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INDICES OF ABUNDANCE FOR LARGE BLUEFIN TUNA, *THUNNUS THYNNUS*, FROM THE U.S. MANDATORY PELAGIC LONGLINE FISHERY IN THE GULF OF MEXICO AND OFF THE FLORIDA EAST COAST

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SUMMARY

Indices of abundance of large bluefin tuna from the pelagic longline fishery in the Gulf of Mexico and off the Florida east coast were derived from a selected subset of vessels which consistently caught bluefin tuna between 1987 and 1992.

RESUME

Les indices d'abondance des grands thons rouges de la pêcherie palangrière pélagique dans le golfe du Mexique et au large de la côte orientale de Floride ont été calculés à partir d'un sous-jeu sélectionné de bateaux qui ont constamment capturé du thon rouge entre 1987 et 1992.

RESUMEN

Se obtuvieron índices de abundancia de grandes atunes procedentes de la pesquería pelágica de palangre del Golfo de México y de la costa este de Florida, de un subconjunto seleccionado de barcos que capturaron atún rojo de forma constante entre 1987 y 1992.

Introduction

The purpose of this paper is to provide standardized CPUE for bluefin tuna in the Gulf of Mexico (GOM) and off the Florida east coast (FEC) for possible use by the SCRS in its stock assessments. This is a continuation of the work by Farber and Turner (1991); it differs from the earlier work in some aspects of the analytical methods.

Large bluefin tuna are caught in the GOM and off the FEC as bycatch by longline vessels fishing for other species of tuna or for swordfish. Although bluefin are considered to be bycatch in this fishery, examination of the data indicated that some vessels have above average catch rates for bluefin tuna. Vessels which consistently catch the most bluefin were identified and catch and effort information from those vessels was used to estimate indices of abundance.

Materials and Methods

U.S. Atlantic fishing vessels which land swordfish have been required to provide daily records of effort and catch since October 1986. Six complete years of data (1987 to 1992) are now available. Since swordfish landings are made by a variety of gear types over a wide geographical area, it was necessary to exclude effort not relevant to catch of bluefin. This was accomplished by defining a subset of times and areas and vessels where bluefin are most likely to be caught.

Examination of the data indicates that catch of large bluefin is primarily reported by longline boats in the GOM and the FEC between January first and the end of May. Therefor these analyses are restricted to those areas and times. In addition, vessels having a greater than average likelihood of catching bluefin were identified by ranking vessels by the number of large bluefin reported caught in the National Marine Fisheries Service Northeast Regional database (NER). The NER was used because it should represent a census of landed bluefin. The NER, however, does not include information on effort associated with the catch of bluefin, while the logbook data set does. Vessels were ranked over all years and for each year from 1987 to 1992. A vessel ranking among the top 30 vessels over all years and among the top 30 in three individual years was considered for inclusion in the analysis. Fourteen vessels met this criterion. Twelve vessels were included in the analyses after close examination of the self reported catch and effort indicated catch information from two vessels was unreliable in the early years.

Analyses

Two related approaches were used to estimate indices of abundance, both applications of general linear models (GLM). We replicated the method applied by Farber and Turner (1991), in which the log-transformed daily catch rates reported in the logbook data set are modelled as a function of categorical and continuous variables, and in which a constant (a value of 1) was added to each observation to allow log-transformation of the zero catch rates and inclusion of these data into the modelling. In addition to using a +1 transform, following from Porch and Scott (SCRS/93/75) a constant equal to 10 times the maximum observed CPUE was also added prior to logging the observations. We also applied the delta-lognormal approach described by Lo *et.al.* (1992) in which the log-transformed positive catch rates (without any constant added) and the proportion of observations (days fishing) for which there was a positive catch were modelled separately to produce an index as:

