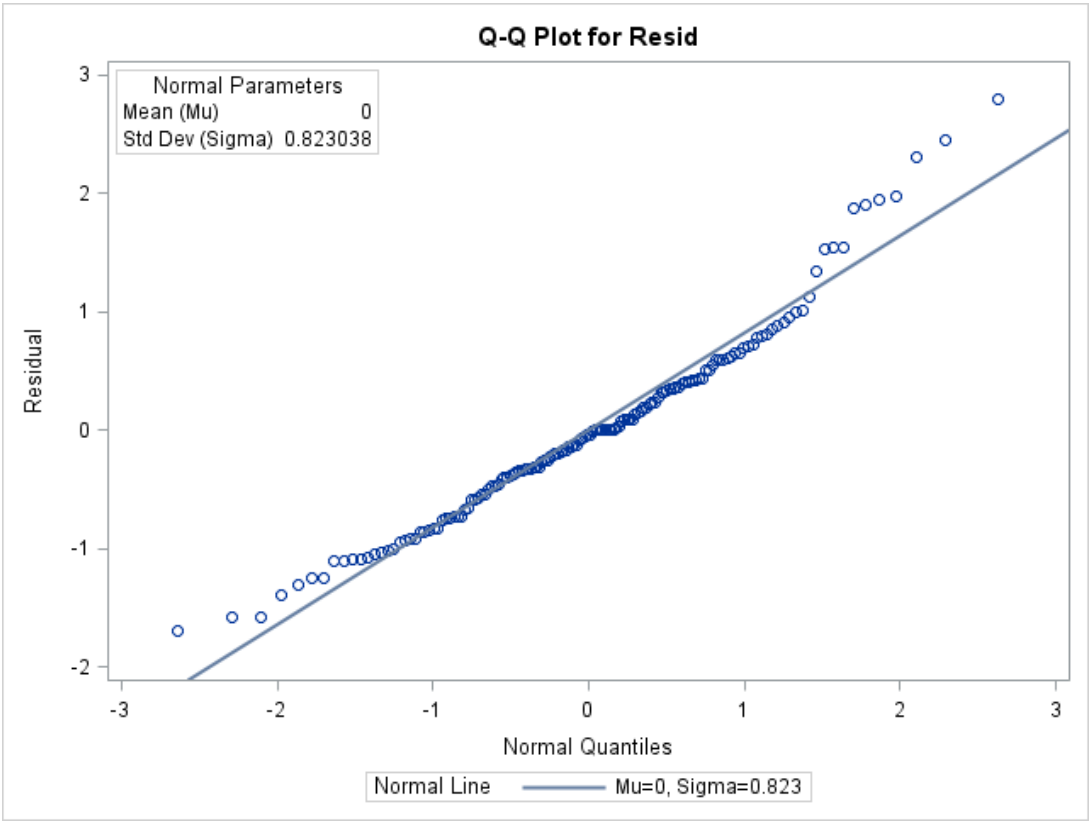



Figure 3. RIDEM monthly trawl survey smooth dogfish nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).

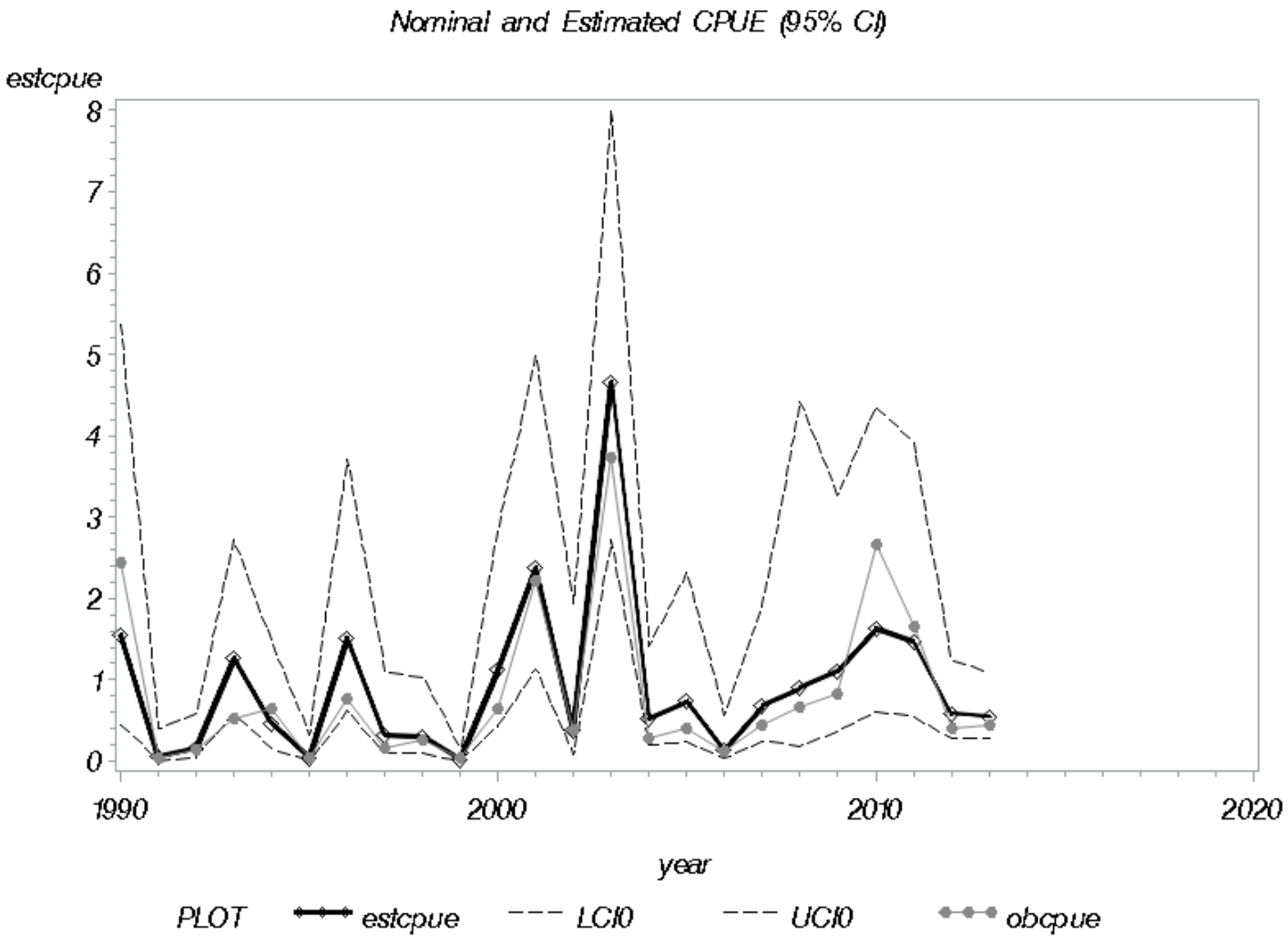


Figure 4. Fork lengths (cm) of smooth dogfish caught during the RIDEM seasonal trawl survey.

