# Patterns of annual abundance of red grouper observed in chevron traps set during the MARMAP Survey (1990 – 2008) in the U.S. South Atlantic.

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## Introduction and Methodology

Red grouper have been sampled by the MARMAP (Marine Resources Monitoring Assessment and Prediction) program using various gears (gears detailed in previous working paper SEDAR10-DW-05). Indices of abundance from the Chevron trap (1990-2007) was recommended for use in the assessment. Other MARMAP gear types were considered, such as, Florida Antillean trap, hook & line, and vertical longlines, but were thought less likely to provide adequate indices because of low to no sample sizes. Chevron traps were baited with cut clupeids and deployed at stations randomly selected by computer from a database of approximately 2,500 live bottom and shelf edge locations and buoyed ("soaked") for approximately 90 minutes. Beginning in the 1990s, additional sites were selected, based on scientific and commercial fisheries sources, off North Carolina and south Florida to facilitate expanding the overall sampling coverage. The site expansion has been ongoing, with a few new sites added each year. As a result, the survey has relatively extensive regional coverage.

The CPUE from MARMAP chevron trap data was computed in units of number fish caught per trap-hour. The duration of the time series was 1990–2008. Spatial coverage included areas from Florida through North Carolina.

Fish in many cases are overdispersed as a result of behavior and/or physical oceanographic processes, resulting in catch data which is not normal. Therefore, samples taken from such overdispersed populations contain many small or zero values and few very large values, and simple estimates of mean abundance from sample data may either be too low if many low values are included or too high if very large values are included. Model-based estimators have been popularized since they may reduce the likelihood of false conclusions about trends in abundance (McConnaughey and Conquest 1992). They may also produce estimators with better precision (Pennington 1983, 1996; Lo *et al*. 1992).

One model-based alternative to the arithmetic mean of the sample is the delta-Poisson method. This method is a modification to that presented by Lo *et al*. (1992). The index computed by this method is a mathematical combination of yearly abundance estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive abundance values (i.e. presence/absence) and a Poisson model which describes variability in only the nonzero abundance data

The delta-Poisson index of relative abundance ($I_y$) can be estimated as

(1) $I_y = c_y p_y$,

where $c_y$ is the estimate of mean CPUE for positive catches only for year $y$; $p_y$ is the estimate of mean probability of occurrence during year $y$. Both $c_y$ and $p_y$ can be

estimated using generalized linear models. Data used to estimate abundance for positive catches ($c$) and probability of occurrence ($p$) are assumed to have a Poisson distribution and a binomial distribution, respectively, and can be modeled using the following equations:

(2) $$\ln(\mathbf{c}) = \mathbf{X\beta} + \boldsymbol{\varepsilon}$$

and

(3) $$\mathbf{p} = \frac{e^{\mathbf{X\beta}+\boldsymbol{\varepsilon}}}{1+e^{\mathbf{X\beta}+\boldsymbol{\varepsilon}}}$$, respectively,

where **c** is a vector of the positive catch data, **p** is a vector of the presence/absence data, **X** is the design matrix for main effects, **β** is the parameter vector for main effects, and **ε** is a vector of independent normally distributed errors with expectation zero and variance $\sigma^2$.

The variables $c_y$ and $p_y$ can be estimated as least-squares means for each year along with their corresponding standard errors, SE($c_y$) and SE($p_y$). From these estimates, $I_y$ can be calculated, as in equation (1), and its variance calculated as

(4)

$$V(I_y) \approx V(c_y)p_y^2 + c_y^2 V(p_y) + 2c_y p_y \mathrm{Cov}(c,p),$$

where

(5) $$\mathrm{Cov}(c,p) \approx \rho_{c,p}[\mathrm{SE}(c_y)\mathrm{SE}(p_y)],$$

and $\rho_{c,p}$ denotes correlation of $c$ and $p$ among years.

There were three variables used in the development of the abundance indices: year, latitude (categorical by degree), and depth class [i.e. station depth (ranging from) categorized into 10-m bins]. The submodels of the delta-Poisson model were built using a backward selection procedure based on type 3 analyses with an inclusion level of significance of $\alpha = 0.05$. Both the Binomial submodel and Poisson submodel performance were evaluated using AIC and analyses of residual scatter and QQ plots. Also, the Poisson submodel was developed to take into account any spatial auto-correlation, based on latitude and longitude of chevron trap set. Abundance (number per chevron trap-hour) was modeled using this approach. Initially, length and age frequency histograms were developed to determine which portion of the stock was represented in these analyses, and charts displaying annual distribution of sampling and abundance were developed.

## Results

Figure 1 illustrates the sampling effort and the number of fish observed per trap set. In order to examine effort and fish observations on an annual basis, Appendix 1 may be examined.

Figures 2 and 3 elucidate the size and age, respectively, of fish observed during the survey over the time series. In order to examine year-specific length frequency histograms, Appendix 2 may be examined. During this survey, 586 red grouper lengths and 549 red grouper ages were estimated. Red grouper ranged in length from approximately 240 to 810 mm total length with a mode of approximately 500 mm (Figure 2). In order to examine year-specific age frequency histograms for, Appendix 3 may be examined. Red grouper ranged in age from approximately 2 to 13 years with a mode of approximately 4 years (Figure 3).

Table 1 and Figure 4 summarize the abundance indices resulting from the previously described methods. For detailed results of the model building process, Appendix 4 may be examined. The nominal average non-zero catch rate was relatively close to one fish per trap-hour, indicating

that a presence/absence (i.e. probability of occurrence) model may be more appropriate than the delta-Poisson model.

## References

LO, N. C. H., 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: 2515-1526.

MCCONNAUGHEY, R.A. and L.L. Conquest. 1993. Trawl survey estimation using a comparative approach based on lognormal theory. Fish. Bull. 91: 107-118.

PENNINGTON, M. 1983. Efficient estimators of abundance, for fish and plankton surveys. Biometrics 39: 281-286.

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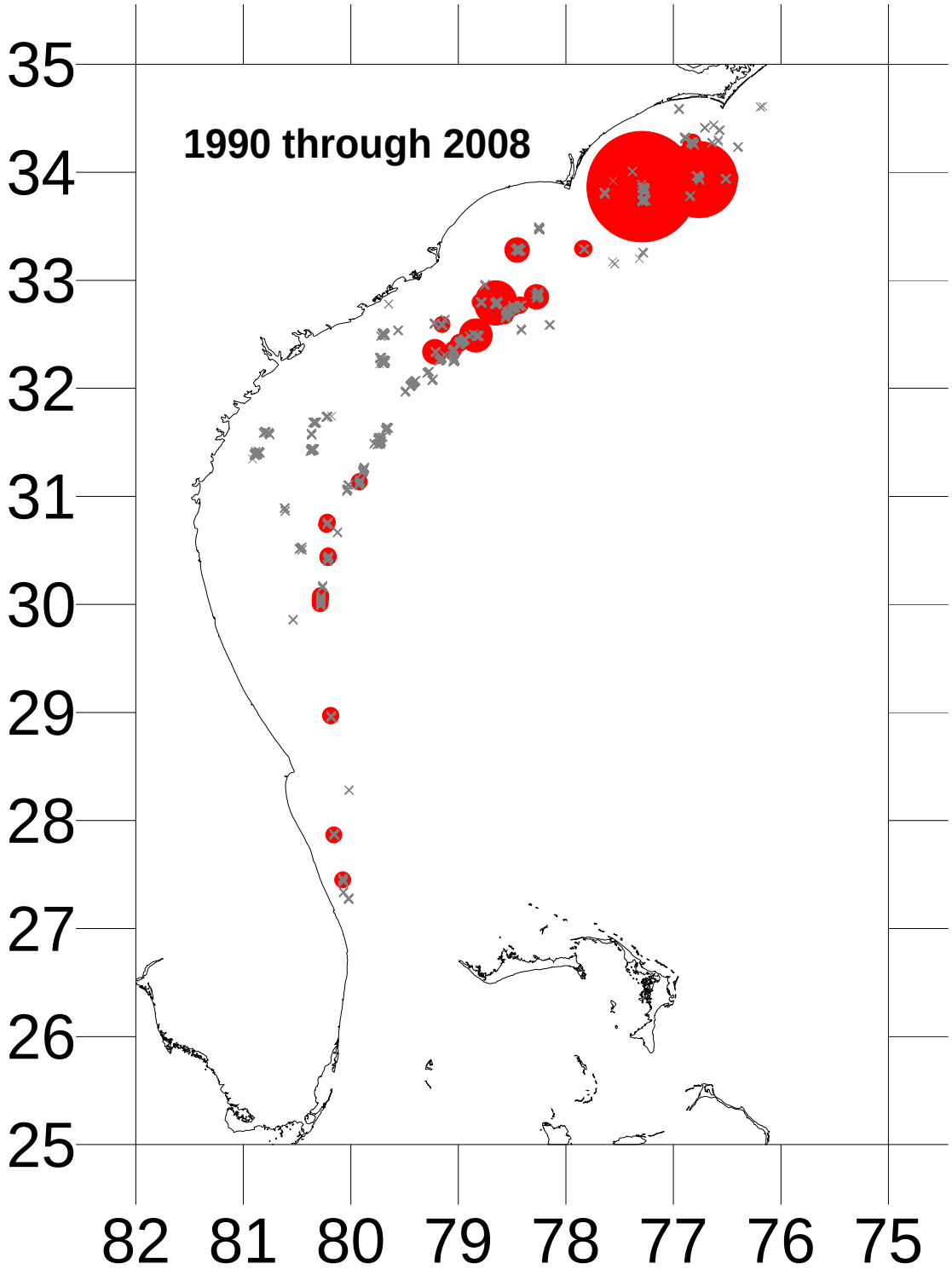



Figure 1. Effort and number of red grouper observed per chevron trap set during the MARMAP Survey (1990 – 2008). Gray crosses represent effort (5662 chevron trap sets). Red circles indicate trap sets where red grouper were observed. The diameters of the circles are linearly related to the number of red grouper observed during each chevron trap set (non-zero range: 1 – 12 red grouper per chevron trap set).

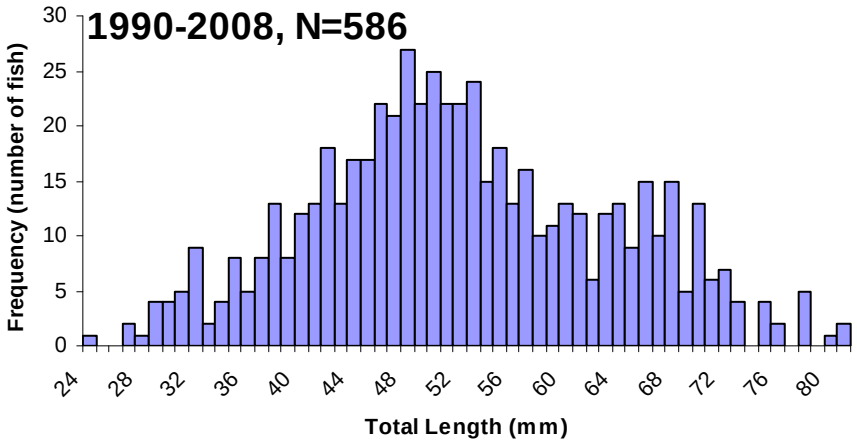



Figure 2. Length frequencies of red grouper observed in chevron traps set during the MARMAP Survey (1990 – 2008).

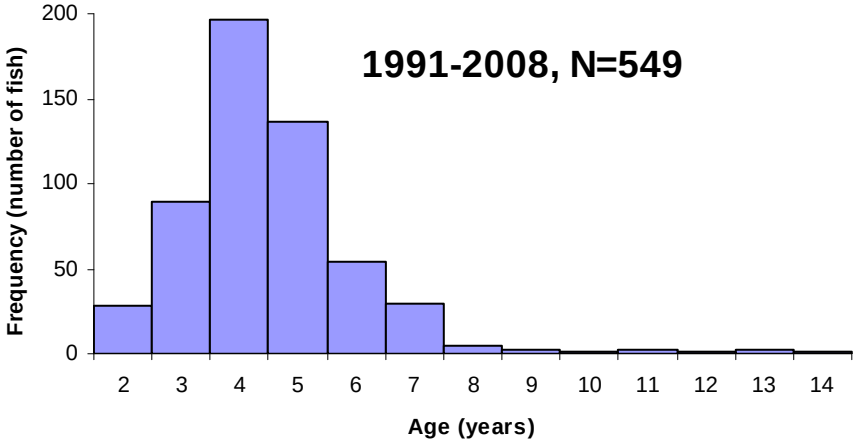



Figure 3. Age frequency of red grouper observed in chevron traps set during the MARMAP Survey (1991 – 2008).

Table 1. Model results for red grouper observed in chevron traps set during the MARMAP Survey (1990 – 2008).

| Survey Year | N | Index (number per trap-hour) | Index (scaled to a mean of one) | CV | LCL | UCL | Nominal Index (scaled to a mean of one) | Nominal Frequency of Occurrence (NFO) | Modeled Frequency of Occurrence (MFO) | CVMFO | LCLMFO | UCLMFO | Modeled Non-Zero CPUE | Nominal Non-Zero CPUE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1990 | 351 | 0.001 | 0.047 | 1.125 | 0.008 | 0.289 | 0.087 | 0.009 | 0.002 | 0.807 | 0.000 | 0.009 | 0.367 | 0.500 |
| 1991 | 301 | 0.002 | 0.119 | 0.936 | 0.024 | 0.581 | 0.135 | 0.013 | 0.007 | 0.641 | 0.002 | 0.023 | 0.265 | 0.500 |
| 1992 | 320 | 0.007 | 0.455 | 0.754 | 0.119 | 1.743 | 0.605 | 0.019 | 0.009 | 0.618 | 0.003 | 0.029 | 0.772 | 1.583 |
| 1993 | 411 | 0.013 | 0.865 | 0.654 | 0.262 | 2.854 | 0.595 | 0.019 | 0.013 | 0.522 | 0.005 | 0.037 | 0.957 | 1.500 |
| 1994 | 368 | 0.016 | 1.105 | 0.621 | 0.353 | 3.461 | 0.942 | 0.027 | 0.019 | 0.494 | 0.007 | 0.051 | 0.848 | 1.700 |
| 1995 | 272 | 0.008 | 0.516 | 0.759 | 0.134 | 1.986 | 0.412 | 0.022 | 0.011 | 0.581 | 0.004 | 0.036 | 0.673 | 0.917 |
| 1996 | 321 | 0.039 | 2.607 | 0.608 | 0.849 | 8.010 | 0.286 | 0.025 | 0.061 | 0.366 | 0.029 | 0.122 | 0.641 | 0.563 |
| 1997 | 350 | 0.005 | 0.323 | 0.884 | 0.071 | 1.476 | 0.262 | 0.011 | 0.005 | 0.712 | 0.001 | 0.021 | 0.937 | 1.125 |
| 1998 | 328 | 0.005 | 0.330 | 0.648 | 0.101 | 1.078 | 0.684 | 0.027 | 0.009 | 0.504 | 0.003 | 0.023 | 0.575 | 1.222 |
| 1999 | 225 | 0.025 | 1.698 | 0.525 | 0.633 | 4.556 | 1.404 | 0.071 | 0.039 | 0.376 | 0.019 | 0.081 | 0.643 | 0.969 |
| 2000 | 265 | 0.017 | 1.128 | 0.494 | 0.443 | 2.873 | 1.077 | 0.068 | 0.045 | 0.337 | 0.023 | 0.086 | 0.377 | 0.778 |
| 2001 | 236 | 0.025 | 1.696 | 0.527 | 0.630 | 4.567 | 1.598 | 0.064 | 0.045 | 0.385 | 0.021 | 0.094 | 0.564 | 1.233 |
| 2002 | 218 | 0.017 | 1.157 | 0.516 | 0.438 | 3.055 | 2.197 | 0.092 | 0.031 | 0.381 | 0.015 | 0.066 | 0.549 | 1.175 |
| 2003 | 218 | 0.015 | 1.018 | 0.524 | 0.380 | 2.727 | 1.403 | 0.069 | 0.033 | 0.371 | 0.016 | 0.068 | 0.458 | 1.000 |
| 2004 | 261 | 0.015 | 1.026 | 0.525 | 0.382 | 2.754 | 1.913 | 0.080 | 0.024 | 0.396 | 0.011 | 0.052 | 0.641 | 1.167 |
| 2005 | 303 | 0.017 | 1.147 | 0.476 | 0.465 | 2.830 | 0.975 | 0.076 | 0.038 | 0.339 | 0.019 | 0.073 | 0.450 | 0.630 |
| 2006 | 285 | 0.025 | 1.697 | 0.520 | 0.638 | 4.516 | 1.860 | 0.063 | 0.028 | 0.396 | 0.013 | 0.060 | 0.918 | 1.444 |
| 2007 | 326 | 0.022 | 1.507 | 0.489 | 0.597 | 3.800 | 1.657 | 0.058 | 0.027 | 0.360 | 0.013 | 0.055 | 0.830 | 1.395 |
| 2008 | 303 | 0.008 | 0.560 | 0.655 | 0.169 | 1.850 | 0.908 | 0.040 | 0.012 | 0.525 | 0.004 | 0.033 | 0.707 | 1.125 |