$$\hat{I}=\hat{C}*\hat{S}=[\Psi_c e^{\beta_c}][\Psi_s e^{\beta_s}-1],$$

where $\hat{I}$ represents the estimated annual index value, $\hat{C}$, the annual standardized positive catch rate, and $\hat{S}$ the annual standardized proportion of days fished for which there was success in catching bluefin. Following Lo *et.al.* (1992), a value of 1 was added to the observed S values to permit inclusion of 0 values in modelling the log-transformed observations. In the above equation, β_c and β_s, represent the log-scale, standardized GLM estimates of marginal mean (LSMEAN) CPUE and proportion of days fished on which bluefin were caught, and Ψ_c and Ψ_s, the log-transformation bias adjustments for β_c and β_s, respectively. Variance in $\hat{I}$ was estimated via the delta method (Seber 1982). The appropriate equations for estimating this variance and calculating the log-transformation bias adjustment terms are provided in Lo *et.al.* (1992) and are not repeated herein. The log-transform bias adjustment was applied to both the Delta-lognormal and added constant transform methods.

Variables Investigated

As in the earlier analysis, bluefin caught included fish both reported kept and discarded. This was done to decrease the possible effects of U.S. regulatory changes which restricted longline landing of bluefin tuna during open season to two fish per trip from 1987 to 1991 and one fish per trip in 1992 and required release of all bluefin after season closure. In 1992 in addition to the 1 bluefin per trip restriction, boats were required to have at least 1134 kg of other species on board before a landing a bluefin.

Variables included in the analyses and thought to influence catch of bluefin were year, area, season, vessel, swordfish catch rate, yellowfin tuna catch rate, depth, and hooks per mile.

Nominal statistics indicated that bluefin catch rates were consistently lower off the FEC than in the GOM (Figure 1) and consistently lower after the season was closed (Figure 2). Season closure dates vary considerably between years (Table 1) with very early (February) closures in 1989 and 1990 and late (April) closures in 1991 and 1992. Lower reported catch rates after season closure may be due to under reporting of discarded bluefin and/or to a change in effort.

Bluefin tuna are considered to be more like yellowfin tuna than like swordfish in respect to feeding behavior. Swordfish are more likely to be caught at deeper depths and at night rather than in the day. No consistent relationships between bluefin and yellowfin catch rates (by area and season) were observed, however bluefin catch rates varied inversely with catch rates of swordfish (Figure 3).

Model Development

Four models were developed using a GLM approach similar to Cramer *et.al.* (1991). In all cases determination of the importance of main effects and interactions were made primarily on the basis of proportion of the total sums of squares explained by the variables. This was done because in many cases the residuals did not appear to be normally distributed.

The first model was developed using all data from the 12 vessels to predict the natural log of the catch rate. A value of one was added to each record before log transformation so that zero values could be transformed. Only records with positive catch rates were used in the second model so it was not necessary to add one to bluefin catch rates. The third model was developed by creating a new dependent variable equal to natural log of the proportion of sets resulting in a catch of bluefin within each year, area, season and vessel. As in model one it was necessary to add one to these proportions in order to accommodate cases in which zero catch was made. The results of the second and third models were combined using the Delta-lognormal method (Lo *et.al.* 1992) to produce a single index. The fourth model used a constant equal to 10 times the maximum observed CPUE (a value of 233 in this case). This value was added prior to logging the observed CPUE.

Results and Discussion

Models 1, 3 and 4 were similar and reflect relationships already observed. Both area, season, and the interaction between area and season were judged significant. As observed in Figures 1 and 2, bluefin catch rates were consistently higher in the GOM than off the FEC and higher during open seasons than during closed seasons. Swordfish catch rate was significantly negatively related to bluefin catch as suggested by Figure 3. Success rate also varied significantly between vessels and a significant vessel season interaction was found in both models. Vessel season interaction was dropped from model 1 since missing cells resulted in inestimable marginal means (LSMEAN) in the model with vessel*season interaction.

Model 2, developed using only positive sets, was somewhat different from models 1, 3 and 4. Significant variables in model 2 include year, vessel, hooks per mile, and depth. No significant interactions were found. Bluefin catch rate was negatively correlated with increases in depth and increases in hooks per mile.