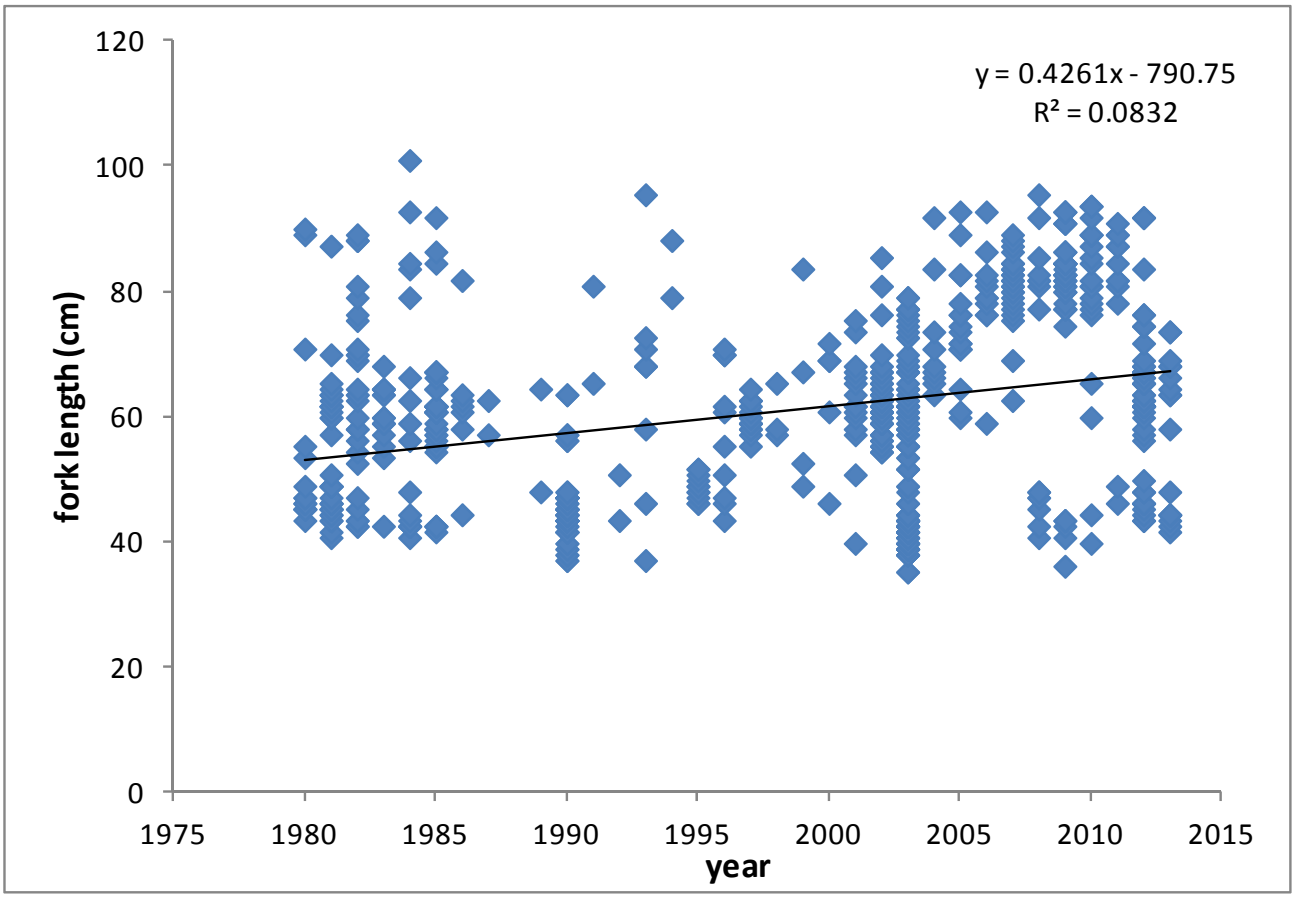
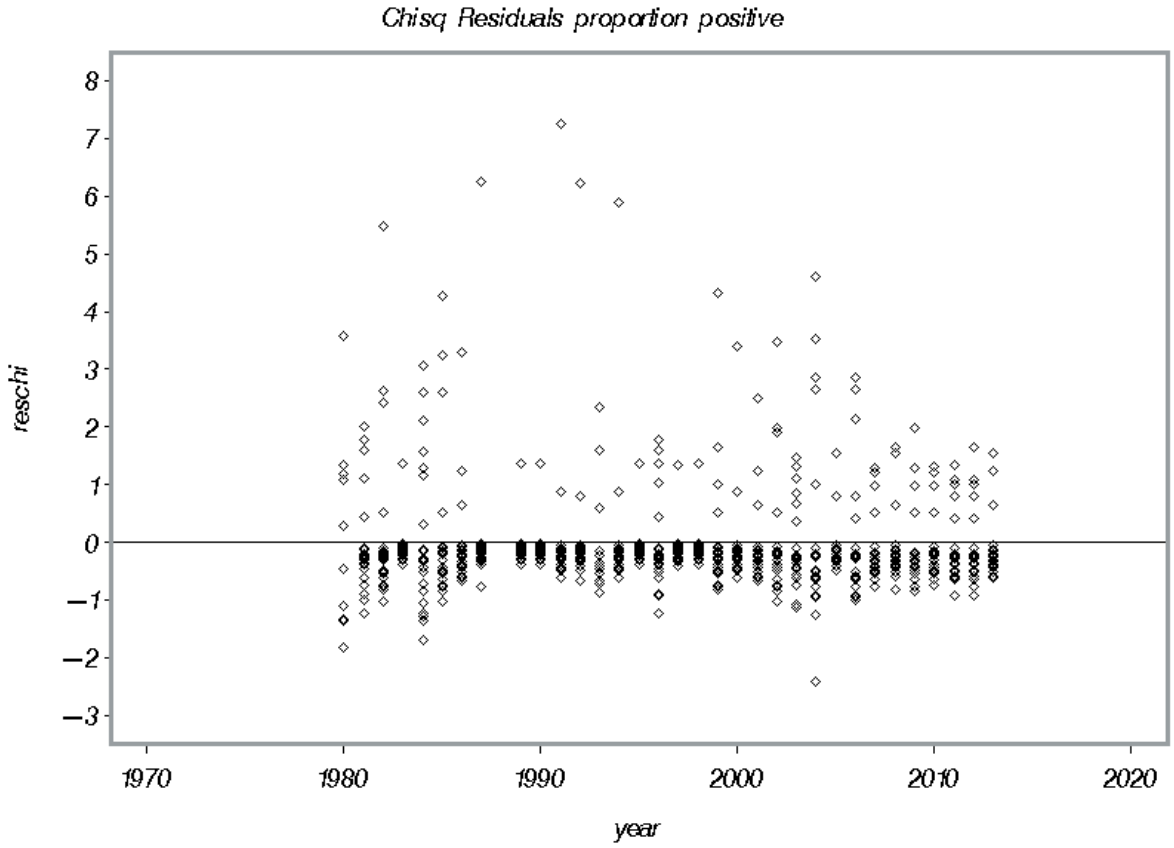


Figure 5a. RIDEM seasonal trawl survey smooth dogfish model diagnostic plots for binomial component.