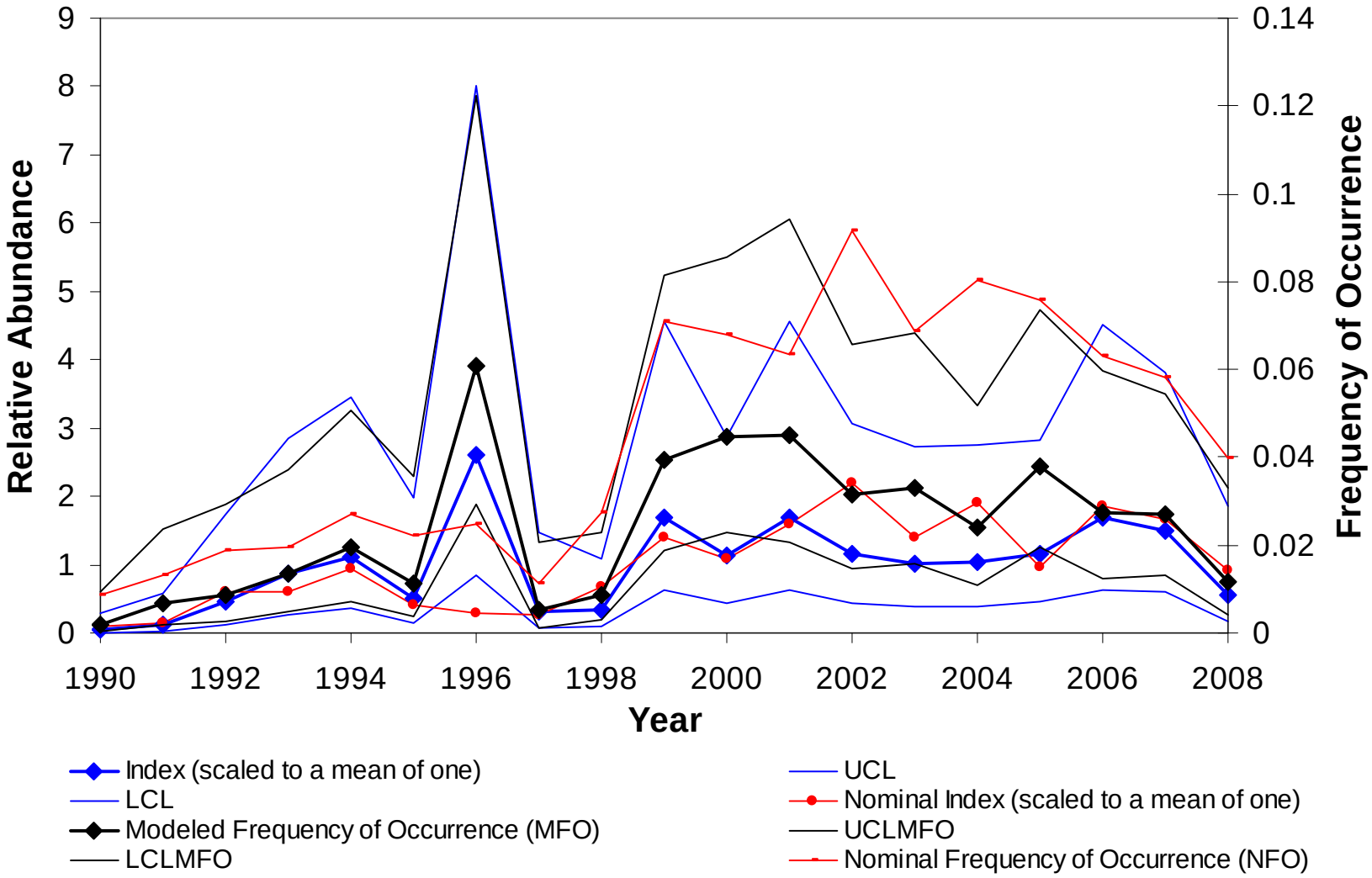
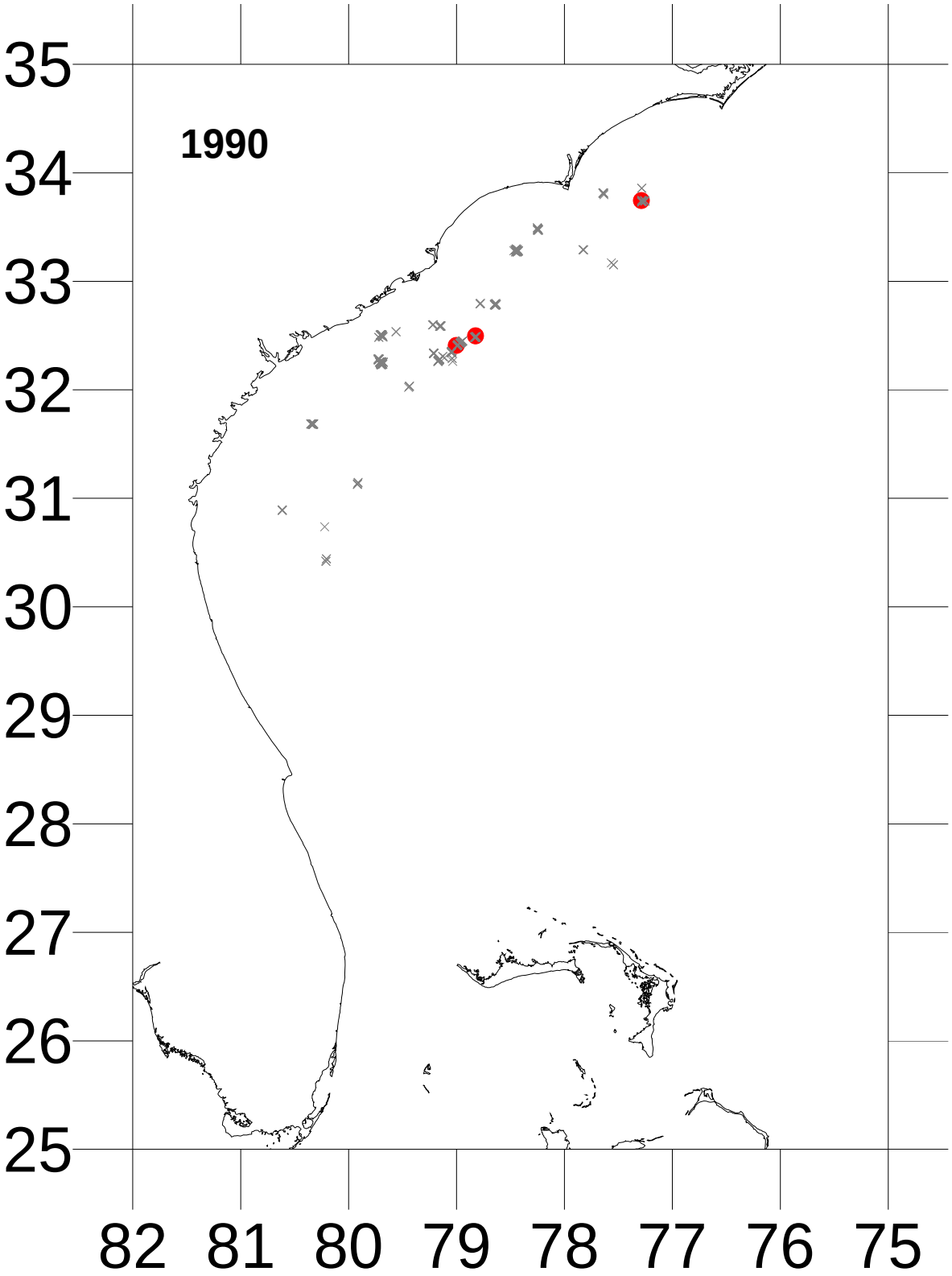



Figure 4. Model results for red grouper observed in chevron traps set during the MARMAP Survey (1990 – 2008).

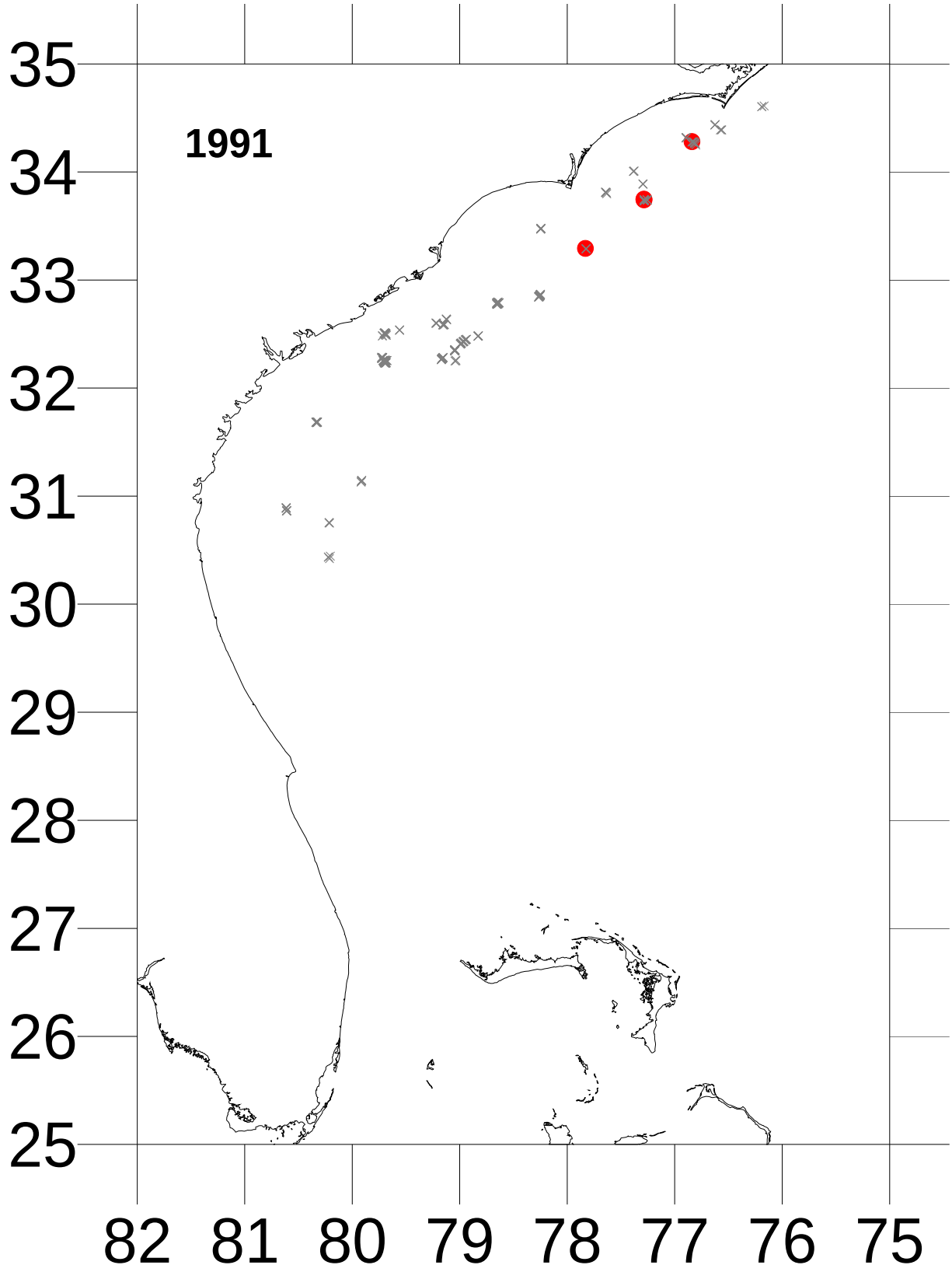
# Appendix 1:

## Effort and number observed from MARMAP chevron trap survey for the U.S. South Atlantic (1990 – 2008).

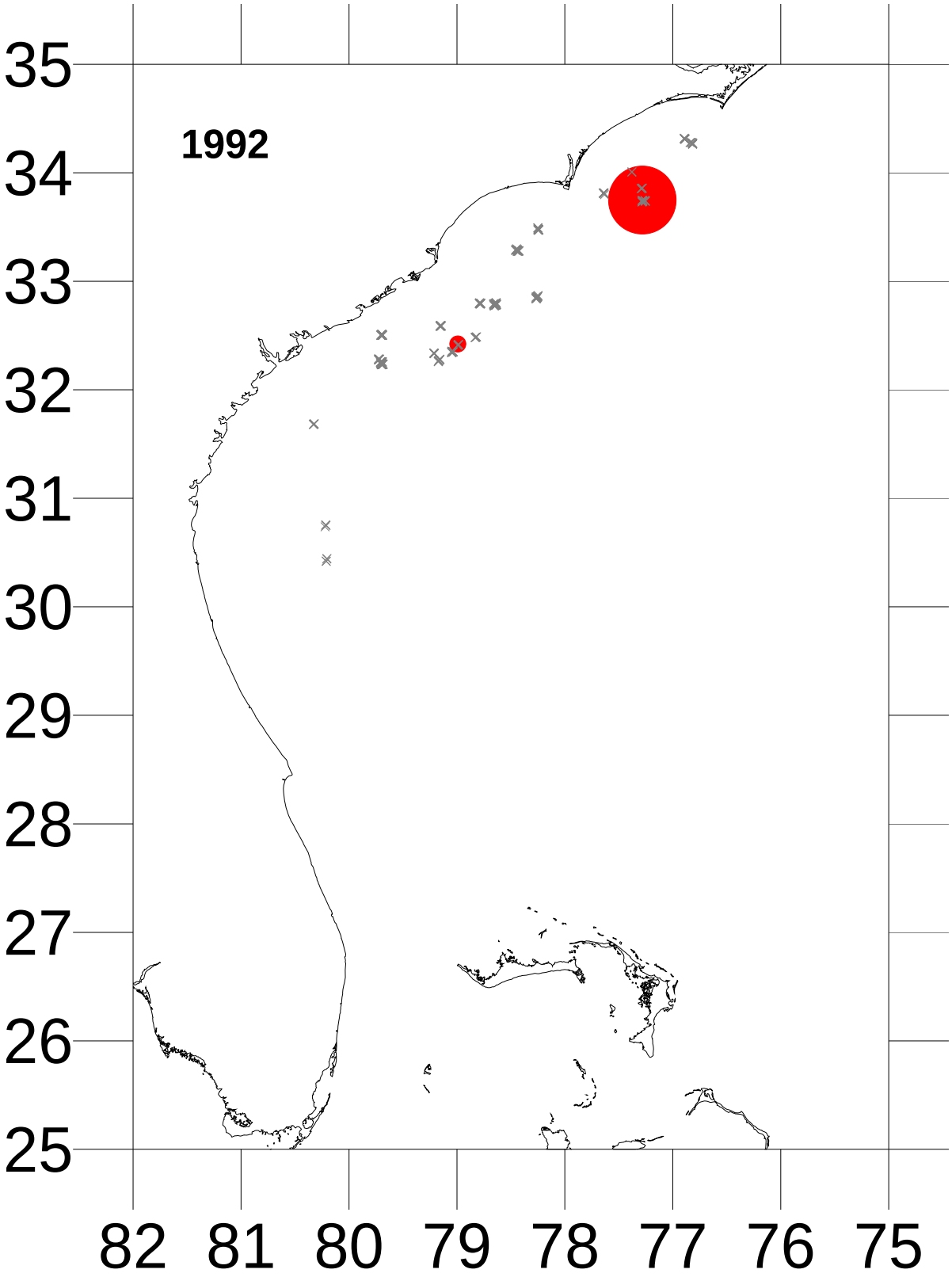
Yearly effort and number of red grouper observed per chevron trap set during the MARMAP Survey (1990 – 2008). Gray crosses represent effort; red circles indicate trap sets where red grouper were observed. The diameters of the circles are linearly related to the number of red grouper observed during each chevron trap set (non-zero range: 1 – 12 red grouper per chevron trap set). Under each chart, the effort (i.e. number of chevron trap sets) and the range of non-zero observations are reported.