Final Models:

Model 1: R^2 = 0.14
ln(bftcr+1) = year area season ves swocr area*season

Model 2: R^2 = 0.36
ln(bftcr) = year ves hpm depth

Model 3: R^2 = 0.64
ln(ppos+1) = year area season ves swocr area*season season*ves

Model 4: R^2 = 0.12
ln(bftcr+233) = year area season ves swocr area*season

Variable descriptions: bftcr = bluefin tuna catch rate (bluefin/1000 hooks), ves = vessel, swocr = swordfish catch rate (swordfish/1000 hooks), hpm = hooks per mile, ppos = proportion of sets catching bluefin tuna

The index of annual abundance estimated using the delta-lognormal method GLMs showed a similar pattern to the added constant transformation GLMs. The resulting index values from the delta-lognormal method were slightly more precise and the residual patterns generally less skewed than in the case of the +1 transformation (Figures 4 and 5, and Table 2). Tables 3-9 present the results of the GLM fits to the data and a description of the residuals of the fits. Each index was complicated by changes in fishery regulations in 1992, apparent shifts in effort, and possible under reporting of discarded fish. Analyses were conducted discounting the 1992 data (the period for which a new regulation was put into effect). Results are summarized in Table 2.

Literature Cited

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Table 1: Date of season closure in years 1987 to 1992.

YEAR	CLOSURE DATE
1987	MARCH 22
1988	MARCH 15
1989	FEBRUARY 18
1990	FEBRUARY 27
1991	APRIL 8
1992	APRIL 10

Table 2: Indices of abundance for large bluefin tuna in the Gulf of Mexico and off the Florida East Coast. Abs represents estimated catch/1000 hooks; Rel represents relative CPUE relative to 1987; CV represents estimated Coefficient of Variation. Fits were made using all data and only data from 1987-1991 (No 1992).

YEAR	+1 TRANSFORM			Delta-Lognormal			+10MAX TRANSFORM		
	Abs	Rel	CV	Abs	Rel	CV	Abs	Rel	CV
a: All Data									
1987	0.67	1.00	.09	0.86	1.00	.07	0.87	1.00	.11
1988	0.36	0.54	.13	0.27	0.32	.16	0.40	0.46	.27
1989	0.50	0.75	.10	0.47	0.54	.10	0.65	0.75	.16
1990	0.46	0.68	.13	0.51	0.59	.12	0.68	0.78	.19
1991	0.64	0.96	.10	0.81	0.95	.07	0.92	1.06	.13
1992	0.23	0.34	.20	0.19	0.22	.19	0.06	0.07	2.10
b: No 1992									
1987	0.71	1.00	.09	0.90	1.00	.07	0.90	1.00	.11
1988	0.36	0.51	.13	0.26	0.29	.15	0.38	0.43	.29
1989	0.51	0.72	.11	0.49	0.54	.09	0.65	0.72	.17
1990	0.49	0.69	.13	0.55	0.62	.11	0.72	0.79	.19
1991	0.68	0.97	.10	0.85	0.95	.07	0.97	1.07	.14

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Table 3.                 GLM on catches +1

Source                 DF     Sum of Squares      F Value        Pr > F
Model                  20       109.94090871        16.85        0.0001
Error                1994       650.54322736
Corrected Total      2014       760.48413607

                 R-Square               C.V.                  LBF Mean
                 0.144567           202.3498                0.28227523

Source                 DF        Type III SS      F Value        Pr > F
YR                      5        22.72500480        13.93        0.0001
AREA                    1         7.84779571        24.05        0.0001
SEASON                  1        12.30192392        37.71        0.0001
ID                     11        32.75134921         9.13        0.0001
SWOCR                   1         5.49631444        16.85        0.0001
AREA*SEASON             1         1.83345482         5.62        0.0179