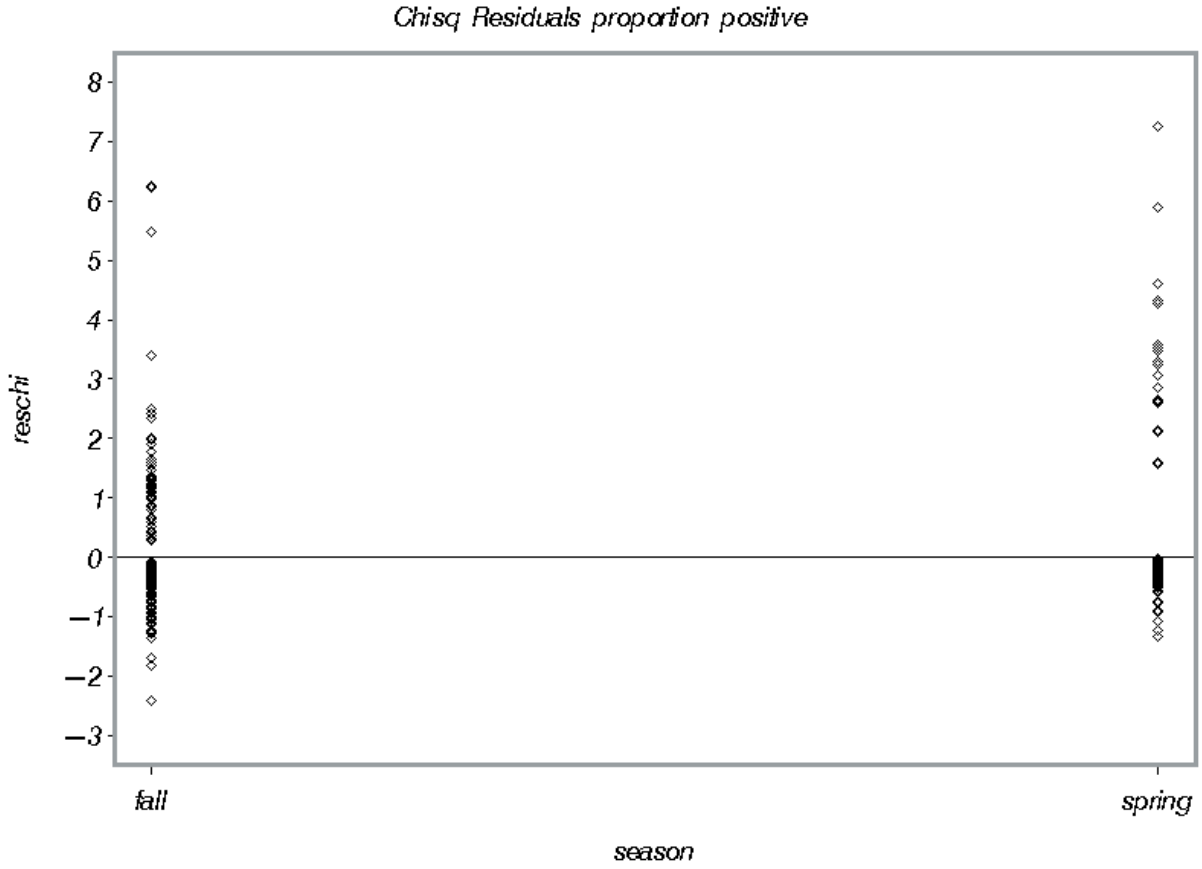
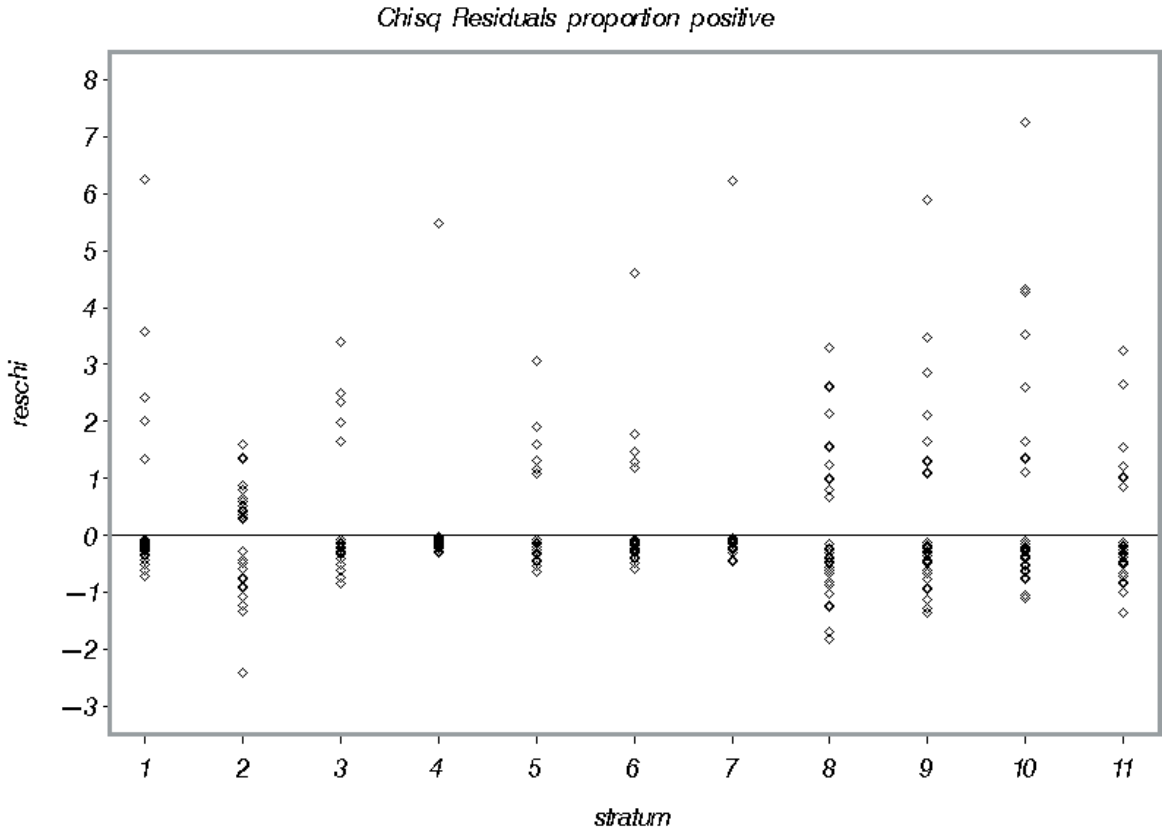



Figure 5a continued. RIDEM seasonal trawl survey smooth dogfish model diagnostic plots for binomial component.



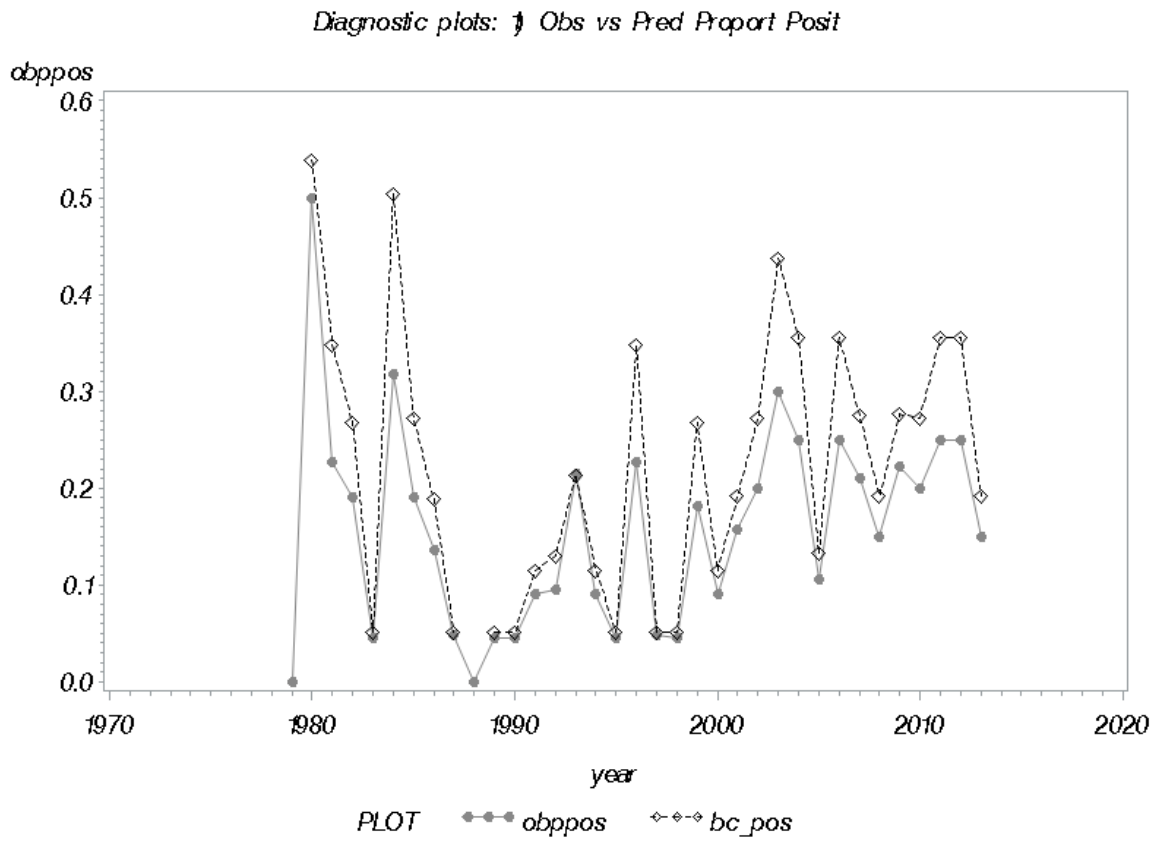
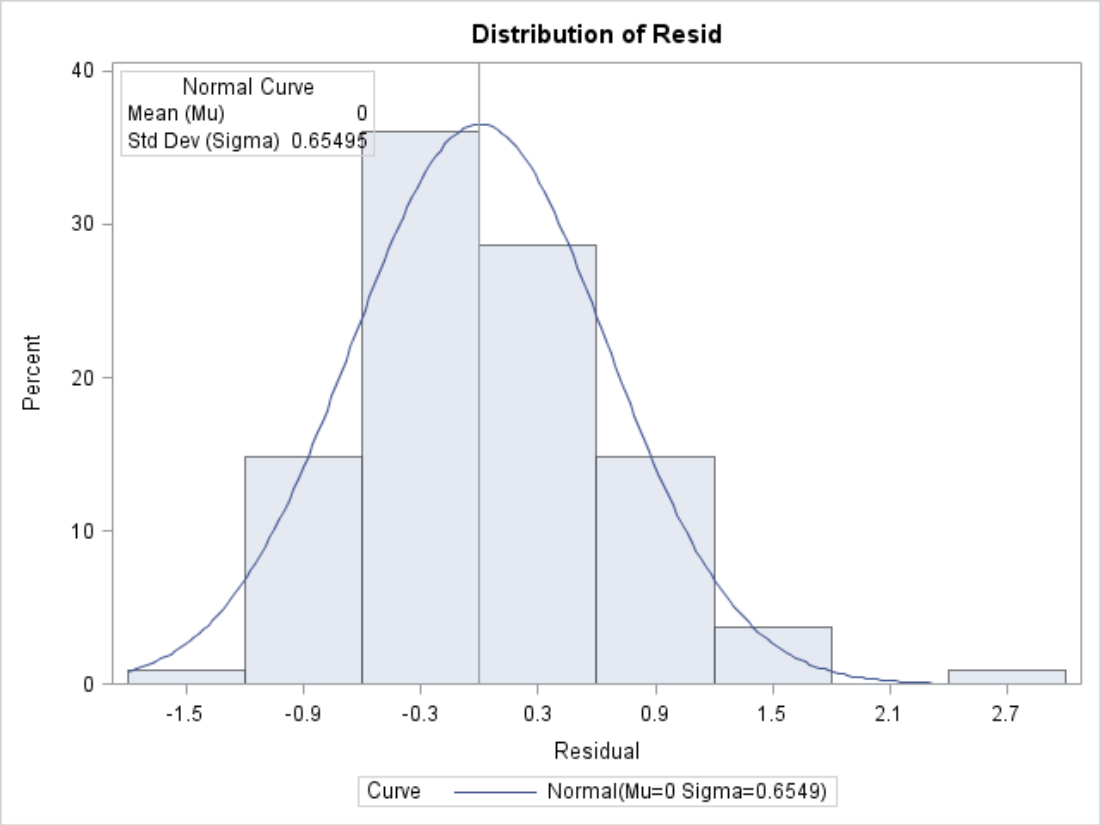