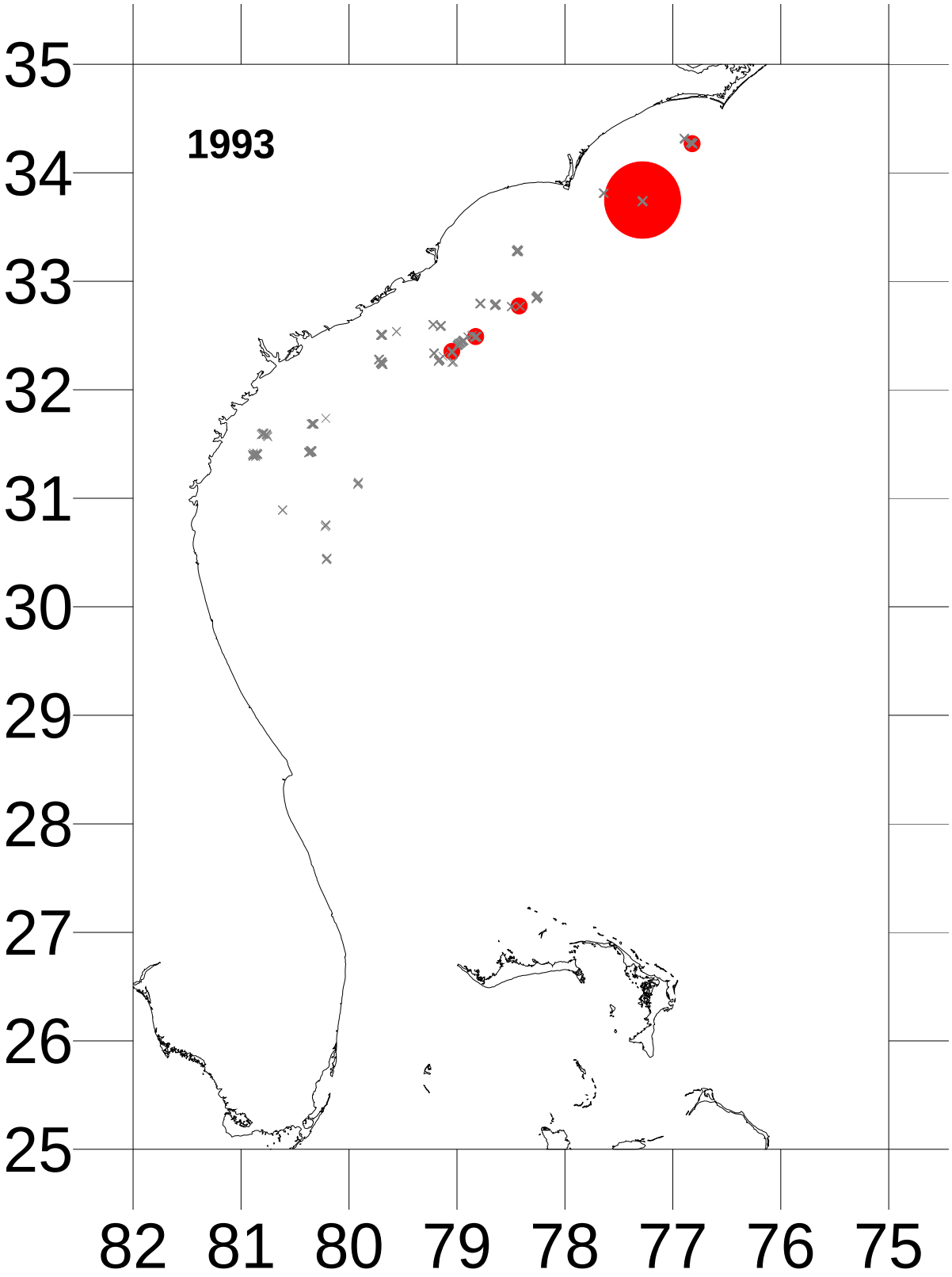

Effort: 351 chevron trap sets
Range of non-zero red grouper observations: 1



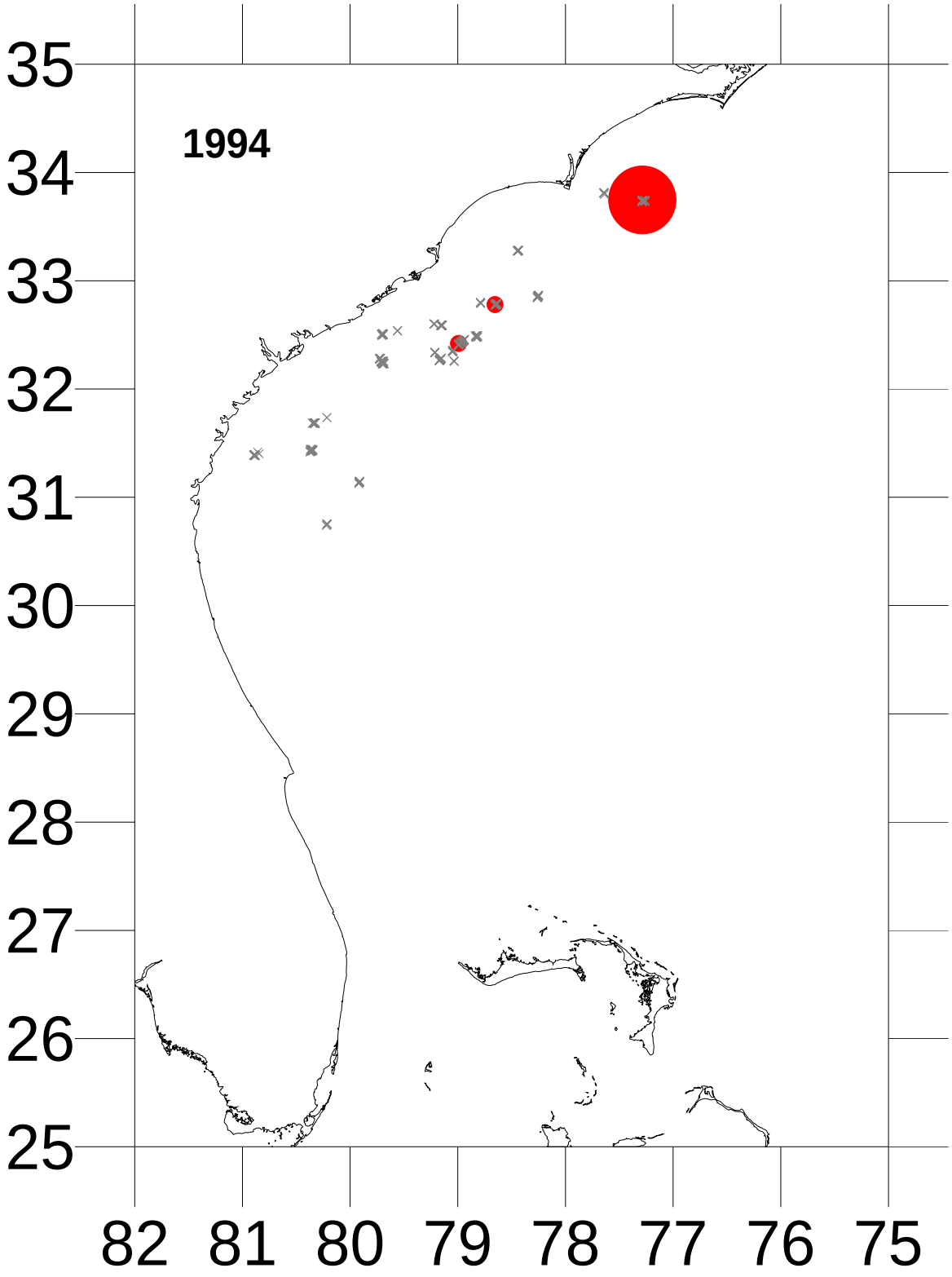

Effort: 301 chevron trap sets
Range of non-zero red grouper observations: 1



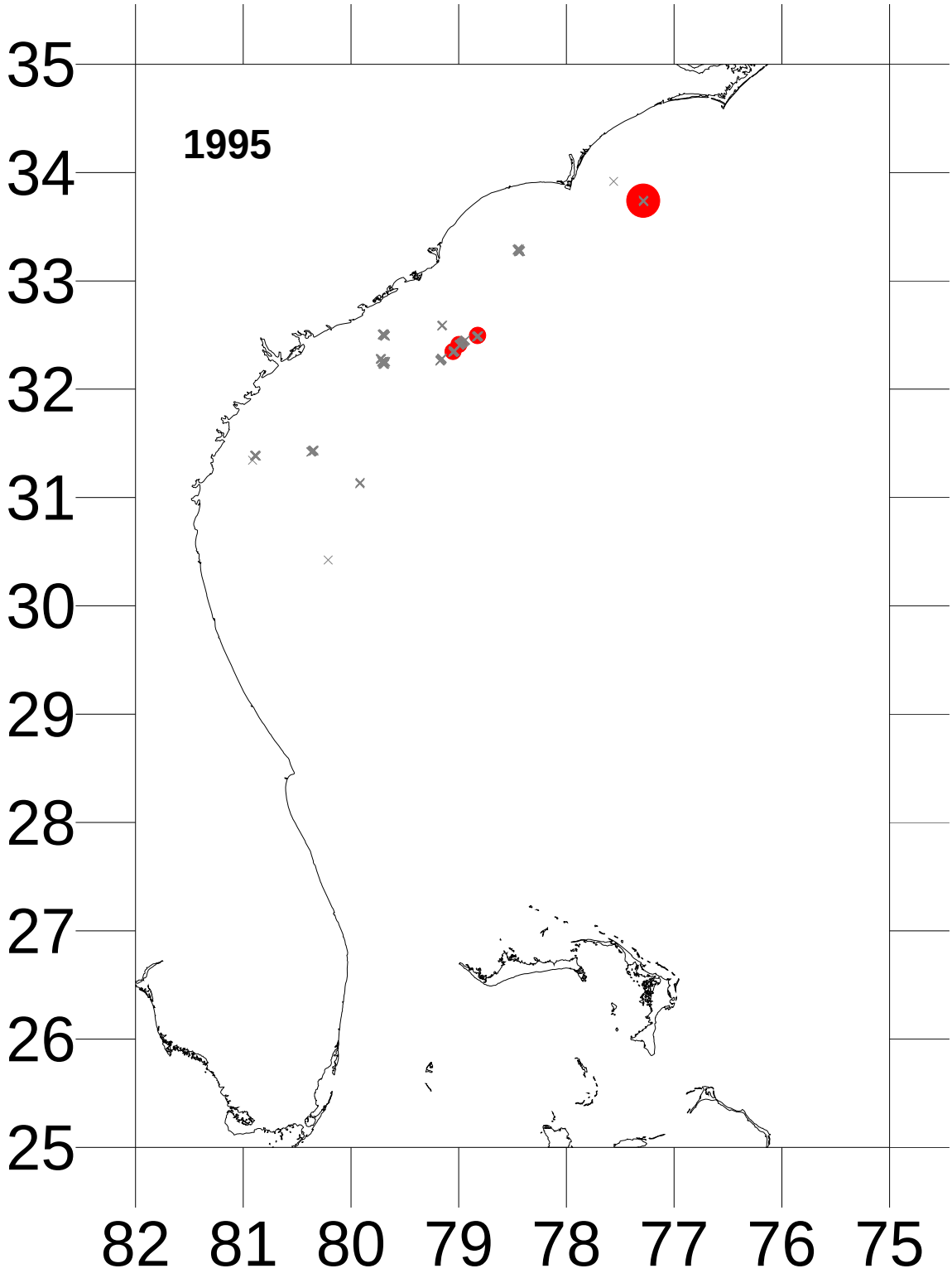

Effort: 320 chevron trap sets
Range of non-zero red grouper observations: 1 – 7



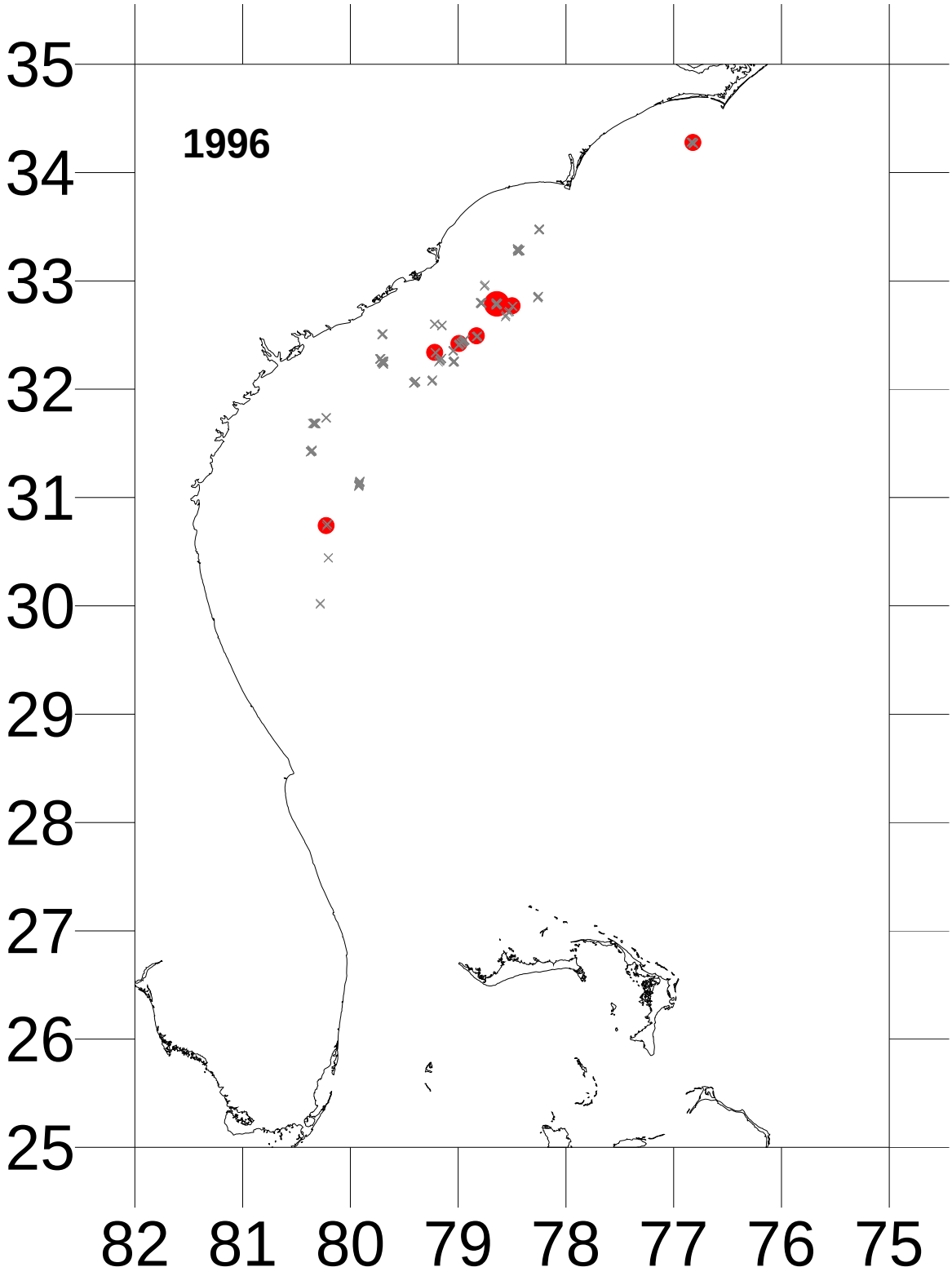

Effort: 411 chevron trap sets
Range of non-zero red grouper observations: 1 – 8



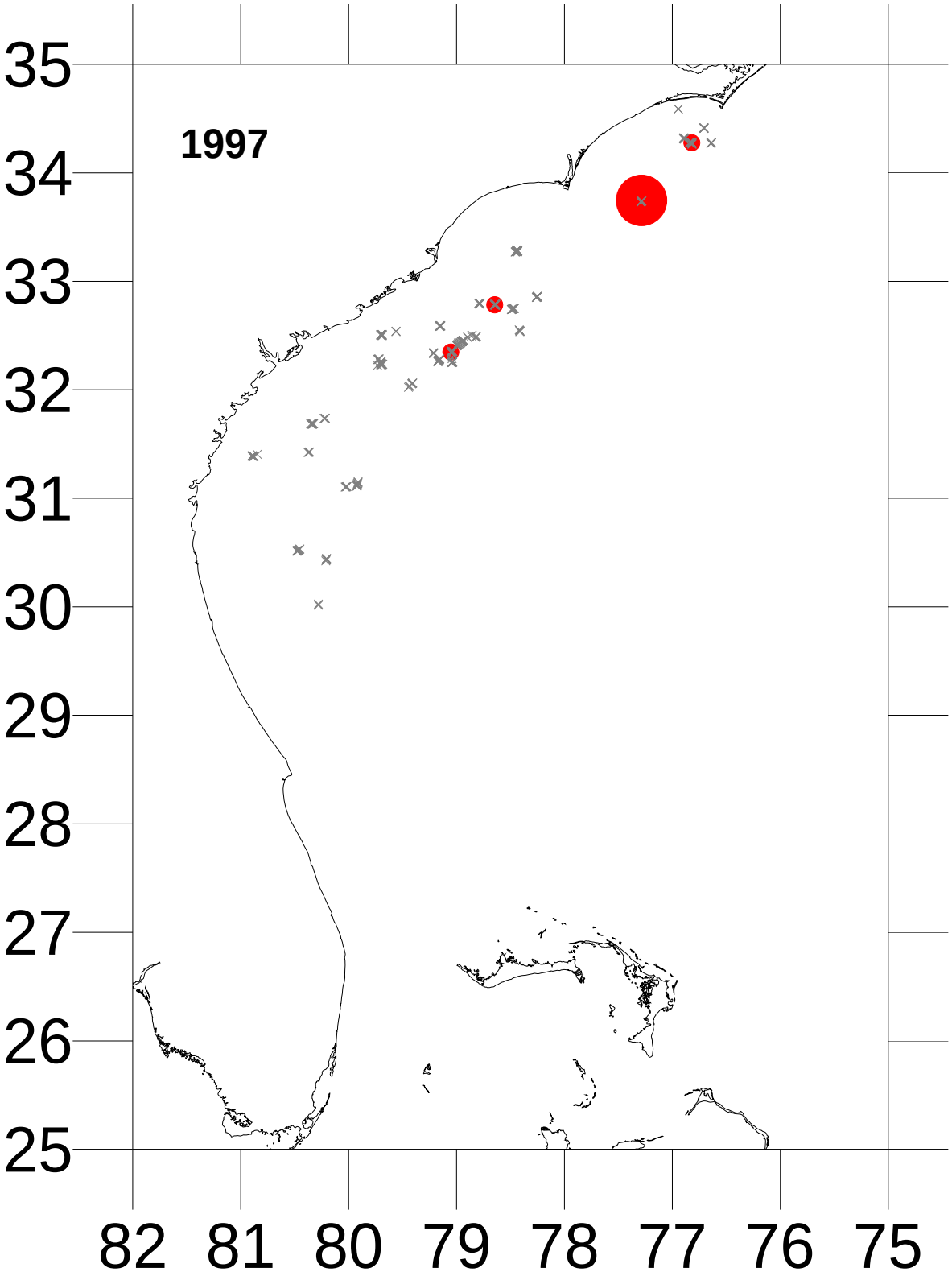

Effort: 368 chevron trap sets
Range of non-zero red grouper observations: 1 – 7



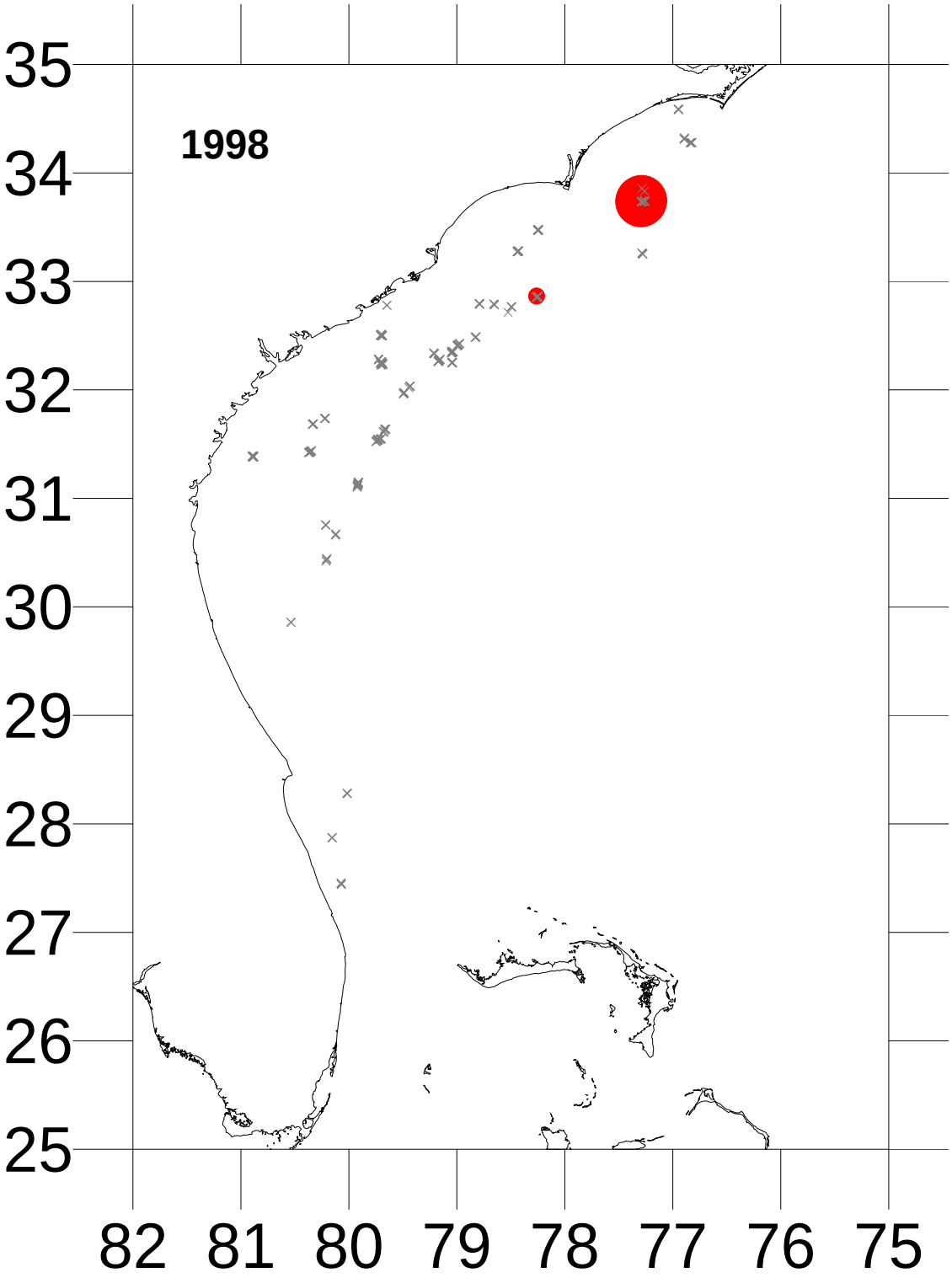

Effort: 272 chevron trap sets
Range of non-zero red grouper observations: 1 – 3



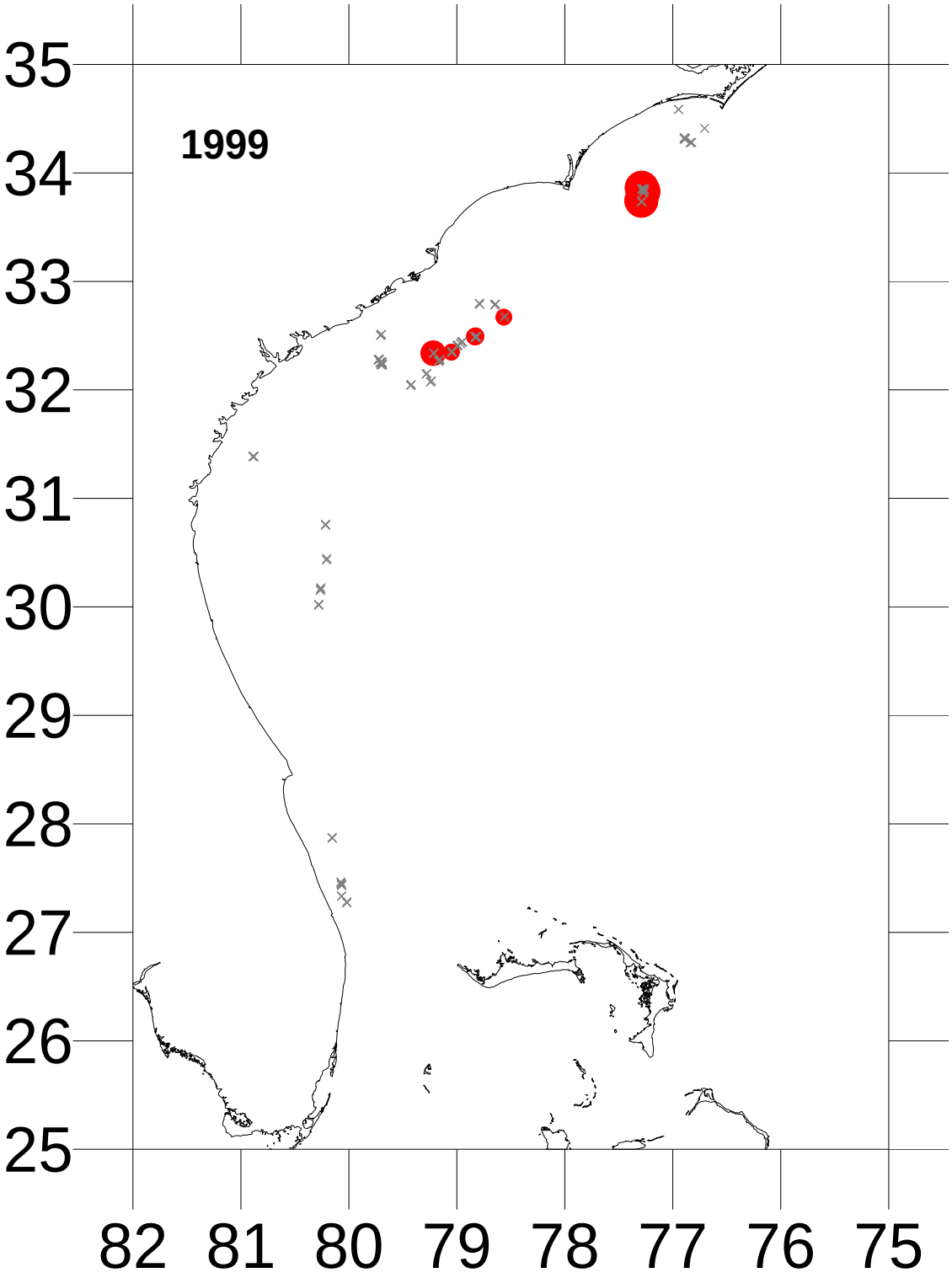

Effort: 321 chevron trap sets
Range of non-zero red grouper observations: 1 – 2



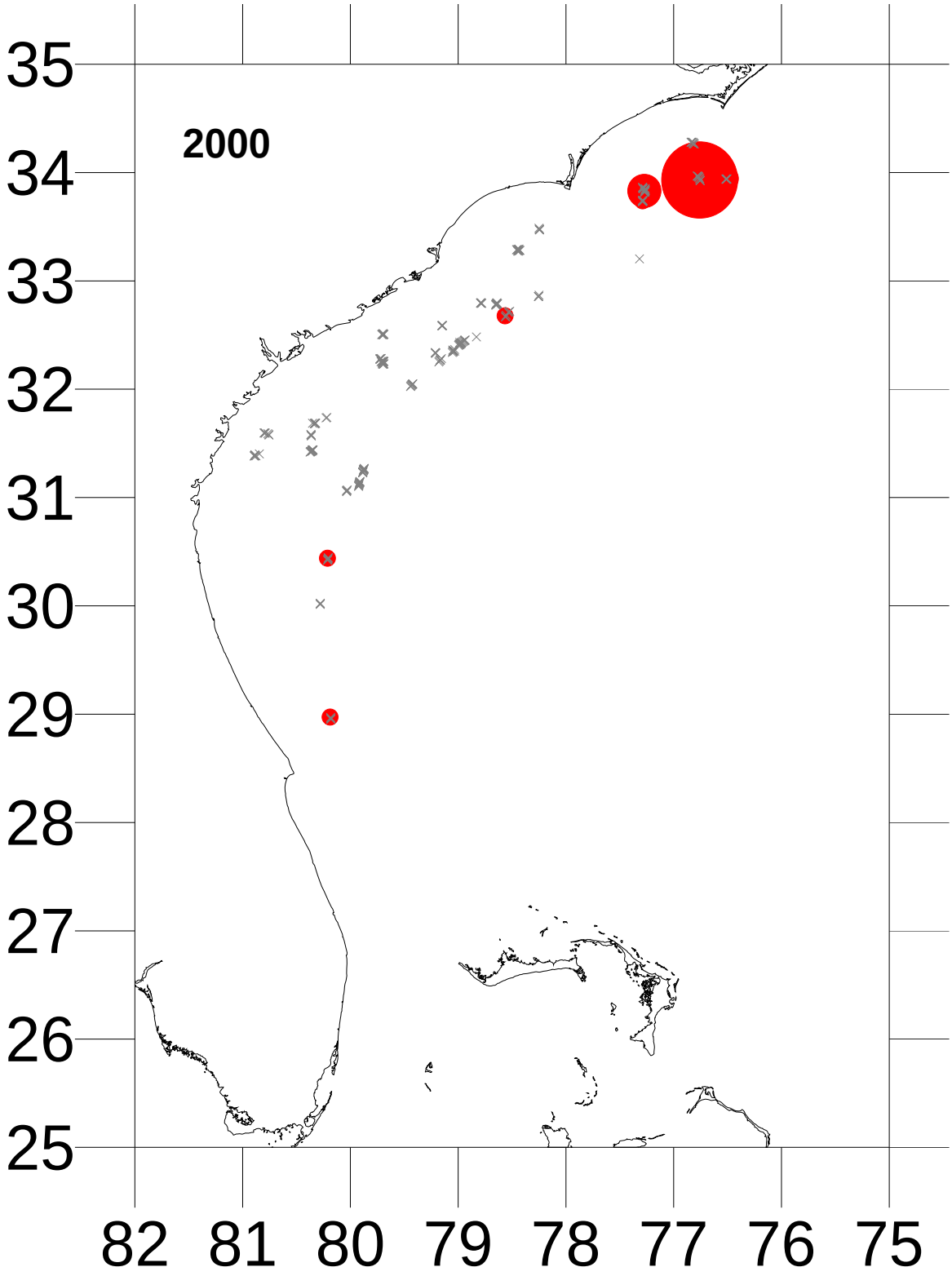