                                        T for H0:     Pr > |T|   Std Error of
Parameter              Estimate       Parameter=0                 Estimate
INTERCEPT           0.0810103583 B           1.19       0.2331     0.06792266
YR             87   0.3082476822 B           6.85       0.0001     0.04497643
               88   0.1016404521 B           2.18       0.0296     0.04669778
               89   0.1987377870 B           4.35       0.0001     0.04565310
               90   0.1747574937 B           3.63       0.0003     0.04816749
               91   0.2922133744 B           6.52       0.0001     0.04485128
               92   0.0000000000 B             .          .           .
AREA           2    0.1208164982 B           2.46       0.0141     0.04917778
               3    0.0000000000 B             .          .           .
SEASON         1    0.1220616819 B           2.34       0.0195     0.05221936
               2    0.0000000000 B             .          .           .
ID             5792-.4133281103 B           -5.34       0.0001     0.07741679
               6060-.1473366627 B           -2.41       0.0163     0.06125996
               6137-.2232156469 B           -3.41       0.0007     0.06543961
               61650.1266319633 B            1.49       0.1377     0.08526892
               6352-.2307792384 B           -3.97       0.0001     0.05817943
               6467-.1861897855 B           -2.85       0.0044     0.06529729
               6467-.0067457782 B           -0.11       0.9123     0.06127493
               6503-.0992151059 B           -1.60       0.1104     0.06212420
               6889-.0375187552 B           -0.54       0.5882     0.06928990
               9025-.4096773071 B           -6.48       0.0001     0.06320583
               9079-.1725363374 B           -1.98       0.0483     0.08733527
               90820.0000000000 B             .          .           .
SWOCR                -.0028296290           -4.10       0.0001     0.00068940
AREA*SEASON    2 1 0.1541230026 B            2.37       0.0179     0.06501415
               2 2 0.0000000000 B             .          .           .
               3 1 0.0000000000 B             .          .           .
               3 2 0.0000000000 B             .          .           .
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Table 4.       Studentized Residuals +1 transform CPUE

               N              2015   Sum Wgts         2015
               Mean       0.000019   Sum          0.037752
               Std Dev    1.000301   Variance     1.000601
               Skewness    1.60814   Kurtosis     2.472205