Figure 5b. RIDEM seasonal trawl survey smooth dogfish model diagnostic plots for lognormal component.



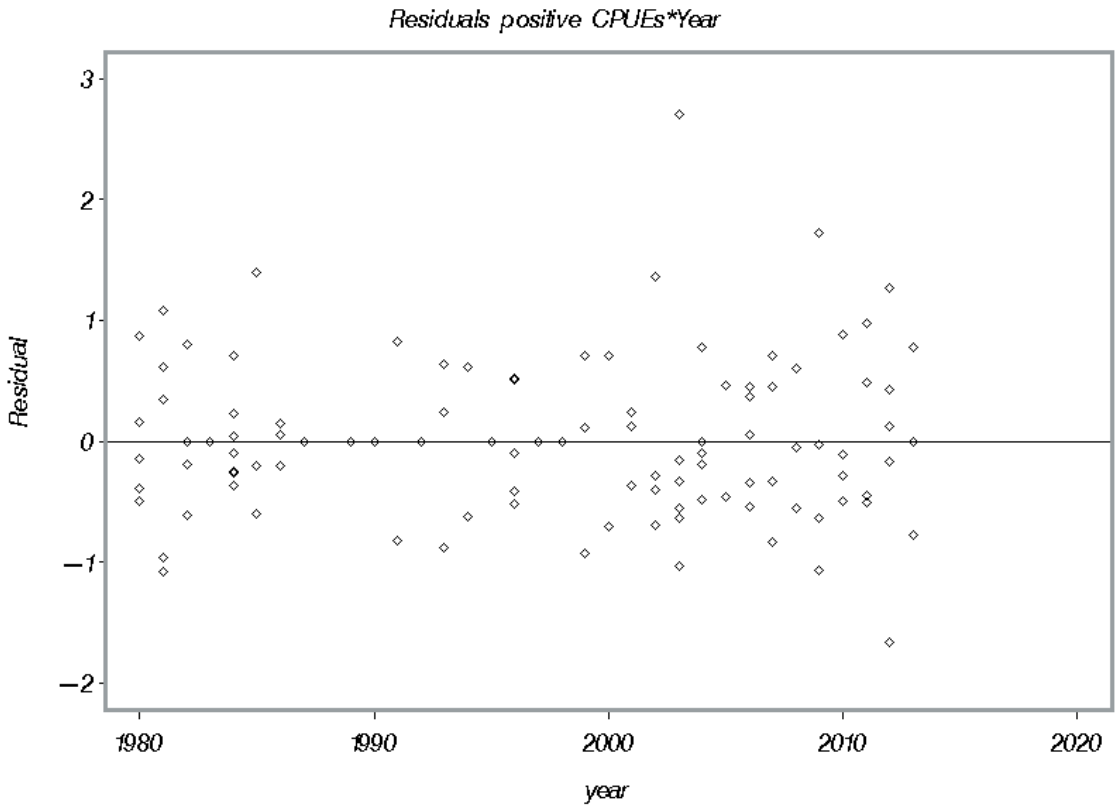
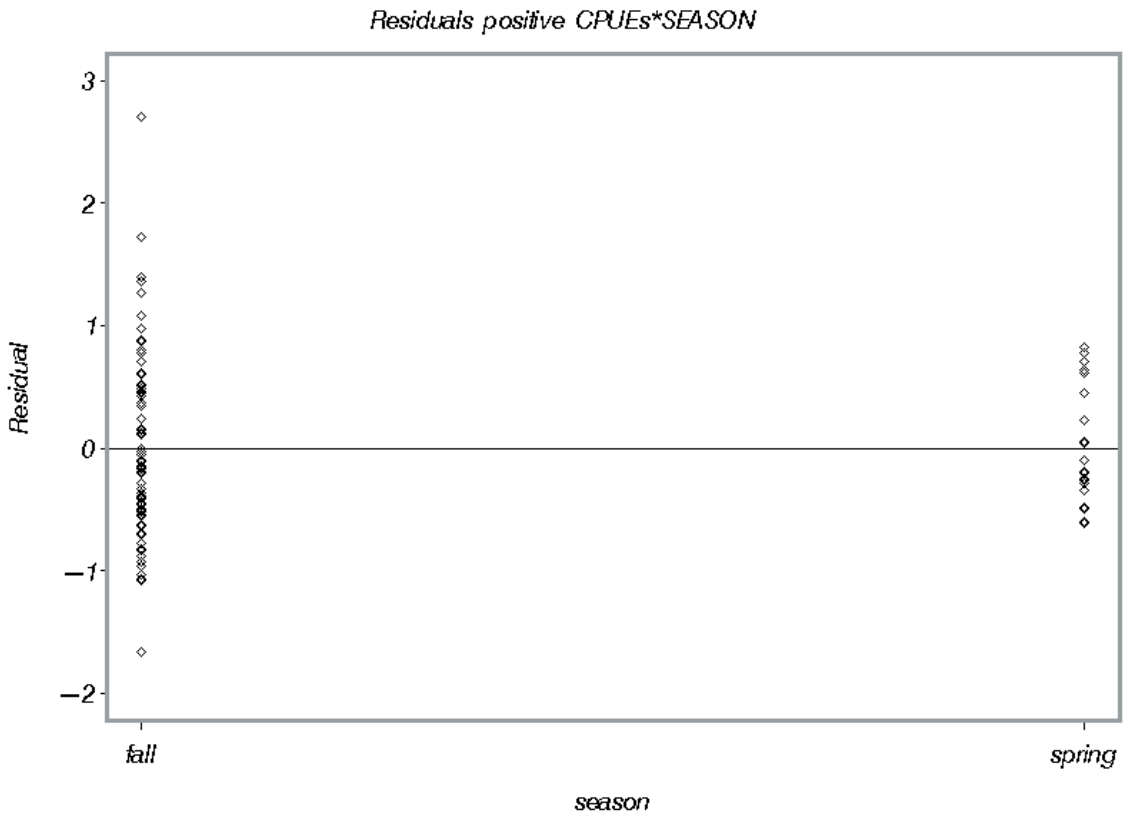



Figure 5b continued. RIDEM seasonal trawl survey smooth dogfish model diagnostic plots for lognormal component.