Effort: 350 chevron trap sets
Range of non-zero red grouper observations: 1 – 5



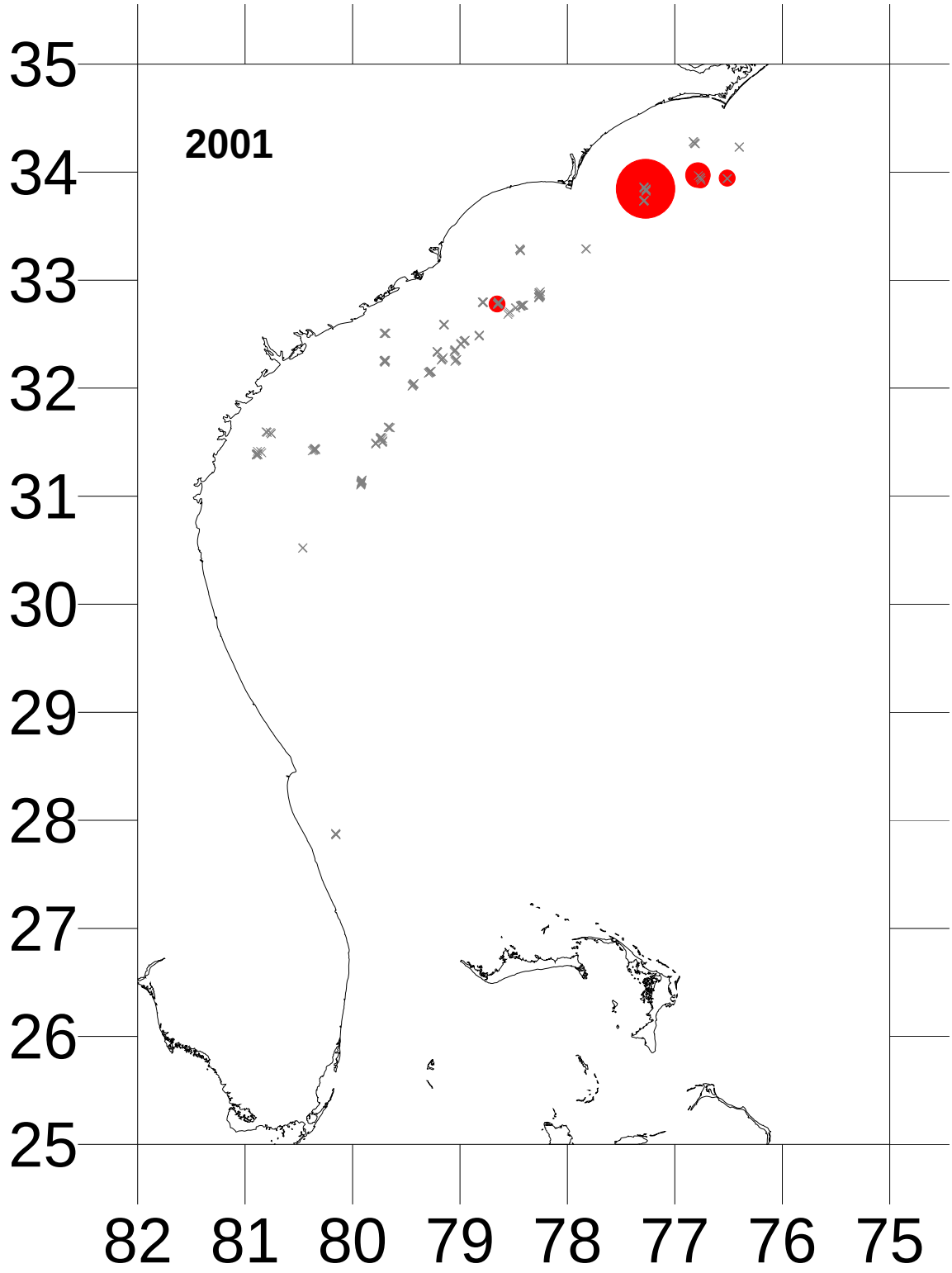

Effort: 328 chevron trap sets
Range of non-zero red grouper observations: 1 – 5



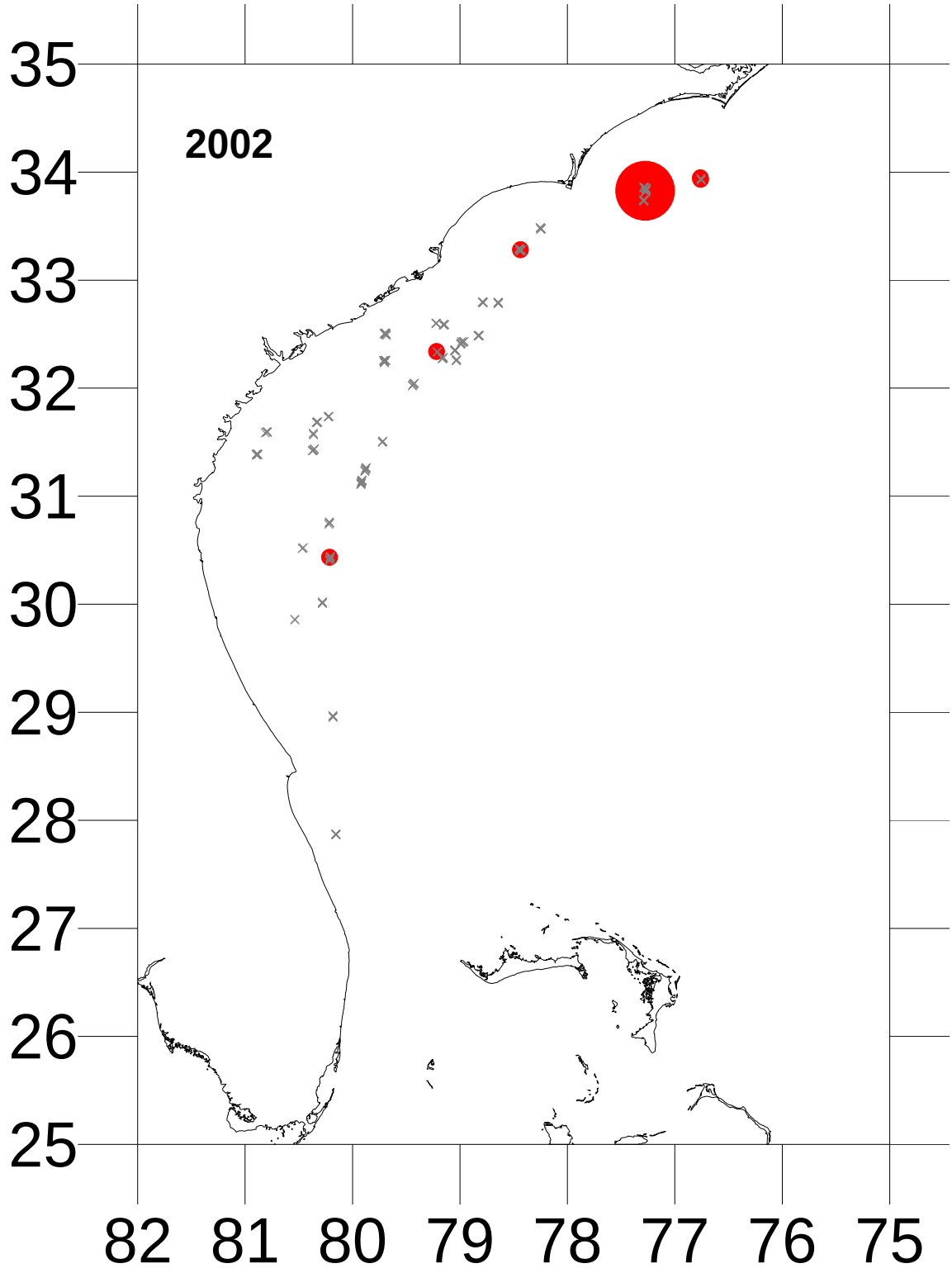

Effort: 225 chevron trap sets
Range of non-zero red grouper observations: 1 – 3



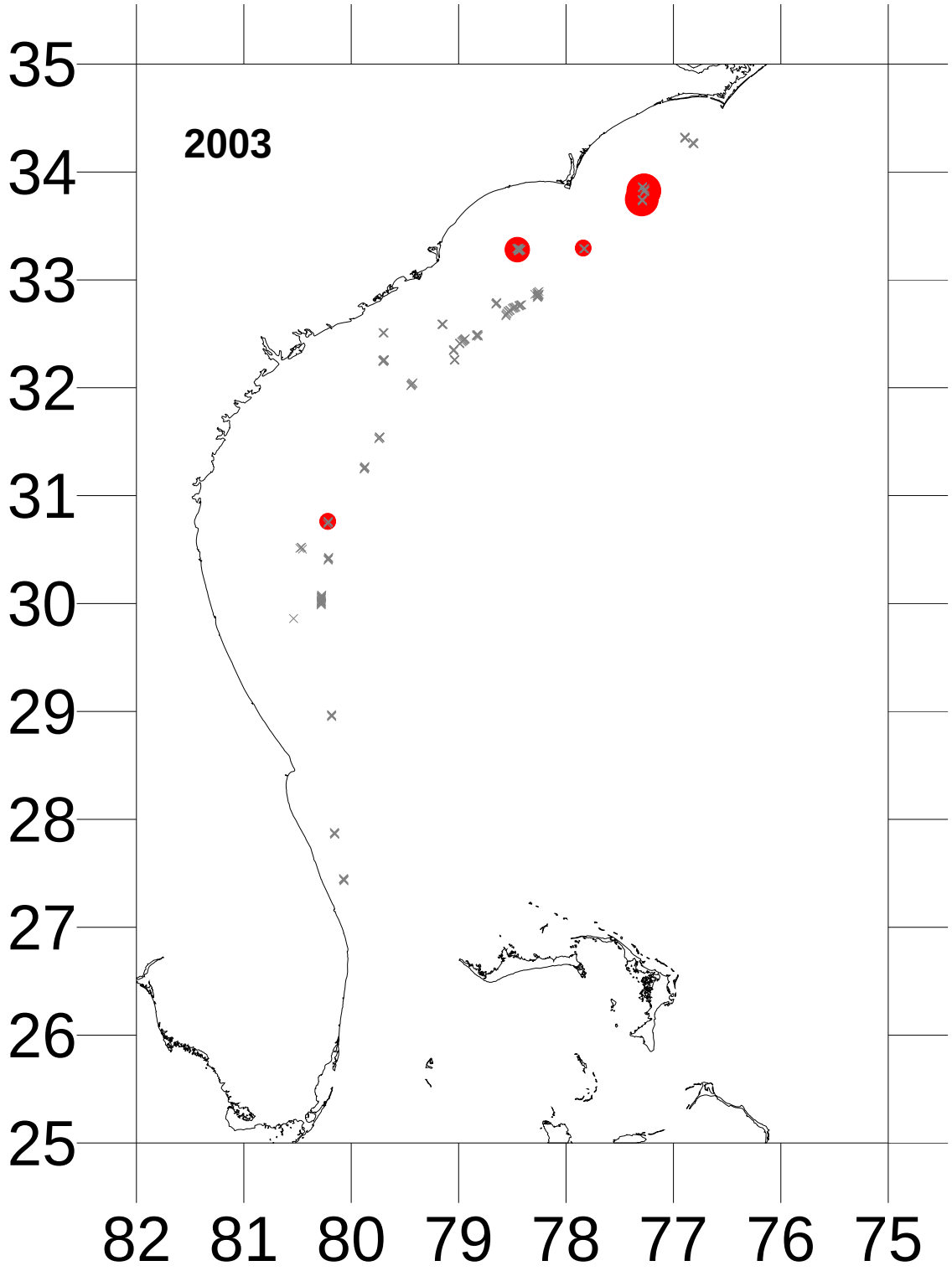

Effort: 265 chevron trap sets
Range of non-zero red grouper observations: 1 – 8



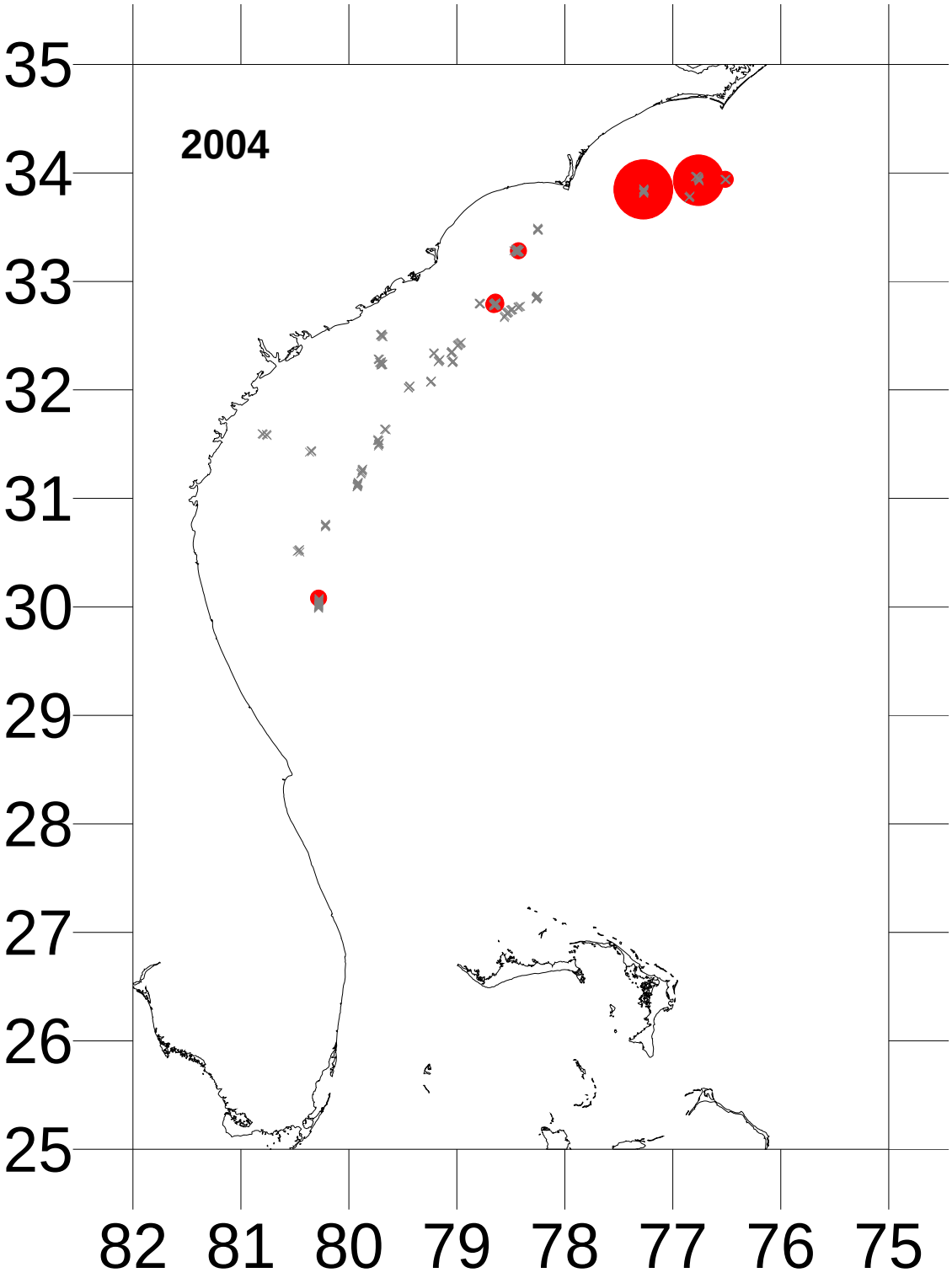

Effort: 236 chevron trap sets
Range of non-zero red grouper observations: 1 – 6



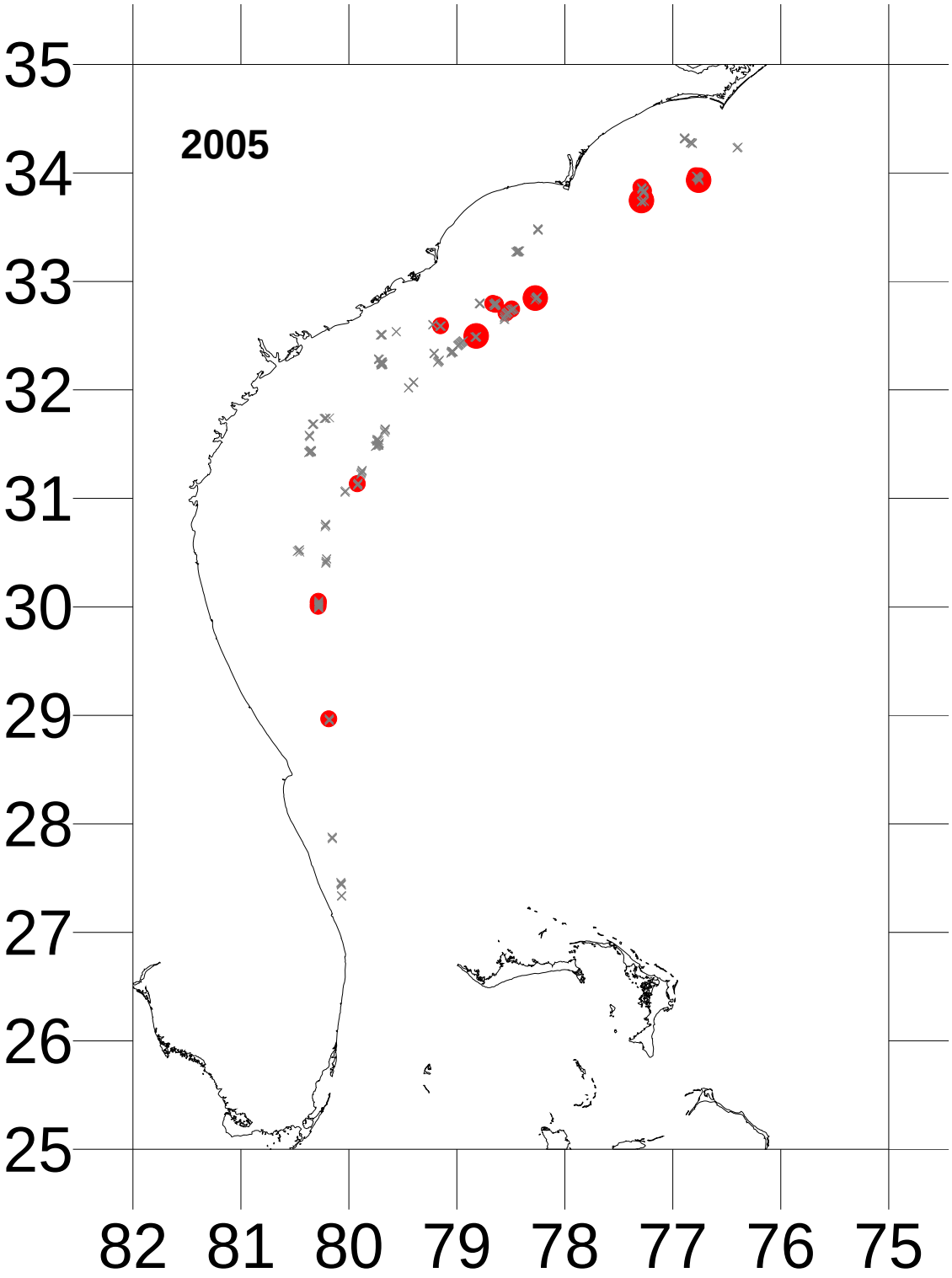

Effort: 218 chevron trap sets
Range of non-zero red grouper observations: 1 – 6



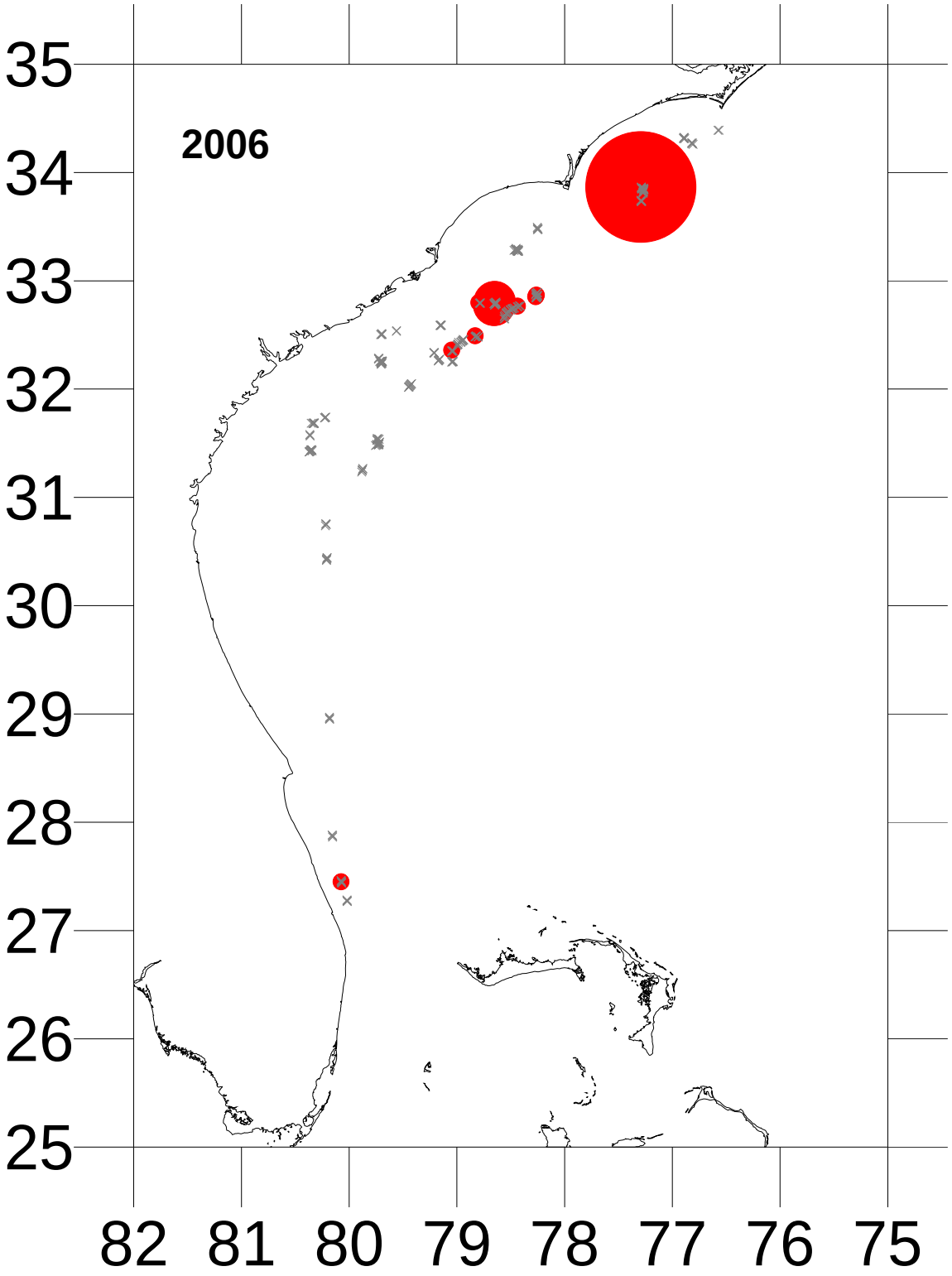

Effort: 218 chevron trap sets
Range of non-zero red grouper observations: 1 – 3



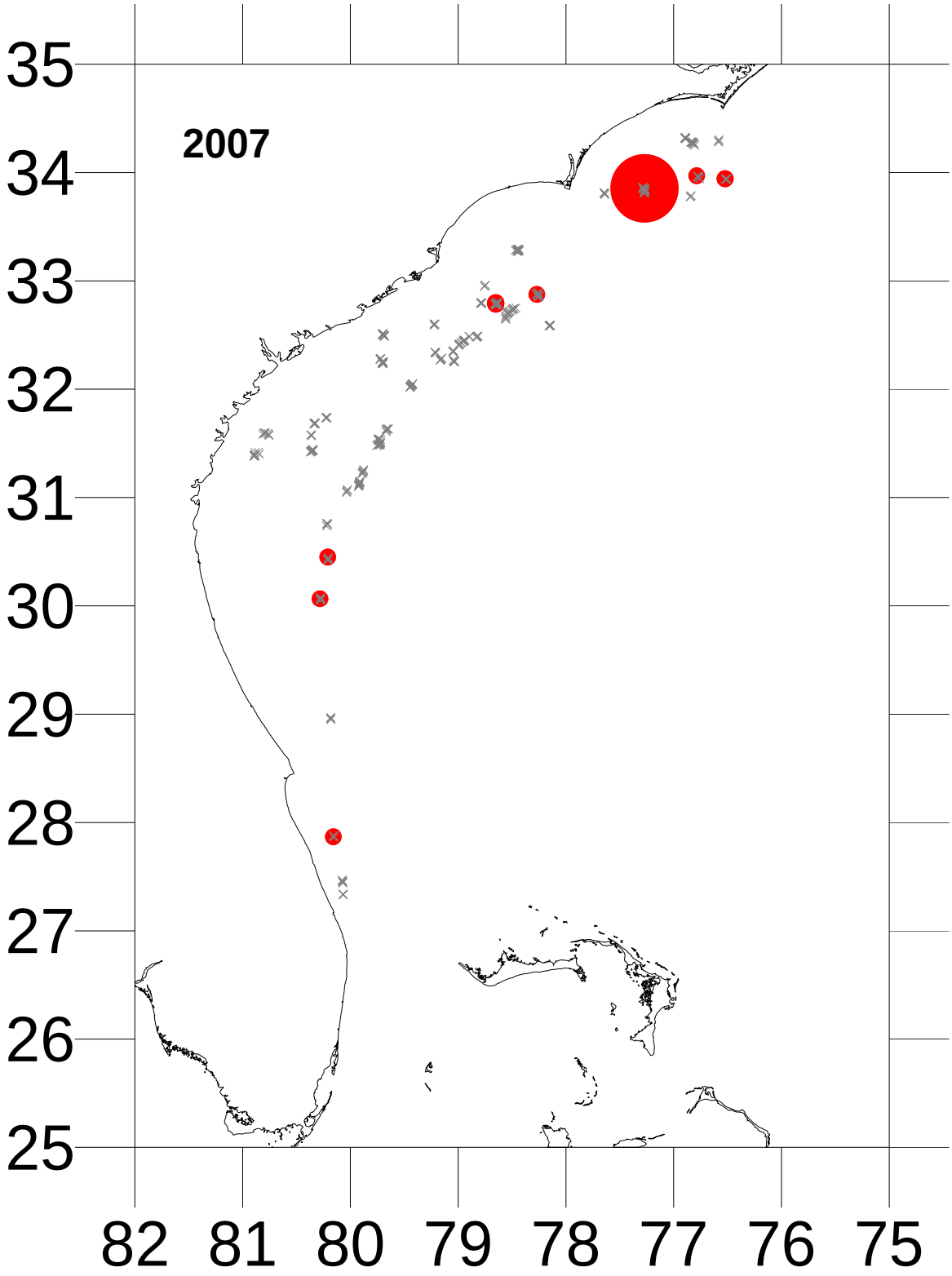

Effort: 261 chevron trap sets
Range of non-zero red grouper observations: 1 – 6