 SRESID                                                  CUM             CUM
MIDPOINT                                        FREQ    FREQ  PERCENT  PERCENT
         |
  -3.0   |                                         0       0     0.00     0.00
  -2.5   |                                         0       0     0.00     0.00
  -2.0   |                                         0       0     0.00     0.00
  -1.5   |*                                       28      28     1.39     1.39
  -1.0   |************                           300     328    14.89    16.28
  -0.5   |****************************           701    1029    34.79    51.07
   0.0   |**********************                 559    1588    27.74    78.81
   0.5   |**                                      61    1649     3.03    81.84
   1.0   |***                                     66    1715     3.28    85.11
   1.5   |*****                                  124    1839     6.15    91.27
   2.0   |***                                     79    1918     3.92    95.19
   2.5   |***                                     63    1981     3.13    98.31
   3.0   |*                                       34    2015     1.69   100.00
         |
         --------+-------+-------+----
                200     400     600
                  FREQUENCY
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Table 5. GLM on proportion positives

```
Source                    DF     Sum of Squares      F Value      Pr > F
Model                     31        31.31589841       113.19      0.0
Error                   1983        17.69794445
Corrected Total         2014        49.01384286

                    R-Square               C.V.                 POS Mean
                    0.638919           59.15672               0.15969672

Source                    DF        Type III SS      F Value      Pr > F
YR                         5         4.84828498       108.65      0.0001
AREA                       1         0.50870711        57.00      0.0001
SEASON                     1         3.18697075       357.09      0.0001
ID                        11         4.25628338        43.35      0.0001
SWOCR                      1         0.13670151        15.32      0.0001
AREA*SEASON                1         1.11299661       124.71      0.0001
SEASON*ID                 11         3.05564670        31.13      0.0001

                                        T for H0:    Pr > |T|   Std Error of
Parameter               Estimate      Parameter=0                 Estimate
INTERCEPT            0.0379077110 B          2.54      0.0112     0.01492541
YR             87    0.1334172675 B         17.72      0.0001     0.00752714
               88    0.0074578265 B          0.95      0.3422     0.00784958
               89    0.0719433601 B          9.36      0.0001     0.00768281
               90    0.0636189334 B          7.89      0.0001     0.00806423
               91    0.1133556718 B         15.16      0.0001     0.00747918
               92    0.0000000000 B           .          .          .
AREA           2     -.0254167004 B         -2.24      0.0249     0.01132319
               3     0.0000000000 B           .          .          .
SEASON         1     0.0505298732 B          2.63      0.0086     0.01922027
               2     0.0000000000 B           .          .          .
ID             5792-.0058745512 B         -0.23      0.8169     0.02536669
               6060-.0219440352 B         -1.03      0.3037     0.02132758
               61370.0952178503 B          4.88      0.0001     0.01951809
               6165-.0838259568 B         -1.89      0.0583     0.04424401
               6352-.0670773599 B         -4.48      0.0001     0.01495604
               6467-.0722185229 B         -4.20      0.0001     0.01719624
               6467-.0407477471 B         -2.53      0.0113     0.01607573
               6503-.0810038704 B         -5.00      0.0001     0.01621075
               68890.0191280005 B          1.18      0.2385     0.01622279
               9025-.0504659925 B         -2.79      0.0054     0.01811701
               9079-.0264571267 B         -0.88      0.3801     0.03013451
               90820.0000000000 B           .          .          .
SWOCR                -.0004782129          -3.91      0.0001     0.00012219
AREA*SEASON  2 1 0.1670063273 B            11.17      0.0001     0.01495499
             2 2 0.0000000000 B              .          .          .
             3 1 0.0000000000 B              .          .          .
             3 2 0.0000000000 B              .          .          .
SEASON*ID    1 57-.1613059281 B            -5.60      0.0001     0.02879224
             1 60-.0062742545 B            -0.25      0.7990     0.02463234
             1 61-.1406815594 B            -6.00      0.0001     0.02344090
             1 610.1760109390 B             3.76      0.0002     0.04678244
             1 63-.0345090166 B            -1.75      0.0798     0.01968712
             1 640.0084029089 B             0.37      0.7091     0.02251873
             1 640.1623711080 B             7.79      0.0001     0.02084873
             1 650.0861348371 B             4.08      0.0001     0.02111433
             1 68-.0133750541 B            -0.57      0.5706     0.02358045
             1 90-.1156096581 B            -5.30      0.0001     0.02182631
             1 900.0228791203 B             0.67      0.5042     0.03424884
             1 900.0000000000 B              .          .          .
             2 570.0000000000 B              .          .          .
             2 600.0000000000 B              .          .          .
             2 610.0000000000 B              .          .          .
             2 610.0000000000 B              .          .          .
             2 630.0000000000 B              .          .          .
             2 640.0000000000 B              .          .          .
             2 640.0000000000 B              .          .          .
             2 650.0000000000 B              .          .          .
             2 680.0000000000 B              .          .          .
             2 900.0000000000 B              .          .          .
             2 900.0000000000 B              .          .          .
             2 900.0000000000 B              .          .          .
```

Table 6. GLM on positive catches

```
Source                    DF     Sum of Squares      F Value      Pr > F
Model                     18        39.54655275        10.94      0.0001
Error                    348        69.88880425
Corrected Total          366       109.43535700

                    R-Square               C.V.               LBFCR Mean
                    0.361369           36.73315               1.21998922

Source                    DF        Type III SS      F Value      Pr > F
YR                         5         4.44786660         4.43      0.0006
ID                        11        12.68247131         5.74      0.0001
HPM                        1         7.45432557        37.12      0.0001
DEPTH                      1         2.04773538        10.20      0.0015

                                      T for H0:    Pr > |T|   Std Error of
Parameter              Estimate     Parameter=0                 Estimate
INTERCEPT           2.442949800 B         11.42      0.0001     0.21397089
YR            87    0.256611875 B          3.00      0.0029     0.08546530
              88    0.229623141 B          2.23      0.0263     0.10294074
              89    0.064257509 B          0.67      0.5040     0.09605970
              90    0.220884667 B          2.17      0.0306     0.10173308
              91    0.320097747 B          3.92      0.0001     0.08157858
              92    0.000000000 B           .          .          .
ID            5792-0.081589327 B         -0.49      0.6264     0.16746129
              6060-0.156927382 B         -1.47      0.1412     0.10641854
              6137-0.380515587 B         -3.05      0.0024     0.12462174
              6165-0.002303285 B         -0.02      0.9858     0.12976855
              6352-0.087562264 B         -0.68      0.4972     0.12883742
              6467-0.154179449 B         -1.23      0.2198     0.12542020
              6467-0.278148447 B         -2.24      0.0255     0.12400917
              6503 0.290798209 B          2.03      0.0434     0.14346972
              6889-0.294606600 B         -2.34      0.0198     0.12584823
              9025-0.435913220 B         -3.06      0.0024     0.14244117
              9079 0.103048128 B          0.63      0.5314     0.16447458
              9082 0.000000000 B           .          .          .
HPM                -0.047379161          -6.09      0.0001     0.00777674
DEPTH              -0.002343902          -3.19      0.0015     0.00073404
```