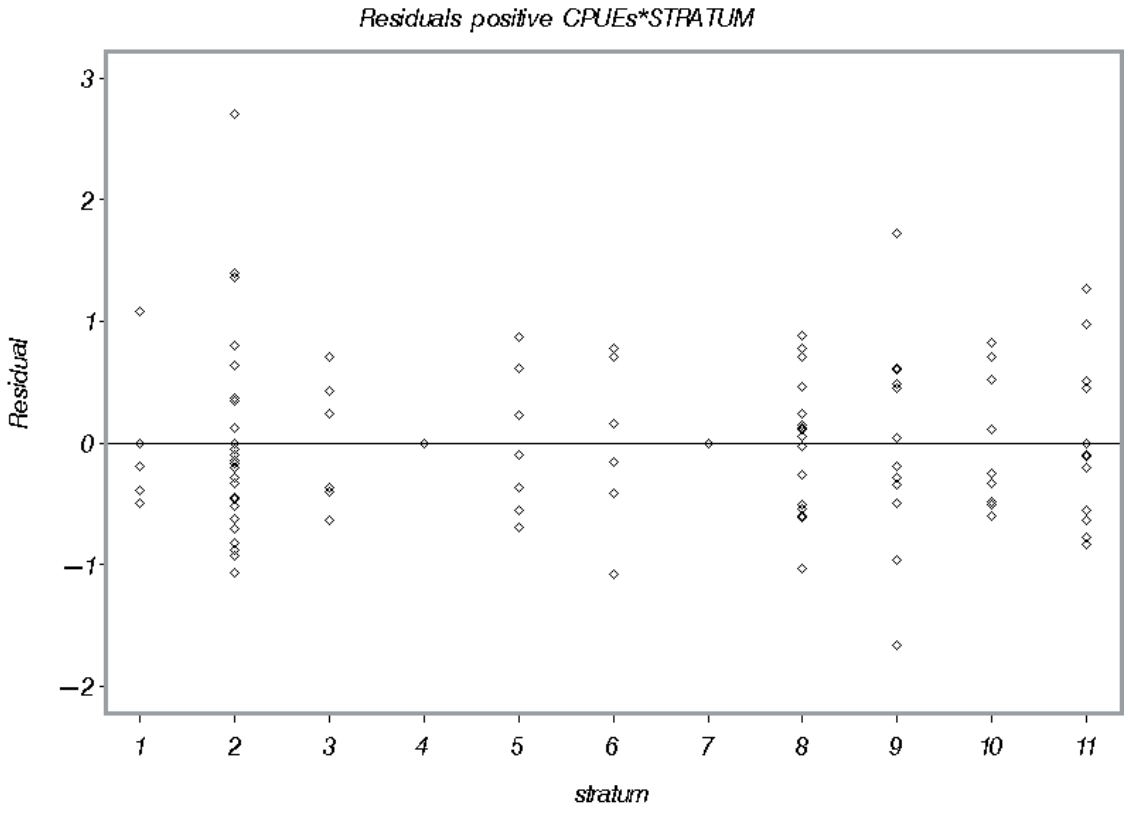



Figure 5b continued. RIDEM seasonal trawl survey smooth dogfish model diagnostic plots for lognormal component.

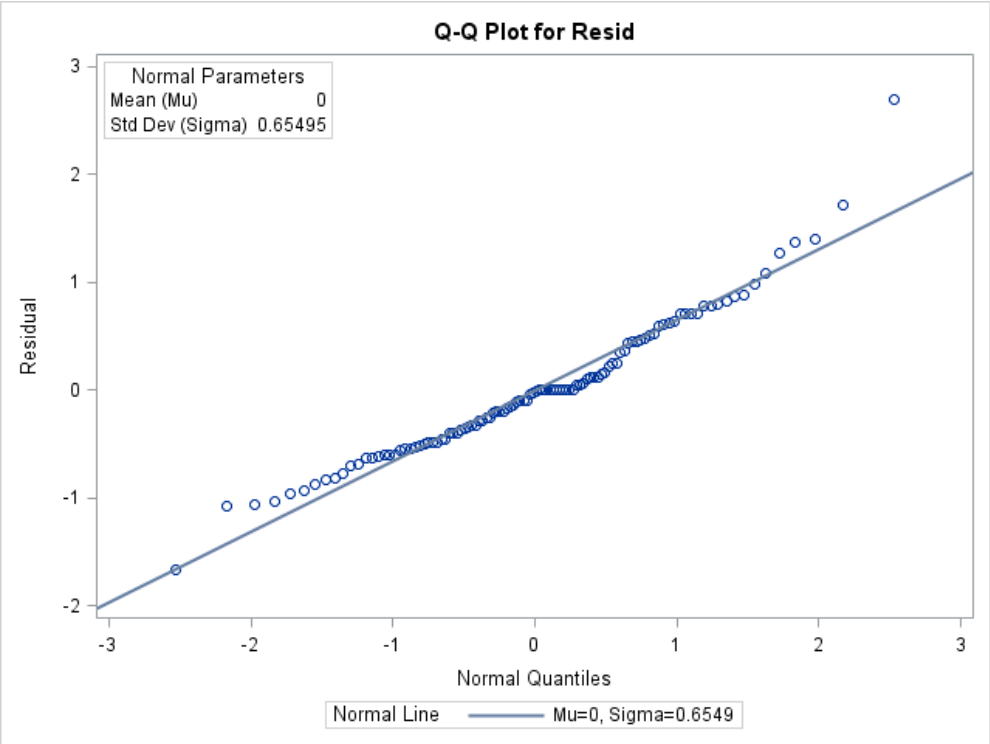
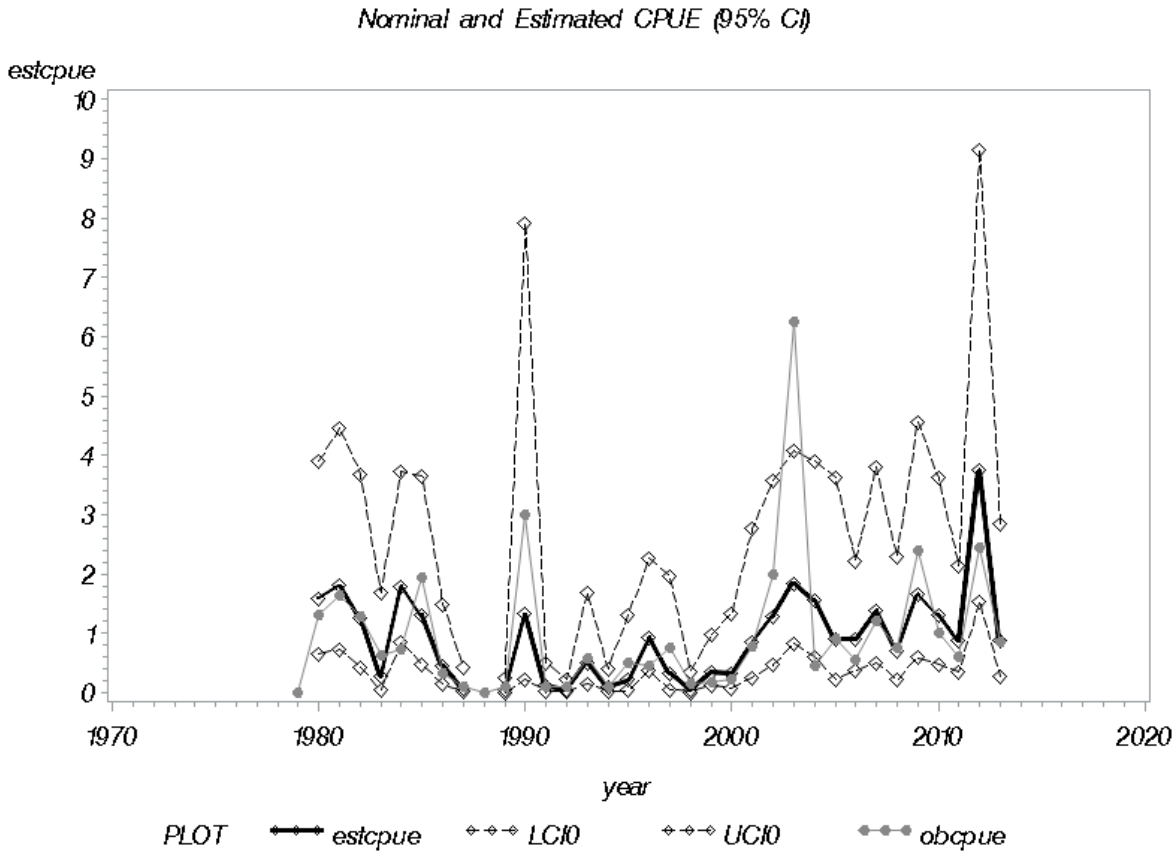