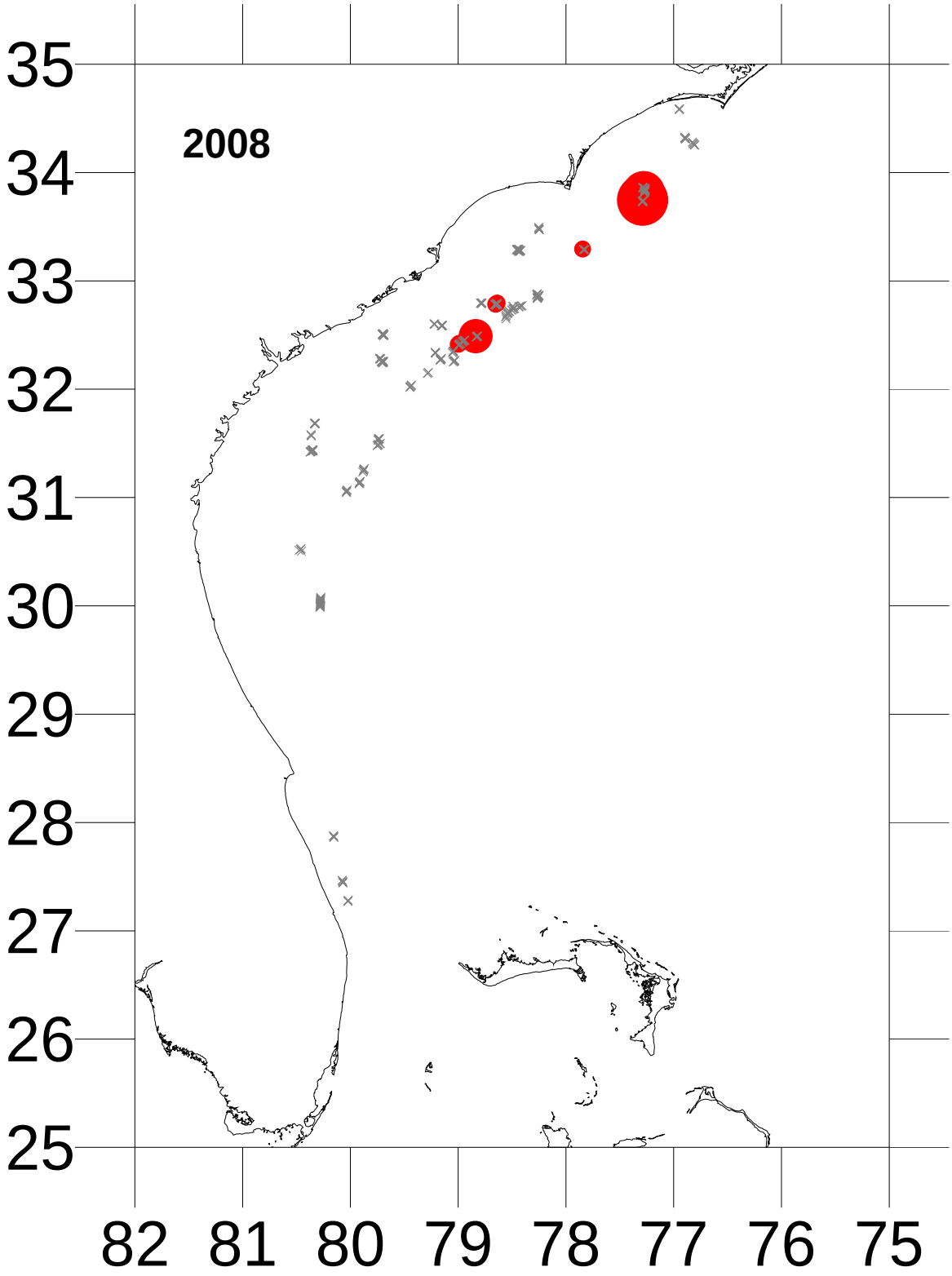

Effort: 303 chevron trap sets
Range of non-zero red grouper observations: 1 – 2




Effort: 285 chevron trap sets
Range of non-zero red grouper observations: 1 – 12



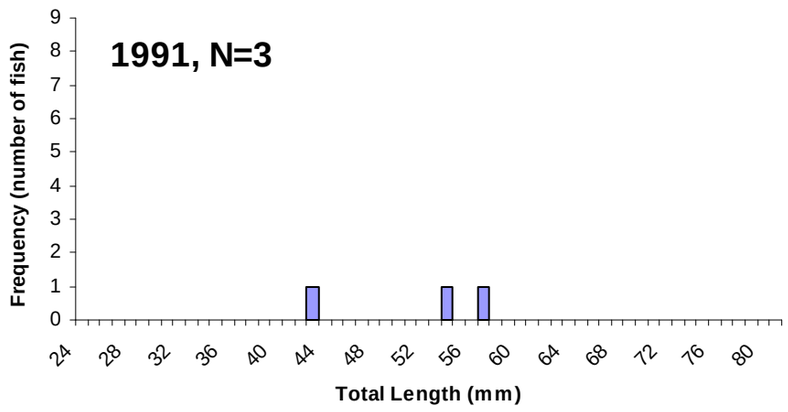

Effort: 326 chevron trap sets
Range of non-zero red grouper observations: 1 – 7

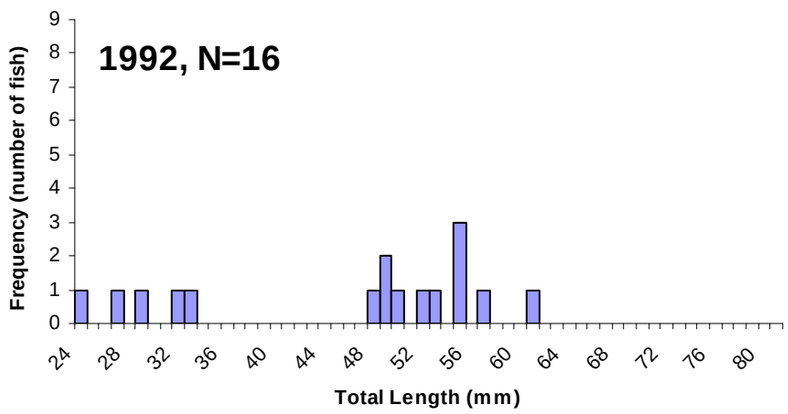


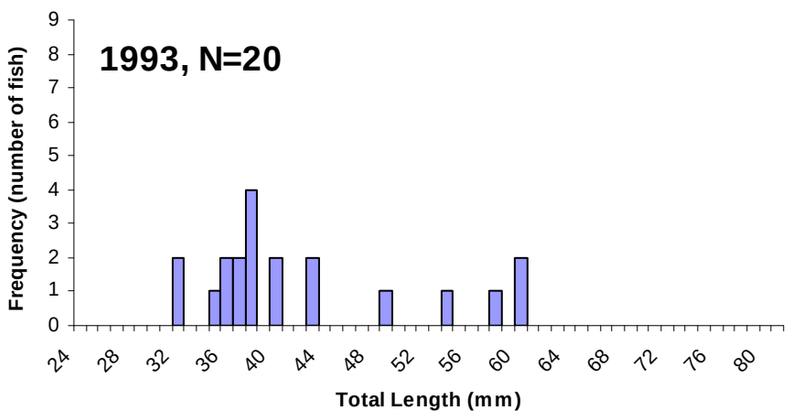

Effort: 303 chevron trap sets
Range of non-zero red grouper observations: 1 – 5

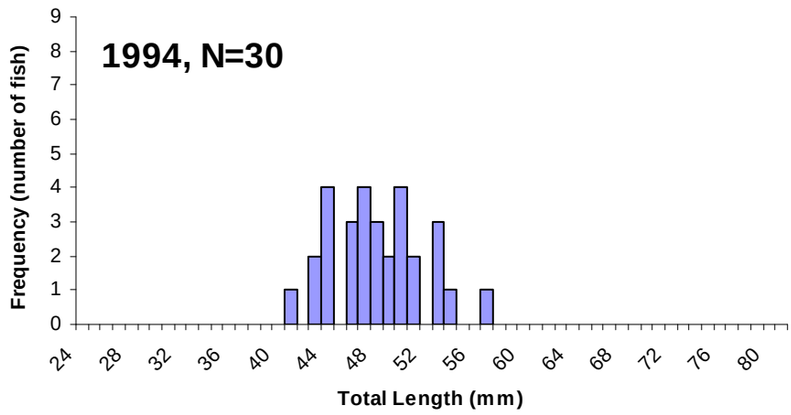
# Appendix 2:

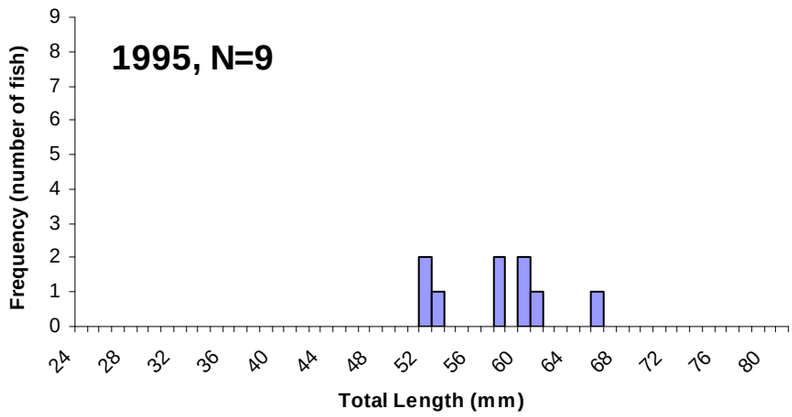
Length frequencies of red grouper observed in chevron traps set during the MARMAP Survey (1990 – 2008).

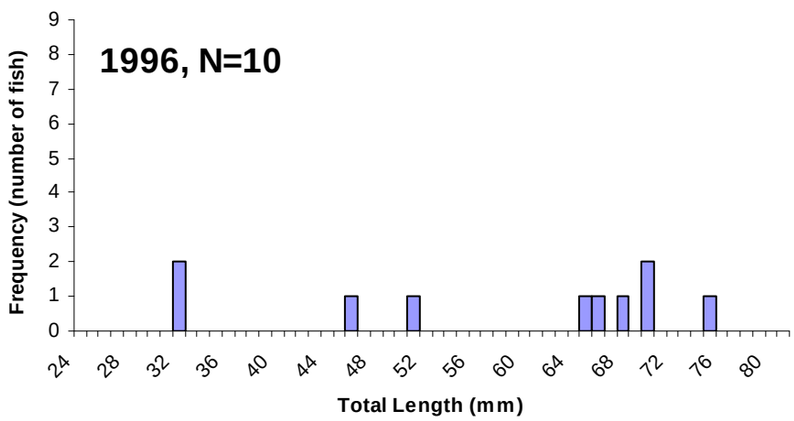


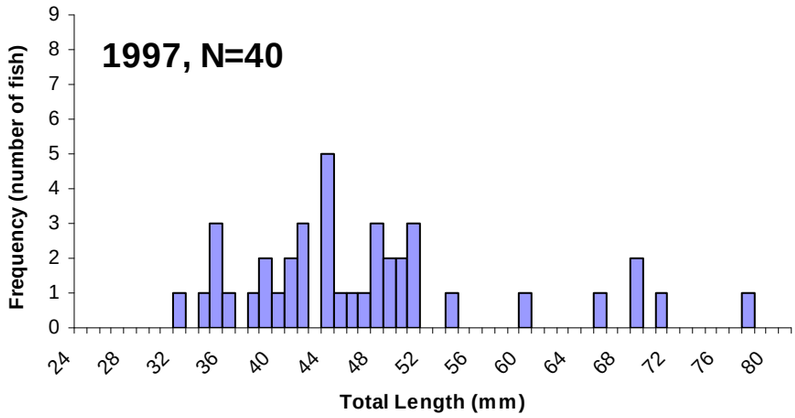



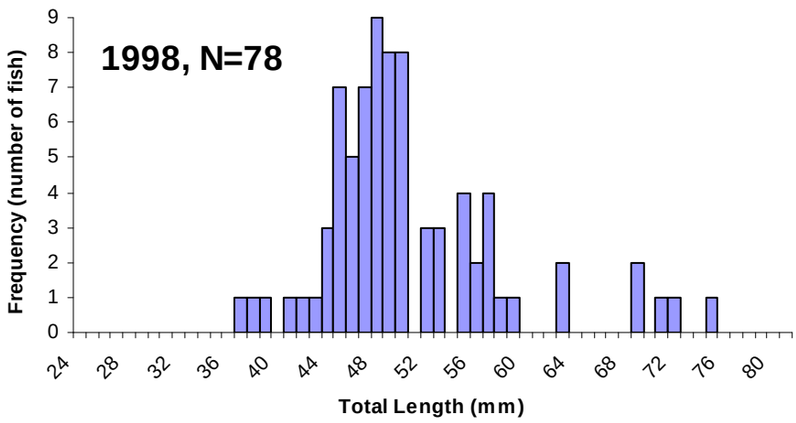



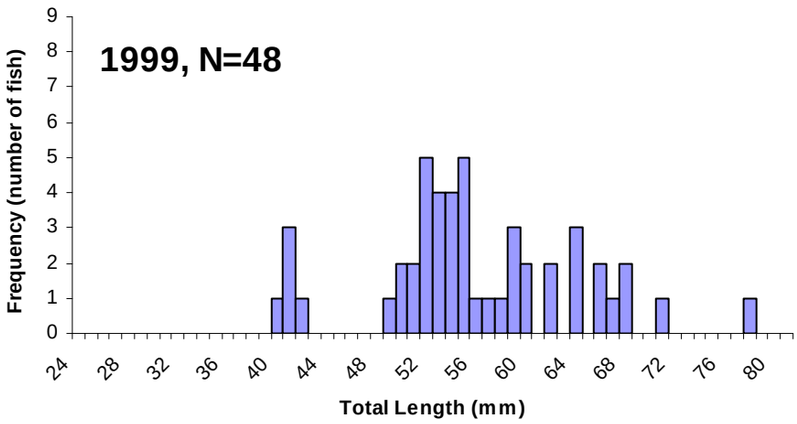

1994, N=30
Frequency (number of fish)