Table 7. Studentized Residuals Proportion Positive

```
               N               2015   Sum Wgts        2015
               Mean        0.000031   Sum         0.063272
               Std Dev     1.000578   Variance    1.001157
               Skewness    0.173005   Kurtosis    2.285352

  SRESID                                           CUM                  CUM
 MIDPOINT                                 FREQ    FREQ   PERCENT    PERCENT
           |
   -3.0    |*                               10      10      0.50       0.50
   -2.5    |*                               22      32      1.09       1.59
   -2.0    |***                             66      98      3.28       4.86
   -1.5    |*****                           93     191      4.62       9.48
   -1.0    |************                   223     414     11.07      20.55
   -0.5    |*****************              342     756     16.97      37.52
    0.0    |**********************         438    1194     21.74      59.26
    0.5    |*********************          421    1615     20.89      80.15
    1.0    |*************                  263    1878     13.05      93.20
    1.5    |**                              47    1925      2.33      95.53
    2.0    |***                             55    1980      2.73      98.26
    2.5    |                                 1    1981      0.05      98.31
    3.0    |**                              34    2015      1.69     100.00
           |
           -----+----+----+----+--
               100  200  300  400
                 FREQUENCY
```

Table 8. Studentized Residuals Positive CPUE

```
               N                367   Sum Wgts         367
               Mean        -0.00023   Sum         -0.08416
               Std Dev     1.001333   Variance    1.002668
               Skewness    1.082041   Kurtosis    1.349154

  SRESID                                        CUM                  CUM
 MIDPOINT                                FREQ   FREQ   PERCENT    PERCENT
           |
   -3.0    |                                0      0      0.00       0.00
   -2.5    |                                0      0      0.00       0.00
   -2.0    |*                               4      4      1.09       1.09
   -1.5    |***                            16     20      4.36       5.45
   -1.0    |************                   57     77     15.53      20.98
   -0.5    |******************             89    166     24.25      45.23
    0.0    |******************             91    257     24.80      70.03
    0.5    |*******                        34    291      9.26      79.29
    1.0    |*******                        34    325      9.26      88.56
    1.5    |****                           20    345      5.45      94.01
    2.0    |*                               7    352      1.91      95.91
    2.5    |*                               6    358      1.63      97.55
    3.0    |**                              9    367      2.45     100.00
           |
           ----+---+---+---+--
              20  40  60  80
               FREQUENCY
```