Figure 6. RIDEM seasonal trawl survey smooth dogfish nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).



Additional analyses were conducted during the data workshop to look at combining the indices, include bottom temperature data to account for some of the variability, and change the years used in the standardization process to fit with the time span of the assessment model. The resulting index values and trends are reported below.

Table A1. Results of combining the RIDEM combined monthly and seasonal surveys during the fall months and including bottom temperature data for the time frame of the preferred assessment model (1981-2012). Analysis nominal cpue as sharks per 20 minute tow (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCL), the upper 95% confidence limit for the est cpue (UCL), and the coefficient of variation for the estimated cpue (CV).

| year | obs cpue | est cpue | LCL | UCL | CV |
|---|---|---|---|---|---|
| 1981 | 4.4286 | 3.3002 | 0.5481 | 19.8725 | 1.1129 |
| 1982 | 6.2500 | . | . | . | . |
| 1983 | 4.6667 | 1.0544 | 0.1459 | 7.6222 | 1.2883 |
| 1984 | 1.4000 | 0.3710 | 0.0433 | 3.1765 | 1.4721 |
| 1985 | 12.6667 | 0.0397 | 0.0030 | 0.5311 | 2.0915 |
| 1986 | 0.4444 | 0.0331 | 0.0026 | 0.4232 | 2.0176 |
| 1987 | 0.3333 | 0.0354 | 0.0027 | 0.4584 | 2.0397 |
| 1988 | 0.0000 | . | . | . | . |
| 1989 | 0.2500 | 0.0378 | 0.0029 | 0.4976 | 2.0639 |
| 1990 | 6.0909 | 0.1463 | 0.0171 | 1.2491 | 1.4689 |
| 1991 | 0.2000 | 0.0304 | 0.0024 | 0.3921 | 2.0307 |
| 1992 | 0.7500 | 0.0306 | 0.0024 | 0.3945 | 2.0325 |
| 1993 | 1.0000 | 0.3997 | 0.0500 | 3.1970 | 1.3955 |
| 1994 | 0.4000 | 0.0296 | 0.0023 | 0.3790 | 2.0211 |
| 1995 | 1.2222 | 0.0265 | 0.0021 | 0.3336 | 1.9931 |
| 1996 | 0.6000 | 0.0304 | 0.0024 | 0.3921 | 2.0307 |
| 1997 | 2.2857 | 0.0271 | 0.0021 | 0.3427 | 1.9989 |
| 1998 | 0.2500 | 0.0107 | 0.0009 | 0.1293 | 1.9325 |
| 1999 | 0.2857 | 0.0189 | 0.0015 | 0.2353 | 1.9775 |
| 2000 | 1.0000 | 0.5390 | 0.0664 | 4.3779 | 1.4124 |
| 2001 | 2.5000 | 1.0114 | 0.1597 | 6.4074 | 1.1595 |
| 2002 | 7.8000 | 0.0289 | 0.0023 | 0.3692 | 2.0152 |
| 2003 | 26.2500 | 0.5468 | 0.0672 | 4.4469 | 1.4138 |
| 2004 | 0.0909 | 0.0113 | 0.0009 | 0.1378 | 1.9427 |
| 2005 | 2.2500 | 0.0306 | 0.0024 | 0.3945 | 2.0325 |
| 2006 | 1.4000 | 0.4759 | 0.0591 | 3.8307 | 1.4023 |
| 2007 | 1.7500 | 0.0927 | 0.0115 | 0.7472 | 1.4043 |
| 2008 | 0.7000 | 0.0121 | 0.0010 | 0.1472 | 1.9404 |
| 2009 | 3.6667 | 0.9964 | 0.1713 | 5.7952 | 1.0819 |
| 2010 | 1.5000 | 0.5465 | 0.0892 | 3.3491 | 1.1289 |
| 2011 | 0.6923 | 0.7875 | 0.1361 | 4.5558 | 1.0772 |
| 2012 | 3.1429 | 0.2346 | 0.0265 | 2.0770 | 1.5114 |

Table A2. Results of the stepwise procedure for development of the RIDEM seasonal trawl survey catch rate model incorporating bottom temperature data for smooth dogfish (preferred assessment model time frame, 1981-2012). DF is the degrees of freedom. %DIF is the percent difference in deviance/DF between each model and the null model. Delta% is the difference in deviance/DF between the newly included factor and the previous entered factor in the model.

**PROPORTION POSITIVE-BINOMIAL ERROR DISTRIBUTION**

| FACTOR | DF | DEVIANCE | DEVIANCE/DF | %DIFF | DELTA% |
|---|---|---|---|---|---|
| NULL | 724 | 613.7948 | 0.8478 | | |
| STRATUM | 714 | 546.3987 | 0.7653 | 9.7311 | 9.7311 |
| TEMP | 722 | 553.8996 | 0.7672 | 9.5070 | |
| SEASON | 723 | 579.6886 | 0.8018 | 5.4258 | |
| YEAR | 693 | 569.8553 | 0.8223 | 3.0078 | |
| STRATUM + | | | | | |
| TEMP | 712 | 486.1642 | 0.6828 | 19.4621 | 9.7311 |
| SEASON | 713 | 513.308 | 0.7199 | 15.0861 | 5.3550 |
| YEAR | 683 | 501.0417 | 0.7336 | 13.4702 | 3.7391 |
| STRATUM + TEMP + | | | | | |
| YEAR | 681 | 443.7209 | 0.6516 | 23.1423 | 3.6801 |
| SEASON | 711 | 484.9367 | 0.682 | 19.5565 | 0.0944 |

| FINAL MODEL | AIC | BIC | (-2) Res Log Likelihood |
|---|---|---|---|
| STRATUM + TEMP + YEAR | 3878.1 | 3882.6 | 3876.1 |

**POSITIVE CATCHES-LOGNORMAL ERROR DISTRIBUTION**

| FACTOR | DF | DEVIANCE | DEVIANCE/DF | %DIFF | DELTA% |
|---|---|---|---|---|---|
| NULL | 108 | 126.7056 | 1.1732 | | |
| TEMP | 106 | 96.0207 | 0.9059 | 22.7838 | 22.7838 |
| STRATUM | 98 | 94.4780 | 0.9641 | 17.8230 | |
| SEASON | 107 | 112.3828 | 1.0503 | 10.4756 | |
| YEAR | 78 | 82.7497 | 1.0609 | 9.5721 | |
| TEMP + | | | | | |
| STRATUM | 96 | 83.0219 | 0.8648 | 26.2871 | 8.4640 |
| SEASON | 105 | 94.5520 | 0.9005 | 23.2441 | 5.4211 |
| YEAR | 76 | 69.868 | 0.9193 | 21.6417 | 3.8186 |
| TEMP + STRATUM + | | | | | |
| YEAR | 66 | 50.8806 | 0.7709 | 34.2908 | 8.0038 |
| SEASON | 95 | 80.1397 | 0.8436 | 28.0941 | 1.8070 |
| TEMP + STRATUM + YEAR + | | | | | |
| SEASON | 65 | 49.5058 | 0.7616 | 35.0835 | 6.9894 |

| FINAL MODEL | AIC | BIC | (-2) Res Log Likelihood |
|---|---|---|---|
| TEMP + STRATUM + YEAR + SEASON | 220.5 | 222.7 | 218.5 |