Total Length (mm)

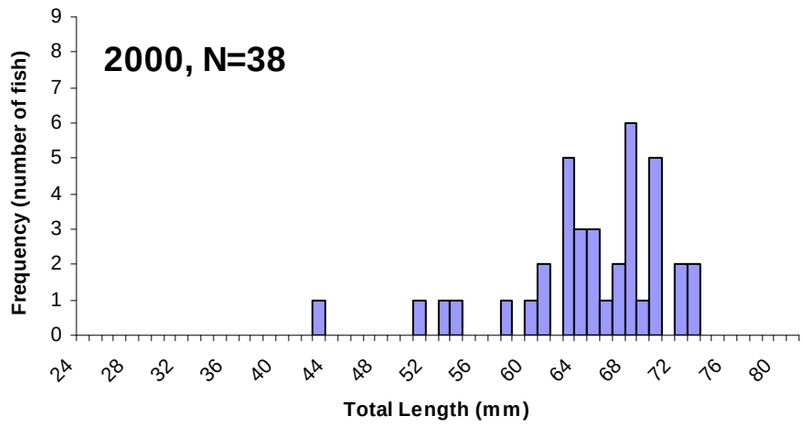

1995, N=9
Frequency (number of fish)
Total Length (mm)

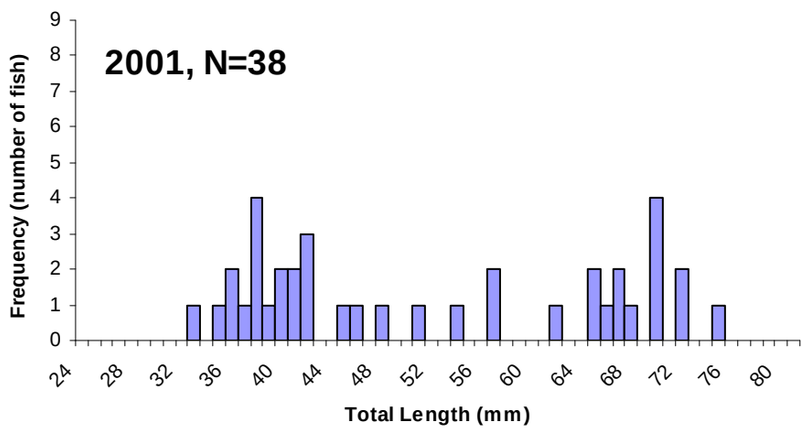

1996, N=10
Frequency (number of fish)
Total Length (mm)

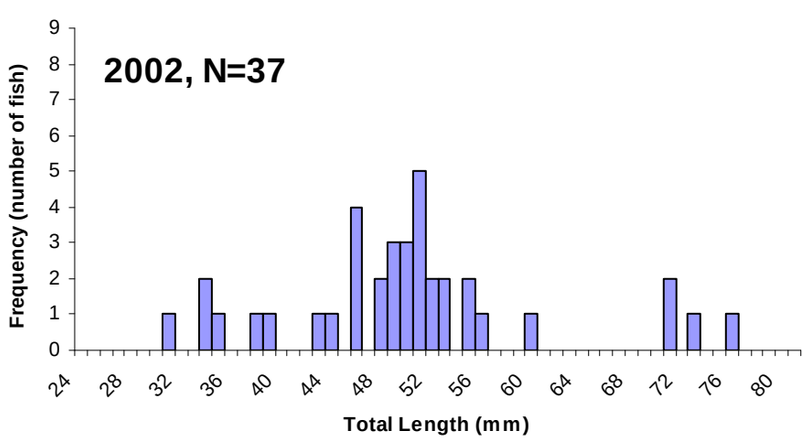

1997, N=40
Frequency (number of fish)
Total Length (mm)

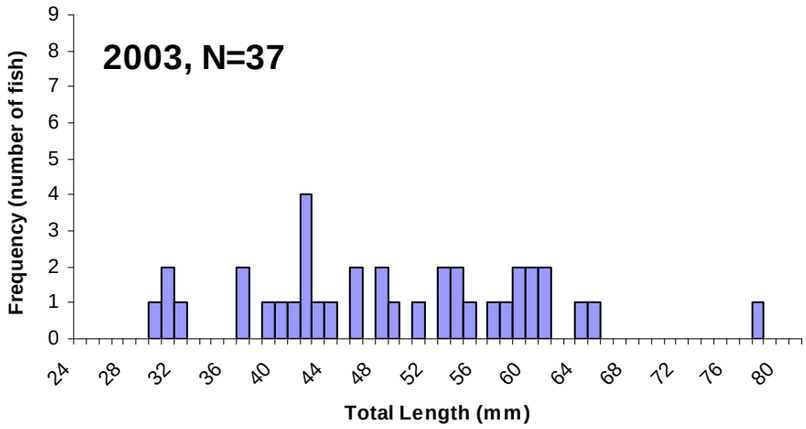

1998, N=78
Frequency (number of fish)
Total Length (mm)

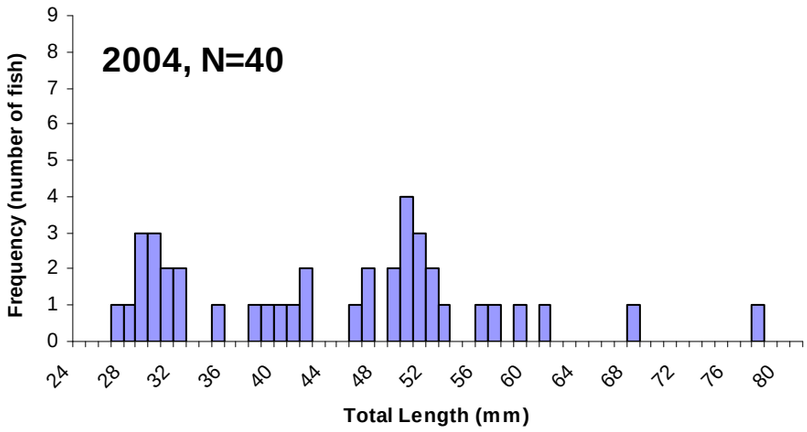

1999, N=48
Frequency (number of fish)
Total Length (mm)

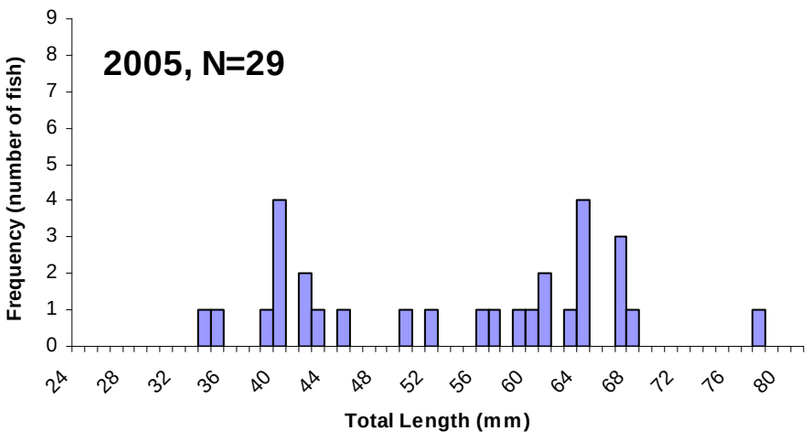

2000, N=38
Frequency (number of fish)
Total Length (mm)

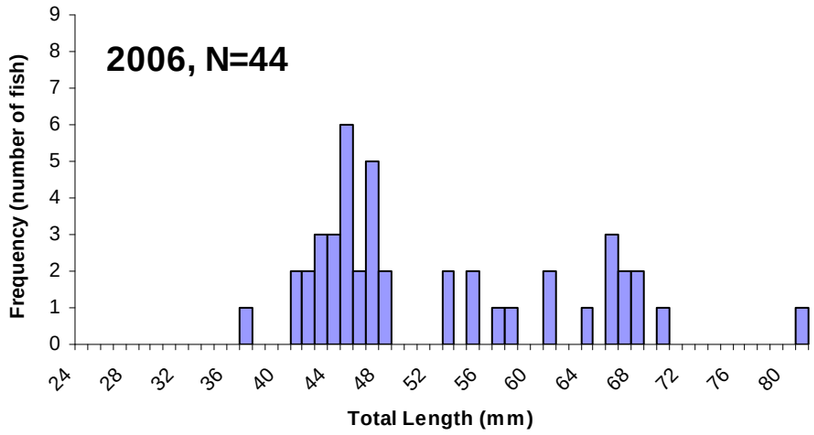

2001, N=38
Frequency (number of fish)
Total Length (mm)

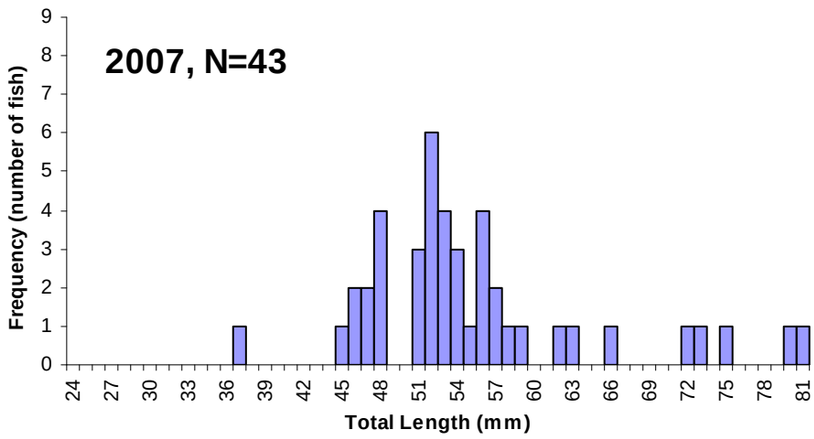

2002, N=37
Frequency (number of fish)
Total Length (mm)

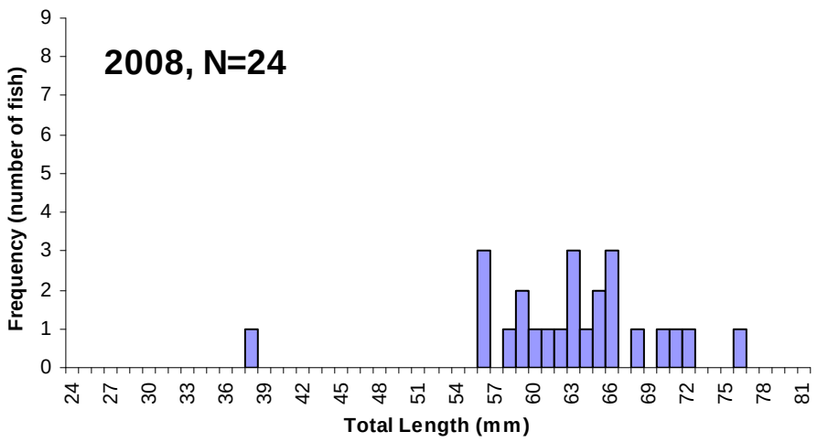

2003, N=37
Frequency (number of fish)
Total Length (mm)