Table 9. GLM on catches +10max_CPUE

```
Source                    DF     Sum of Squares      F Value      Pr > F
Model                     20         0.01537215        12.39      0.0001
Error                   1994         0.12368799
Corrected Total         2014         0.13906014

                    R-Square               C.V.                LBFN Mean
                    0.110543           0.144401               5.45420709

Source                    DF        Type III SS      F Value      Pr > F
YR                         5         0.00315528        10.17      0.0001
AREA                       1         0.00103696        16.72      0.0001
SEASON                     1         0.00148776        23.98      0.0001
ID                        11         0.00532426         7.80      0.0001
SWOCR                      1         0.00075121        12.11      0.0005
AREA*SEASON                1         0.00020362         3.28      0.0702

                                      T for H0:    Pr > |T|   Std Error of
Parameter              Estimate     Parameter=0                 Estimate
INTERCEPT           5.452934978 B       5822.24      0.0        0.00093657
YR            87    0.003469817 B          5.59      0.0001     0.00062017
              88    0.001473627 B          2.29      0.0222     0.00064391
              89    0.002548523 B          4.05      0.0001     0.00062950
              90    0.002668610 B          4.02      0.0001     0.00066417
              91    0.003701211 B          5.98      0.0001     0.00061844
              92    0.000000000 B           .          .          .
AREA          2     0.001462494 B          2.16      0.0311     0.00067810
              3     0.000000000 B           .          .          .
SEASON        1     0.001377683 B          1.91      0.0558     0.00072004
              2     0.000000000 B           .          .          .
ID            5792-0.005772187 B         -5.41      0.0001     0.00106748