Table A3. Results of the RIDEM seasonal trawl survey incorporating bottom temperature data and the time frame of the preferred assessment model (1981-2012). Analysis number of tows (n tows), number of sharks (catch), number of model observations per year (n obs), number of positive model observations per year (obs pos), proportion of positive model observations per year (obs ppos), nominal cpue as sharks per 20 minute tow (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCL), the upper 95% confidence limit for the est cpue (UCL), and the coefficient of variation for the estimated cpue (CV).

| year | n tows | catch | n obs | obs pos | obs ppos | obs cpue | est cpue | LCL | UCL | CV |
|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 136 | 36 | 22 | 5 | 0.2273 | 1.6364 | 1.7350 | 0.6881 | 4.3752 | 0.4883 |
| 1982 | 139 | 27 | 21 | 4 | 0.1905 | 1.2857 | 1.0397 | 0.3423 | 3.1582 | 0.6013 |
| 1983 | 139 | 14 | 22 | 1 | 0.0455 | 0.6364 | 0.2792 | 0.0459 | 1.6985 | 1.1220 |
| 1984 | 132 | 16 | 22 | 7 | 0.3182 | 0.7273 | 1.8842 | 0.8913 | 3.9831 | 0.3878 |
| 1985 | 123 | 41 | 21 | 4 | 0.1905 | 1.9524 | 1.2714 | 0.4477 | 3.6110 | 0.5596 |
| 1986 | 108 | 7 | 22 | 3 | 0.1364 | 0.3182 | 0.4775 | 0.1445 | 1.5774 | 0.6550 |
| 1987 | 103 | 2 | 21 | 1 | 0.0476 | 0.0952 | 0.0355 | 0.0055 | 0.2293 | 1.1764 |
| 1988 | 85 | 0 | 22 | 0 | 0 | 0 | . | . | . | . |
| 1989 | 84 | 2 | 22 | 1 | 0.0455 | 0.0909 | 0.0399 | 0.0066 | 0.2426 | 1.1220 |
| 1990 | 87 | 66 | 22 | 1 | 0.0455 | 3.0000 | 1.3164 | 0.2164 | 8.0070 | 1.1220 |
| 1991 | 81 | 2 | 22 | 2 | 0.0909 | 0.0909 | 0.1217 | 0.0293 | 0.5063 | 0.8135 |
| 1992 | 77 | 2 | 21 | 2 | 0.0952 | 0.0952 | 0.0513 | 0.0110 | 0.2396 | 0.9002 |
| 1993 | 60 | 8 | 14 | 3 | 0.2143 | 0.5714 | 0.5069 | 0.1511 | 1.6999 | 0.6649 |
| 1994 | 82 | 2 | 22 | 2 | 0.0909 | 0.0909 | 0.0988 | 0.0238 | 0.4099 | 0.8116 |
| 1995 | 84 | 11 | 22 | 1 | 0.0455 | 0.5000 | 0.2194 | 0.0361 | 1.3345 | 1.1220 |
| 1996 | 75 | 10 | 22 | 5 | 0.2273 | 0.4545 | 0.9926 | 0.3980 | 2.4755 | 0.4818 |
| 1997 | 82 | 16 | 21 | 1 | 0.0476 | 0.7619 | 0.3237 | 0.0531 | 1.9720 | 1.1234 |
| 1998 | 83 | 3 | 22 | 1 | 0.0455 | 0.1364 | 0.0598 | 0.0098 | 0.3640 | 1.1220 |
| 1999 | 83 | 4 | 22 | 4 | 0.1818 | 0.1818 | 0.3658 | 0.1297 | 1.0322 | 0.5555 |
| 2000 | 81 | 5 | 22 | 2 | 0.0909 | 0.2273 | 0.3321 | 0.0794 | 1.3890 | 0.8177 |
| 2001 | 79 | 15 | 19 | 3 | 0.1579 | 0.7895 | 0.8950 | 0.2703 | 2.9633 | 0.6565 |
| 2002 | 81 | 40 | 20 | 4 | 0.2000 | 2.0000 | 1.3687 | 0.4874 | 3.8434 | 0.5526 |
| 2003 | 83 | 125 | 20 | 6 | 0.3000 | 6.2500 | 2.0099 | 0.8958 | 4.5094 | 0.4211 |
| 2004 | 79 | 9 | 20 | 5 | 0.2500 | 0.4500 | 1.4911 | 0.5831 | 3.8132 | 0.4966 |
| 2005 | 83 | 17 | 19 | 2 | 0.1053 | 0.8947 | 0.9350 | 0.2254 | 3.8787 | 0.8116 |
| 2006 | 85 | 11 | 20 | 5 | 0.2500 | 0.5500 | 0.9047 | 0.3643 | 2.2469 | 0.4794 |
| 2007 | 82 | 23 | 19 | 4 | 0.2105 | 1.2105 | 1.4459 | 0.5166 | 4.0463 | 0.5506 |
| 2008 | 84 | 15 | 20 | 3 | 0.1500 | 0.7500 | 0.7169 | 0.2171 | 2.3674 | 0.6547 |
| 2009 | 84 | 43 | 18 | 4 | 0.2222 | 2.3889 | 1.7550 | 0.6256 | 4.9236 | 0.5521 |
| 2010 | 85 | 20 | 20 | 4 | 0.2000 | 1.0000 | 1.3757 | 0.4916 | 3.8494 | 0.5505 |
| 2011 | 86 | 12 | 20 | 5 | 0.2500 | 0.6000 | 0.9313 | 0.3762 | 2.3053 | 0.4775 |
| 2012 | 88 | 49 | 20 | 5 | 0.2500 | 2.4500 | 3.9289 | 1.5923 | 9.6940 | 0.4756 |

Table A3. Results of the RIDEM seasonal trawl survey incorporating bottom temperature data and the time frame of the alternate assessment model (1979-2012) using the same factors as the preferred model (1981-2012). Analysis number of tows (n tows), number of sharks (catch), number of model observations per year (n obs), number of positive model observations per year (obs pos), proportion of positive model observations per year (obs ppos), nominal cpue as sharks per 20 minute tow (obs cpue), resulting estimated cpue from the model (est cpue), the lower 95% confidence limit for the est cpue (LCL), the upper 95% confidence limit for the est cpue (UCL), and the coefficient of variation for the estimated cpue (CV).