2004, N=40
Frequency (number of fish)
Total Length (mm)


2005, N=29
Frequency (number of fish)
Total Length (mm)

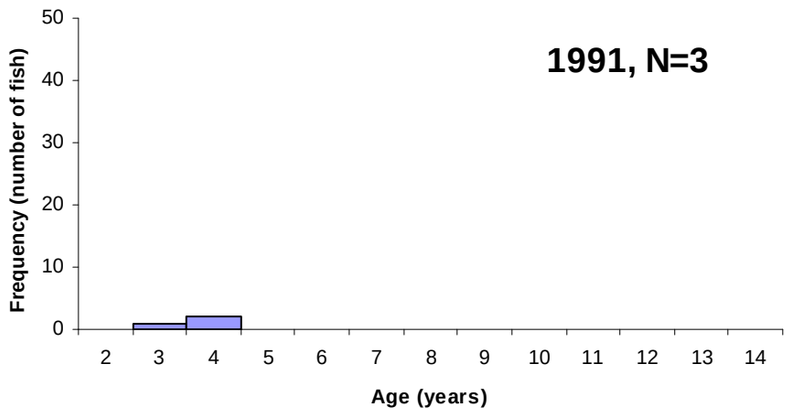

2006, N=44
Frequency (number of fish)
Total Length (mm)

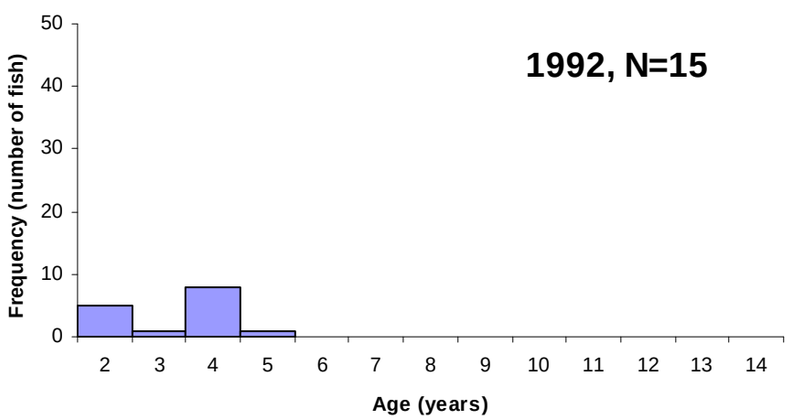

2007, N=43
Frequency (number of fish)
Total Length (mm)

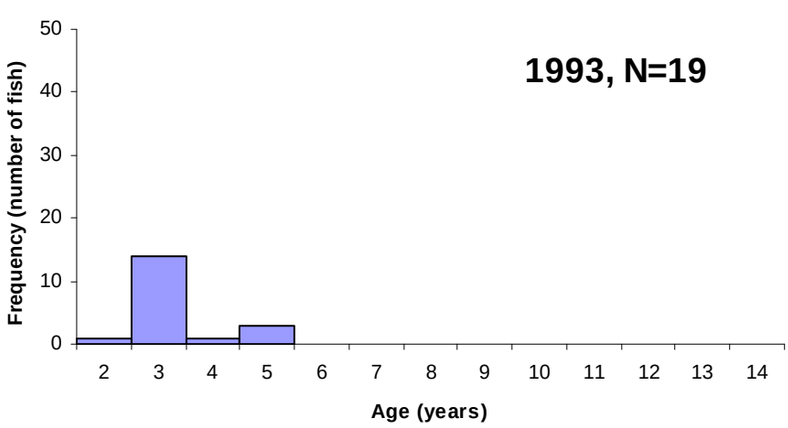

2008, N=24
Frequency (number of fish)
Total Length (mm)

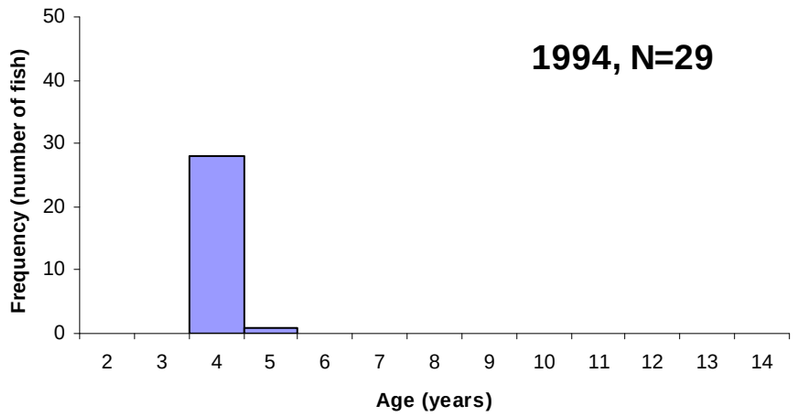
# Appendix 3:

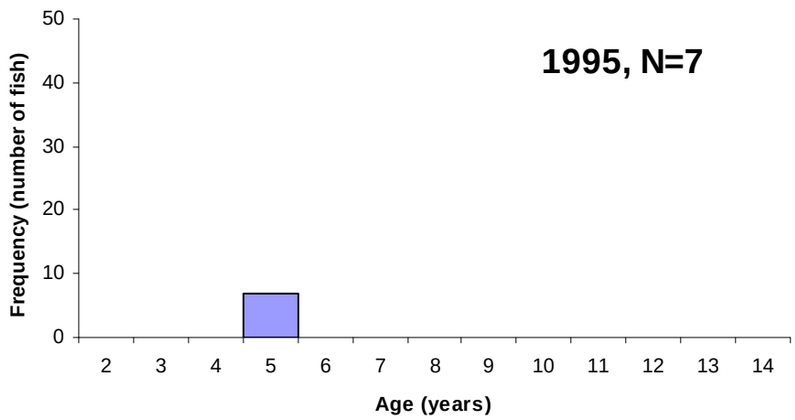
Age frequencies of red grouper observed in chevron traps set during the MARMAP Survey (1991 – 2008).

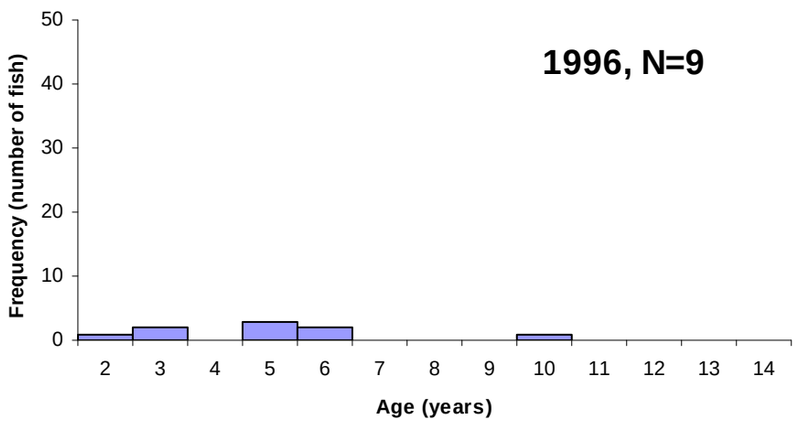


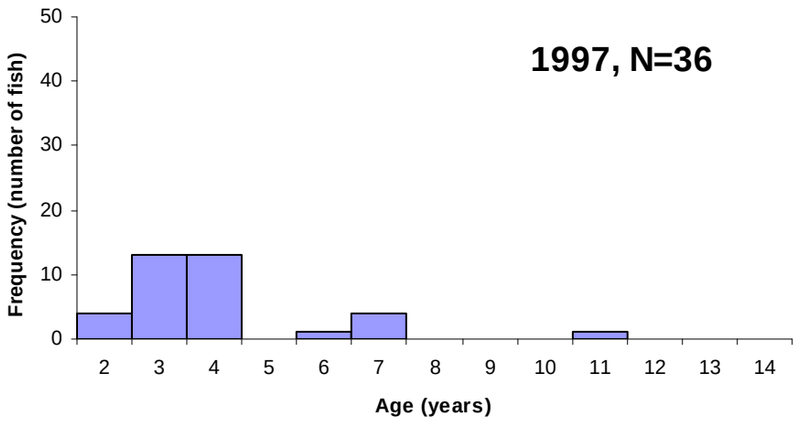



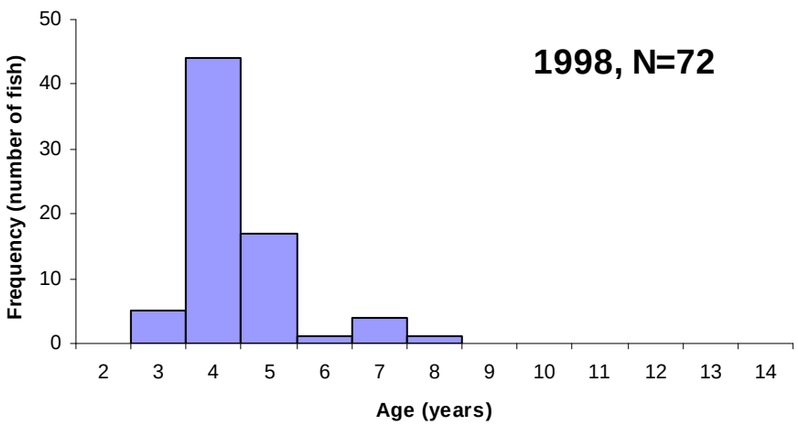



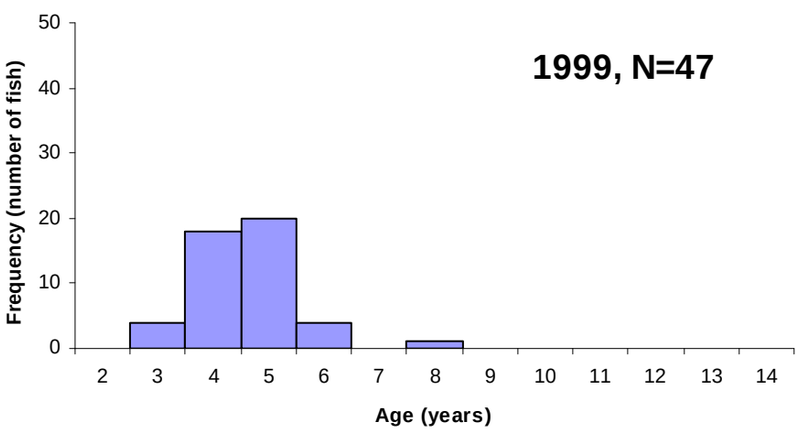

1994, N=29
Frequency (number of fish)
0
10
20
30
40
50
2
3
4
5
6
7
8
9
10
11
12
13
14
Age (years)

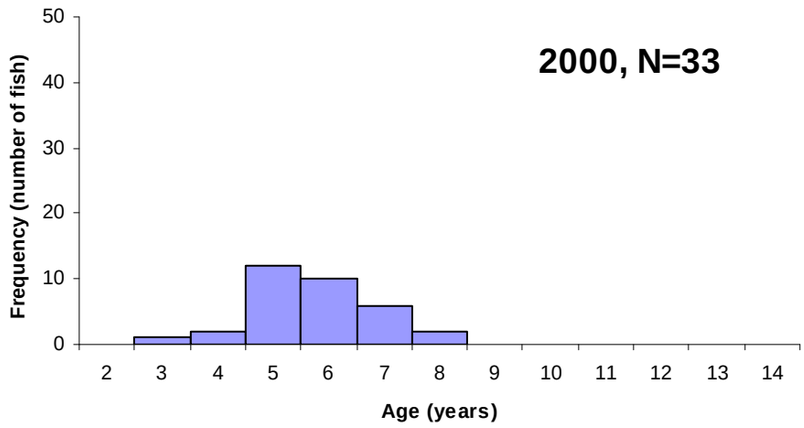

1995, N=7
Frequency (number of fish)
0
10
20
30
40
50
2
3
4
5
6
7
8
9
10
11
12
13
14
Age (years)

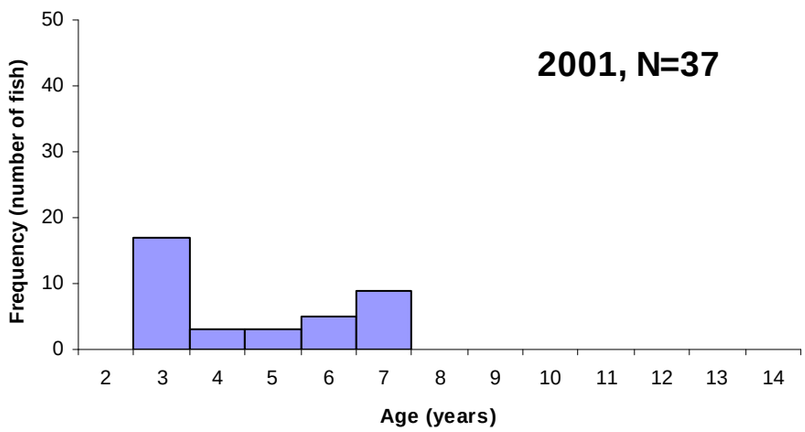

1996, N=9
Frequency (number of fish)
0
10
20
30
40
50
2
3
4
5
6
7
8
9
10
11
12
13
14
Age (years)

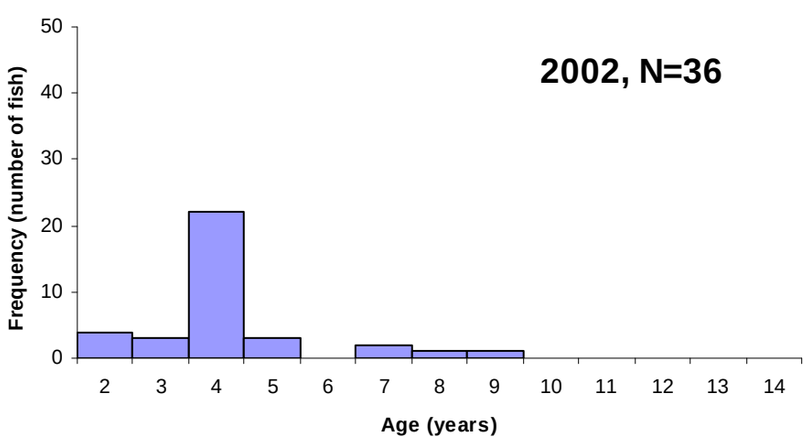

1997, N=36
Frequency (number of fish)
0
10
20
30
40
50
2
3
4
5
6
7
8
9
10
11
12
13
14
Age (years)

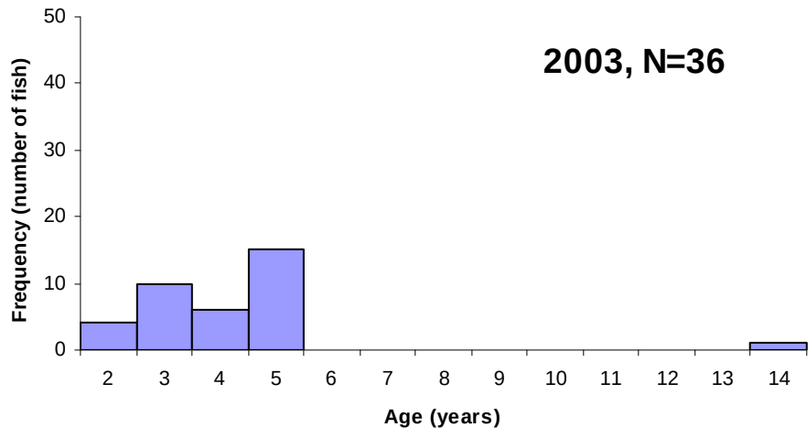

1998, N=72
Frequency (number of fish)
0
10
20
30
40
50
2
3
4
5
6
7
8
9
10
11
12
13
14
Age (years)

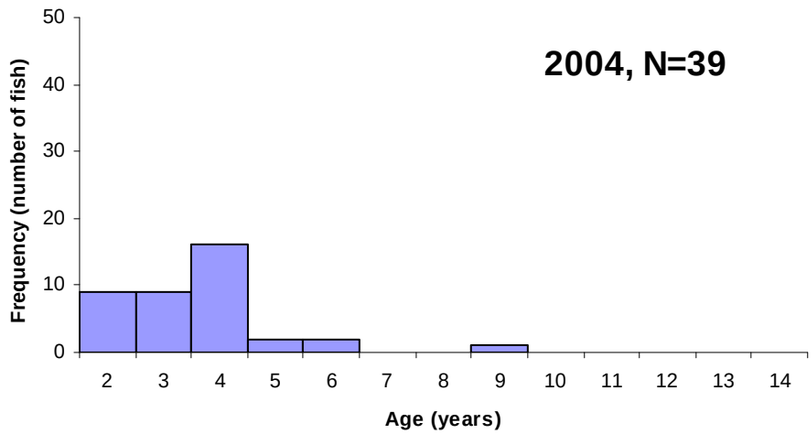

1999, N=47
Frequency (number of fish)
0
10
20
30
40
50
2
3
4
5
6
7
8
9
10
11
12
13
14
Age (years)

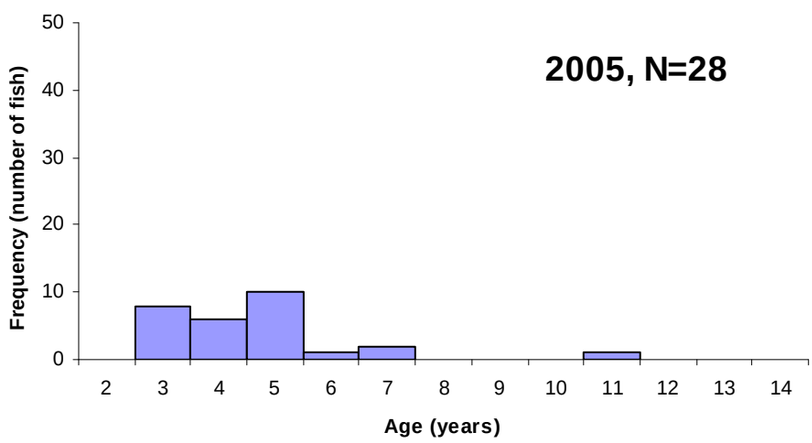

2000, N=33
Frequency (number of fish)
0
10
20
30
40
50
2
3
4
5
6
7
8
9
10
11
12
13
14
Age (years)

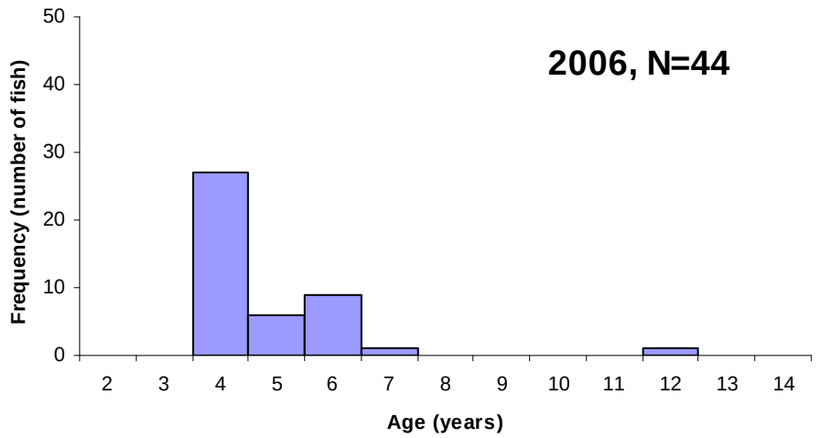

2001, N=37
Frequency (number of fish)
0
10
20
30
40
50
2
3
4
5
6
7
8
9
10
11
12
13
14
Age (years)