              6060-0.002642326 B         -3.13      0.0018     0.00084470
              6137-0.004573786 B         -5.07      0.0001     0.00090233
              6165 0.000421399 B          0.36      0.7201     0.00117575
              6352-0.003920421 B         -4.89      0.0001     0.00080222
              6467-0.003244867 B         -3.60      0.0003     0.00090037
              6467-0.002111296 B         -2.50      0.0125     0.00084491
              6503-0.001907498 B         -2.23      0.0261     0.00085662
              6889-0.001741005 B         -1.82      0.0686     0.00095542
              9025-0.006124914 B         -7.03      0.0001     0.00087153
              9079-0.003553337 B         -2.95      0.0032     0.00120425
              9082 0.000000000 B           .          .          .
SWOCR              -0.000033081          -3.48      0.0005     0.00000951
AREA*SEASON   2 1   0.001624212 B          1.81      0.0702     0.00089647
              2 2   0.000000000 B           .          .          .
              3 1   0.000000000 B           .          .          .
              3 2   0.000000000 B           .          .          .
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FIGURE 1: BLUEFIN TUNA CATCH RATES
BY YEAR AND AREA

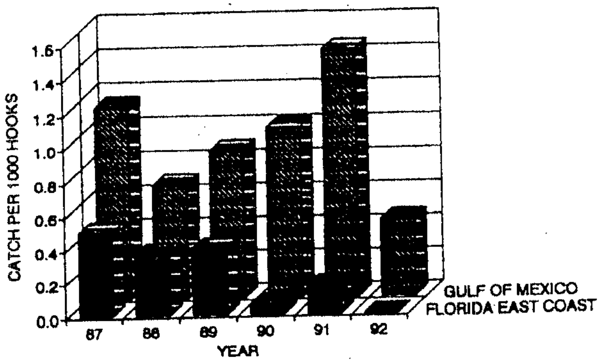

FIGURE 2: BLUEFIN TUNA CATCH RATES
BY YEAR AND SEASON

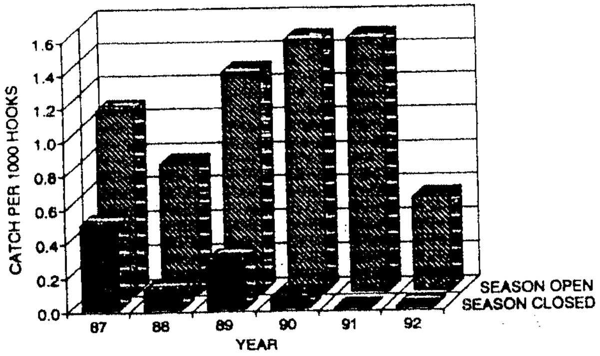

FIGURE 3: CATCH RATES
BY AREA AND SEASON

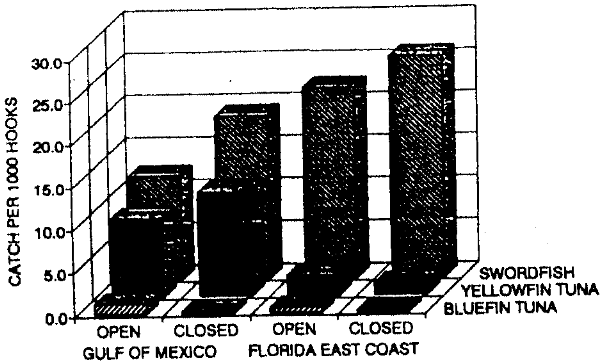

FIGURE 4a: INDICES OF ABUNDANCE
1987 - 1992

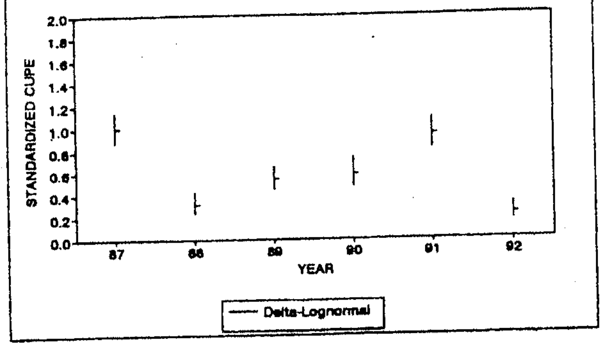

FIGURE 4b: INDICES OF ABUNDANCE
1987 - 1992

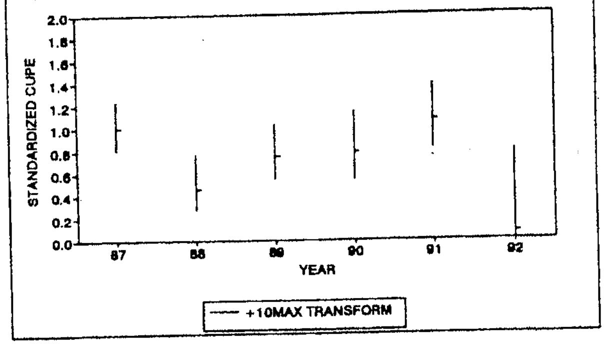

FIGURE 4c: INDICES OF ABUNDANCE
1987 - 1992

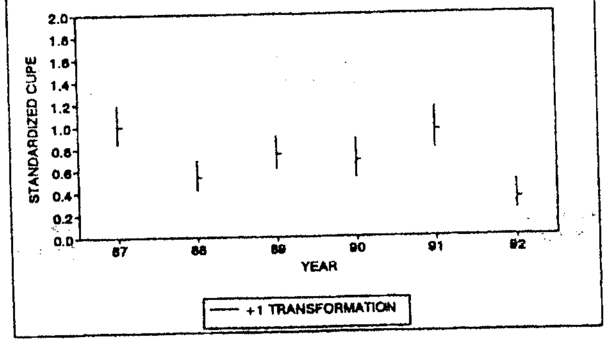

FIGURE 5a: INDICES OF ABUNDANCE
1987 - 1991

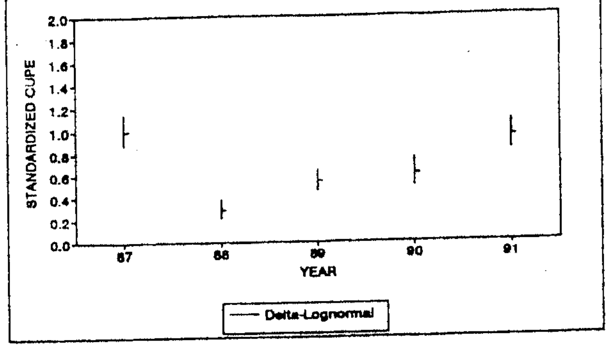

FIGURE 5b: INDICES OF ABUNDANCE
1987 - 1991

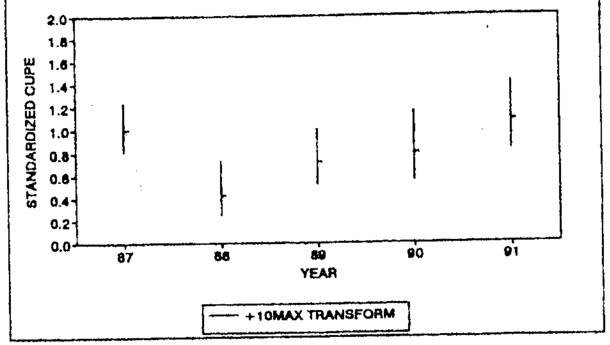

FIGURE 5c: INDICES OF ABUNDANCE
1987 - 1991