| year | n tows | catch | n obs | obs pos | obs ppos | obs cpue | est cpue | LCL | UCL | CV |
|---|---|---|---|---|---|---|---|---|---|---|
| 1979 | 70 | 0 | 13 | 0 | 0 | 0 | | | | |
| 1980 | 74 | 13 | 10 | 5 | 0.5000 | 1.3000 | 1.5730 | 0.6437 | 3.8442 | 0.4700 |
| 1981 | 136 | 36 | 22 | 5 | 0.2273 | 1.6364 | 1.7686 | 0.7170 | 4.3626 | 0.4754 |
| 1982 | 139 | 27 | 21 | 4 | 0.1905 | 1.2857 | 1.2645 | 0.4329 | 3.6939 | 0.5769 |
| 1983 | 139 | 14 | 22 | 1 | 0.0455 | 0.6364 | 0.2797 | 0.0471 | 1.6602 | 1.0999 |
| 1984 | 132 | 16 | 22 | 7 | 0.3182 | 0.7273 | 1.7593 | 0.8433 | 3.6704 | 0.3805 |
| 1985 | 123 | 41 | 21 | 4 | 0.1905 | 1.9524 | 1.2717 | 0.4558 | 3.5479 | 0.5487 |
| 1986 | 108 | 7 | 22 | 3 | 0.1364 | 0.3182 | 0.4717 | 0.1457 | 1.5274 | 0.6420 |
| 1987 | 103 | 2 | 21 | 1 | 0.0476 | 0.0952 | 0.0699 | 0.0114 | 0.4299 | 1.1318 |
| 1988 | 85 | 0 | 22 | 0 | 0 | 0 | . | . | . | . |
| 1989 | 84 | 2 | 22 | 1 | 0.0455 | 0.0909 | 0.0400 | 0.0067 | 0.2372 | 1.0999 |
| 1990 | 87 | 66 | 22 | 1 | 0.0455 | 3.0000 | 1.3188 | 0.2222 | 7.8269 | 1.0999 |
| 1991 | 81 | 2 | 22 | 2 | 0.0909 | 0.0909 | 0.1212 | 0.0298 | 0.4924 | 0.7965 |
| 1992 | 77 | 2 | 21 | 2 | 0.0952 | 0.0952 | 0.0507 | 0.0111 | 0.2311 | 0.8818 |
| 1993 | 60 | 8 | 14 | 3 | 0.2143 | 0.5714 | 0.5081 | 0.1548 | 1.6673 | 0.6507 |
| 1994 | 82 | 2 | 22 | 2 | 0.0909 | 0.0909 | 0.0995 | 0.0246 | 0.4033 | 0.7945 |
| 1995 | 84 | 11 | 22 | 1 | 0.0455 | 0.5000 | 0.2198 | 0.0370 | 1.3045 | 1.0999 |
| 1996 | 75 | 10 | 22 | 5 | 0.2273 | 0.4545 | 0.8890 | 0.3630 | 2.1773 | 0.4713 |
| 1997 | 82 | 16 | 21 | 1 | 0.0476 | 0.7619 | 0.3247 | 0.0546 | 1.9297 | 1.1011 |
| 1998 | 83 | 3 | 22 | 1 | 0.0455 | 0.1364 | 0.0599 | 0.0101 | 0.3558 | 1.0999 |
| 1999 | 83 | 4 | 22 | 4 | 0.1818 | 0.1818 | 0.3472 | 0.1251 | 0.9636 | 0.5455 |
| 2000 | 81 | 5 | 22 | 2 | 0.0909 | 0.2273 | 0.3249 | 0.0795 | 1.3273 | 0.8006 |
| 2001 | 79 | 15 | 19 | 3 | 0.1579 | 0.7895 | 0.8622 | 0.2657 | 2.7974 | 0.6433 |
| 2002 | 81 | 40 | 20 | 4 | 0.2000 | 2.0000 | 1.2678 | 0.4596 | 3.4974 | 0.5418 |
| 2003 | 83 | 125 | 20 | 6 | 0.3000 | 6.2500 | 1.8002 | 0.8136 | 3.9830 | 0.4133 |
| 2004 | 79 | 9 | 20 | 5 | 0.2500 | 0.4500 | 1.4625 | 0.5813 | 3.6799 | 0.4870 |
| 2005 | 83 | 17 | 19 | 2 | 0.1053 | 0.8947 | 0.9032 | 0.2232 | 3.6550 | 0.7937 |
| 2006 | 85 | 11 | 20 | 5 | 0.2500 | 0.5500 | 0.8926 | 0.3641 | 2.1881 | 0.4718 |
| 2007 | 82 | 23 | 19 | 4 | 0.2105 | 1.2105 | 1.3518 | 0.4913 | 3.7200 | 0.5403 |
| 2008 | 84 | 15 | 20 | 3 | 0.1500 | 0.7500 | 0.6743 | 0.2085 | 2.1809 | 0.6412 |
| 2009 | 84 | 43 | 18 | 4 | 0.2222 | 2.3889 | 1.6534 | 0.5992 | 4.5625 | 0.5420 |
| 2010 | 85 | 20 | 20 | 4 | 0.2000 | 1.0000 | 1.2857 | 0.4673 | 3.5378 | 0.5403 |
| 2011 | 86 | 12 | 20 | 5 | 0.2500 | 0.6000 | 0.8592 | 0.3518 | 2.0984 | 0.4696 |
| 2012 | 88 | 49 | 20 | 5 | 0.2500 | 2.4500 | 3.6678 | 1.5054 | 8.9364 | 0.4683 |

Figure A1. Results of the RIDEM seasonal trawl survey incorporating bottom temperature data and the time frame of the preferred assessment model (1981-2012). Smooth dogfish nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).

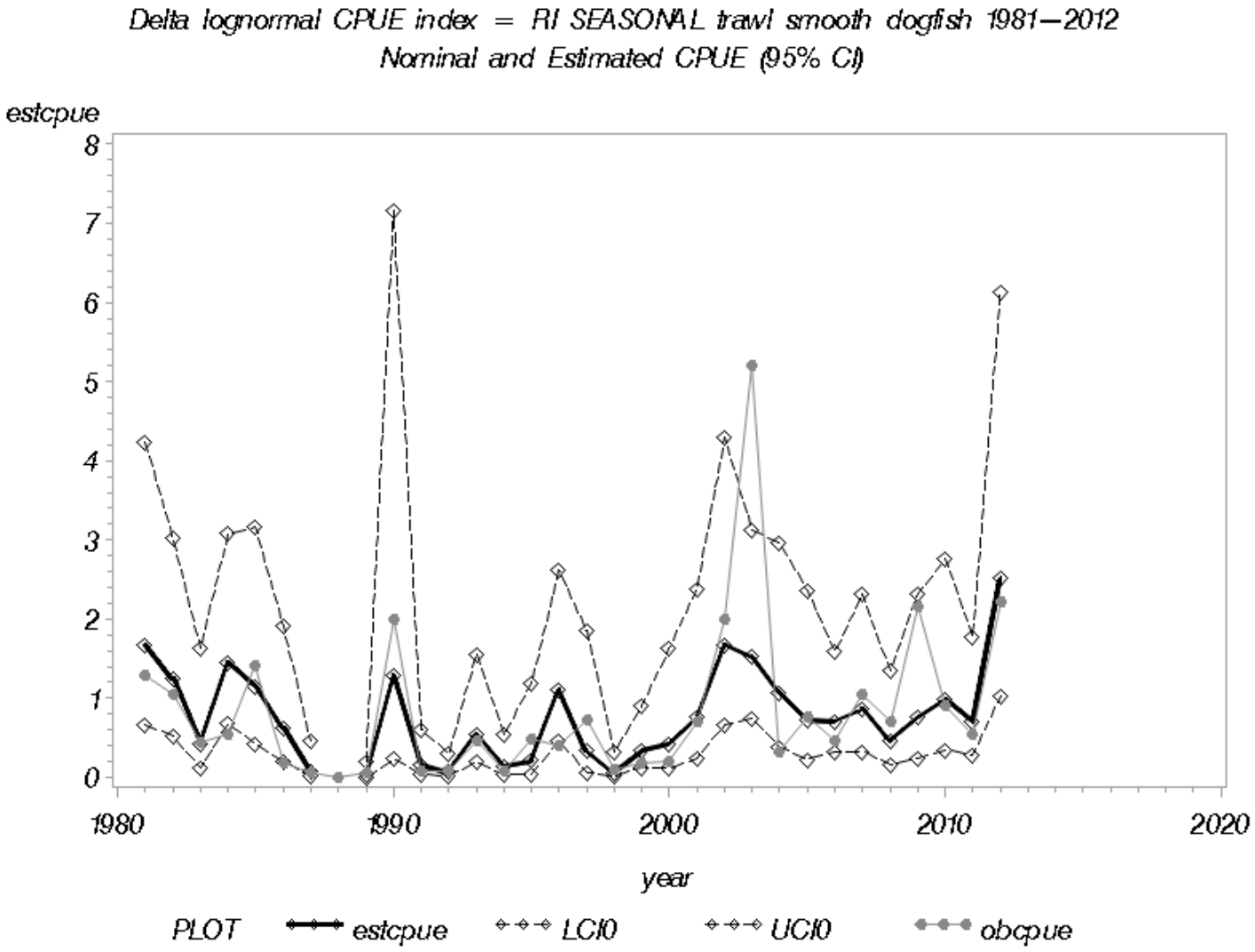


Figure A2. Results of the RIDEM seasonal trawl survey incorporating bottom temperature data and the time frame of the alternate assessment model (1979-2012). Smooth dogfish nominal (obcpue) and estimated (estcpue) indices with 95% confidence limits (LCI0, UCI0).