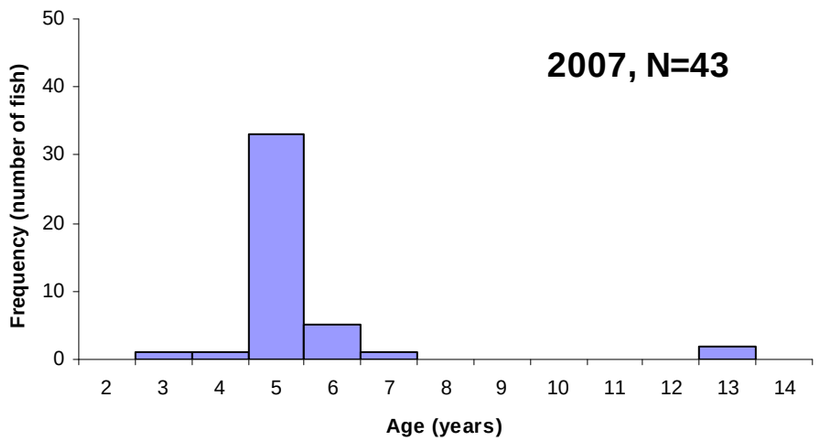

2002, N=36
Frequency (number of fish)
0
10
20
30
40
50
2
3
4
5
6
7
8
9
10
11
12
13
14
Age (years)

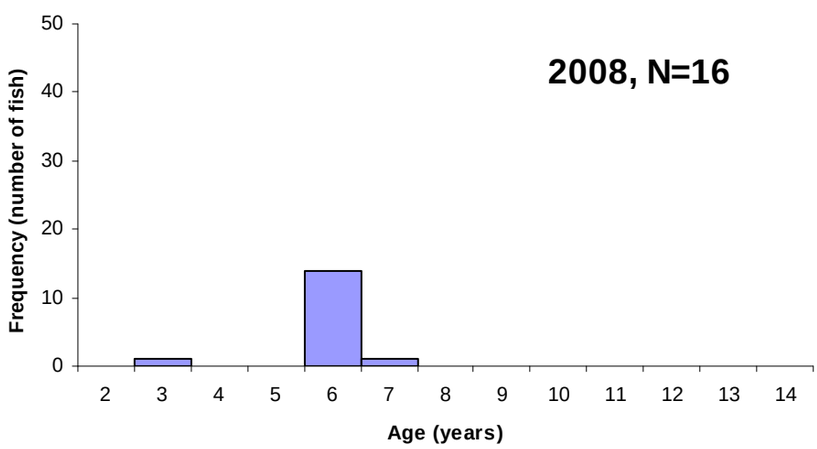

2003, N=36
Frequency (number of fish)
0
10
20
30
40
50
2
3
4
5
6
7
8
9
10
11
12
13
14
Age (years)


2004, N=39
Frequency (number of fish)
0
10
20
30
40
50
2
3
4
5
6
7
8
9
10
11
12
13
14
Age (years)


2005, N=28
Frequency (number of fish)
0
10
20
30
40
50
2
3
4
5
6
7
8
9
10
11
12
13
14
Age (years)

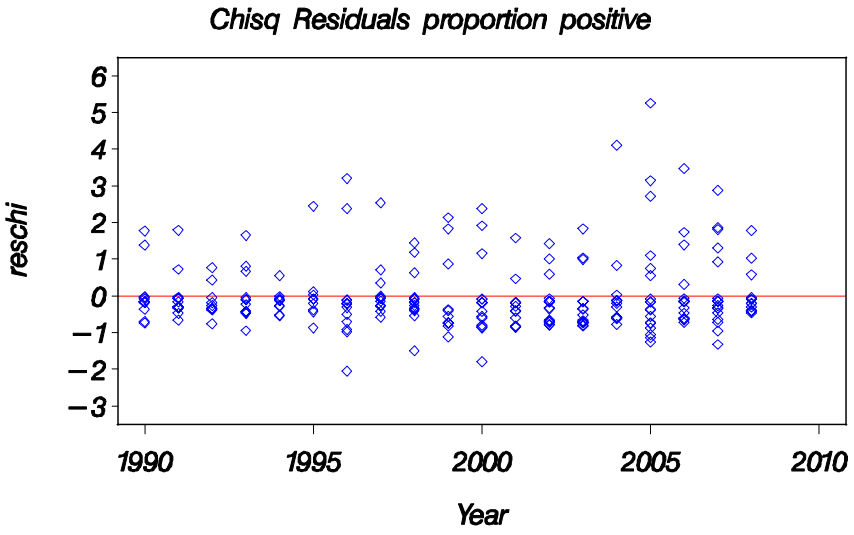

2006, N=44
Frequency (number of fish)
Age (years)
0
10
20
30
40
50
2 3 4 5 6 7 8 9 10 11 12 13 14

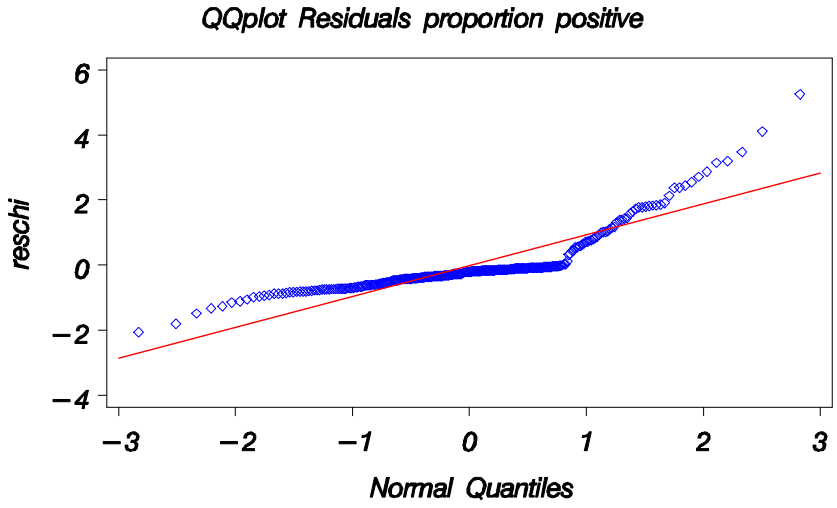

2007, N=43
Frequency (number of fish)
Age (years)
0
10
20
30
40
50
2 3 4 5 6 7 8 9 10 11 12 13 14


2008, N=16
Frequency (number of fish)
Age (years)
0
10
20
30
40
50
2 3 4 5 6 7 8 9 10 11 12 13 14

# Appendix 4:
Model building results for red grouperobserved in chevron traps set during the MARMAP Survey (1990 – 2008).

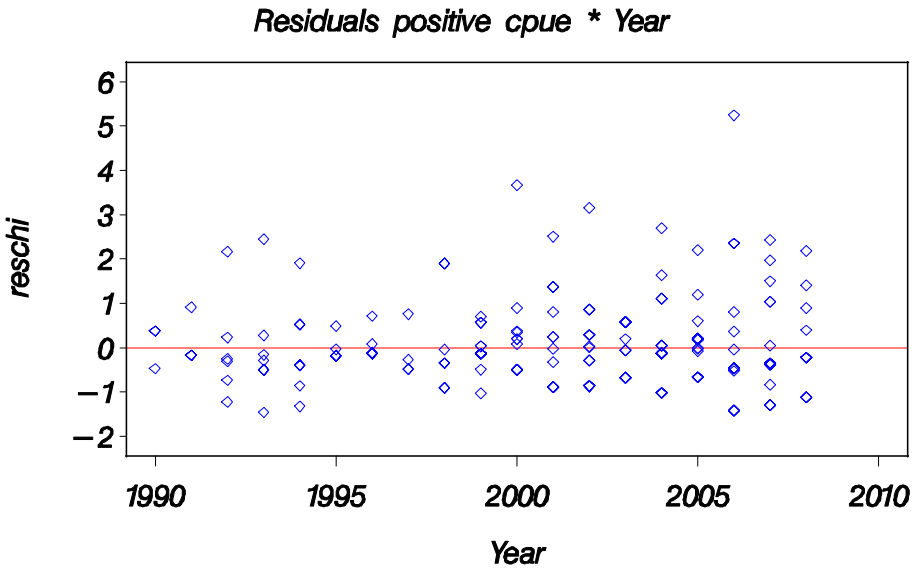
| Binomial: *Type 3 Tests of Fixed Effects, AIC* =1256.5 | | | | | | |
|---|---|---|---|---|---|---|
| *Effect* | *Num DF* | *Den DF* | *Chi-Square* | *F Value* | *Pr > ChiSq* | *Pr > F* |
| *Year* | 18 | 238 | 52.95 | 2.94 | <.0001 | <.0001 |
| *Latitude Degree Category* | 6 | 238 | 159.01 | 26.50 | <.0001 | <.0001 |
| *Depth Class* | 3 | 238 | 37.97 | 12.66 | <.0001 | <.0001 |

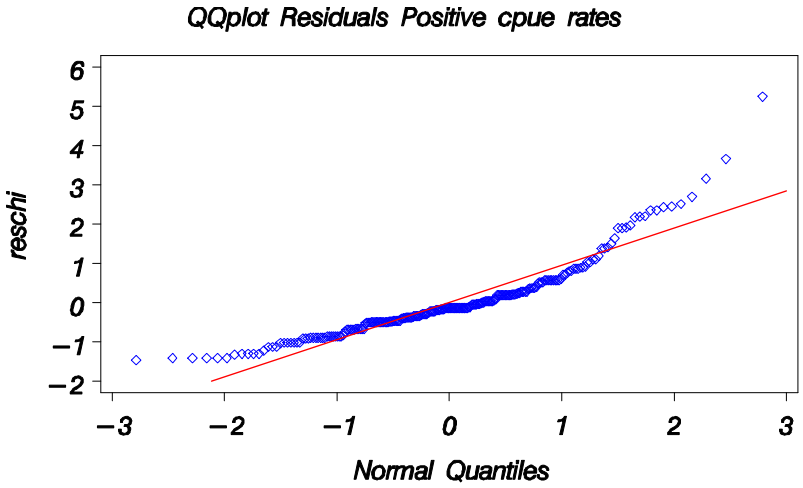


| Run: 2. Poisson: *Type 3 Tests of Fixed Effects, AIC* = 544.9 | | | | | | |
|---|---|---|---|---|---|---|
| *Effect* | *Num DF* | *Den DF* | *Chi-Square* | *F Value* | *Pr > ChiSq* | *Pr > F* |
| *Year* | 18 | 207 | 29.05 | 1.61 | 0.0478 | 0.0589 |
| *Latitude Degree Category* | 6 | 207 | 23.95 | 3.99 | 0.0005 | 0.0008 |
| *Depth Class* | 3 | 207 | 5.21 | 1.74 | 0.1571 | 0.1606 |

| Run: 2. Poisson: *Type 3 Tests of Fixed Effects, AIC* = 547.7 | | | | | | |
|---|---|---|---|---|---|---|
| *Effect* | *Num DF* | *Den DF* | *Chi-Square* | *F Value* | *Pr > ChiSq* | *Pr > F* |
| *Year* | 18 | 210 | 31.66 | 1.76 | 0.0241 | 0.0321 |
| *Latitude Degree Category* | 6 | 210 | 49.18 | 8.20 | <.0001 | <.0001 |



***Appendix 1***
***Additional Analyses to MARMAP***
***Chevron Trap Data***

A separate analysis was run on the MARMAP chevron trap data. Standardized catch rates were estimated using a delta-GLM error structure modified from Lo et al. (1992), in which the binomial distribution describes proportion of positive CPUE, and Poisson distribution describes the positive CPUE. Explanatory variables considered, in addition to year (necessarily included), were bottom temperature (continuous variable), month (categorical variable), latitude degree (categorical variable), depth (continuous variable), and trap set duration (continuous variable). Both model components (binomial and Poisson) included main effects only.

***Delta Poisson CPUE for red grouper***
***GLIMMIX binomial on proportion of positive***
***GLIMMIX Model Statistics***

| *Fit Statistics* | |
|---|---|
| *-2 Res Log Likelihood* | 23229.6 |
| *AIC (smaller is better)* | 23231.6 |
| *AICC (smaller is better)* | 23231.6 |
| *BIC (smaller is better)* | 23237.8 |

*Type 3 Tests of Fixed Effects*

| *Effect* | *Num DF* | *Den DF* | *Chi-Square* | *F Value* | *Pr > ChiSq* | *Pr > F* |
|---|---|---|---|---|---|---|
| *Year* | 18 | 3476 | 73.39 | 4.08 | <.0001 | <.0001 |
| *LatDeg* | 6 | 3476 | 216.86 | 36.14 | <.0001 | <.0001 |
| *depthclass* | 3 | 3476 | 70.26 | 23.42 | <.0001 | <.0001 |
| *Month* | 4 | 3476 | 18.74 | 4.68 | 0.0009 | 0.0009 |
| *Duration* | 1 | 3476 | 8.58 | 8.58 | 0.0034 | 0.0034 |

| *Description* | *Value* |
|---|---|
| Deviance | 938.5857 |
| Scaled Deviance | 1449.0785 |
| Pearson Chi-Square | 2251.4472 |
| Scaled Pearson Chi-Square | 3476.0000 |
| Extra-Dispersion Scale | 0.6477 |

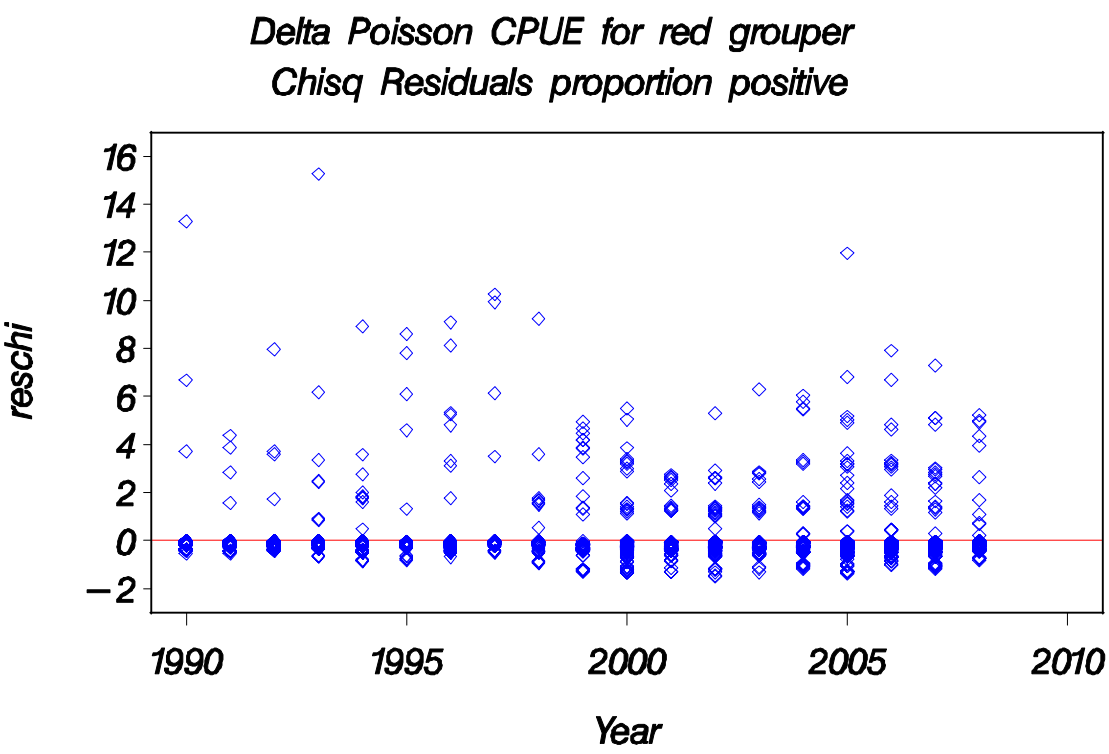
***Delta Poisson CPUE for red grouper***
***GLIMMIX on positive catches***
***GLIMMIX Model Statistics***

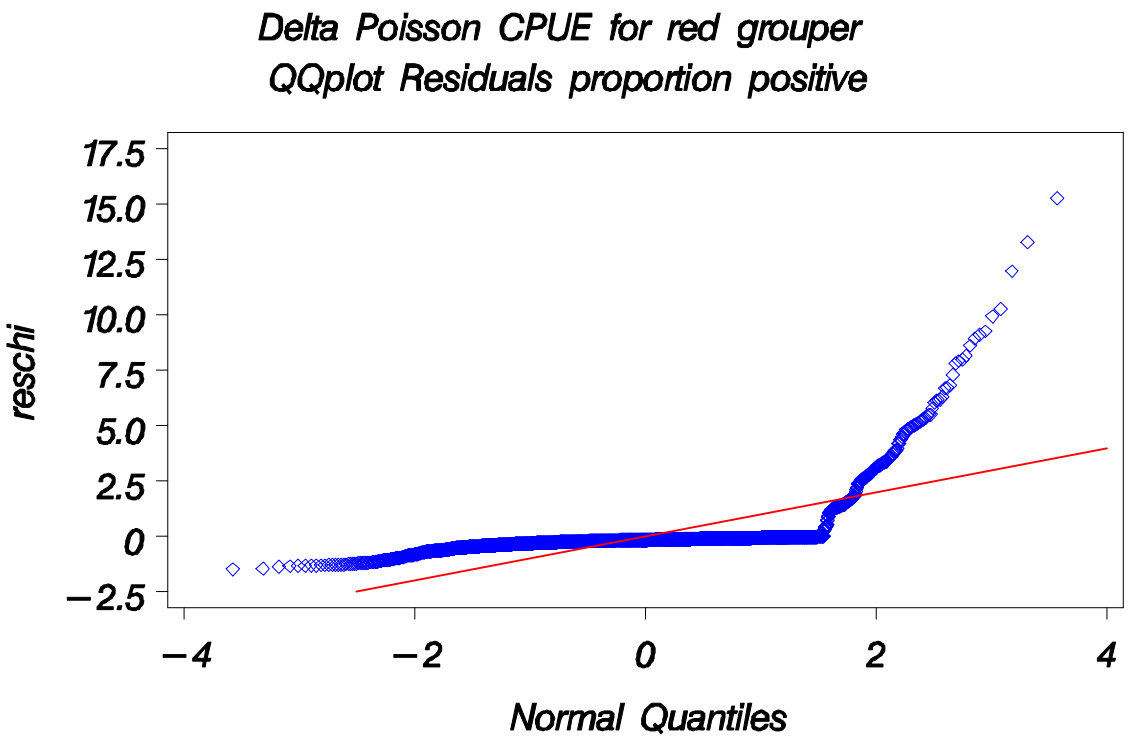
| *Fit Statistics* | |
|---|---|
| *-2 Res Log Likelihood* | 506.0 |
| *AIC (smaller is better)* | 508.0 |
| *AICC (smaller is better)* | 508.0 |
| *BIC (smaller is better)* | 511.3 |

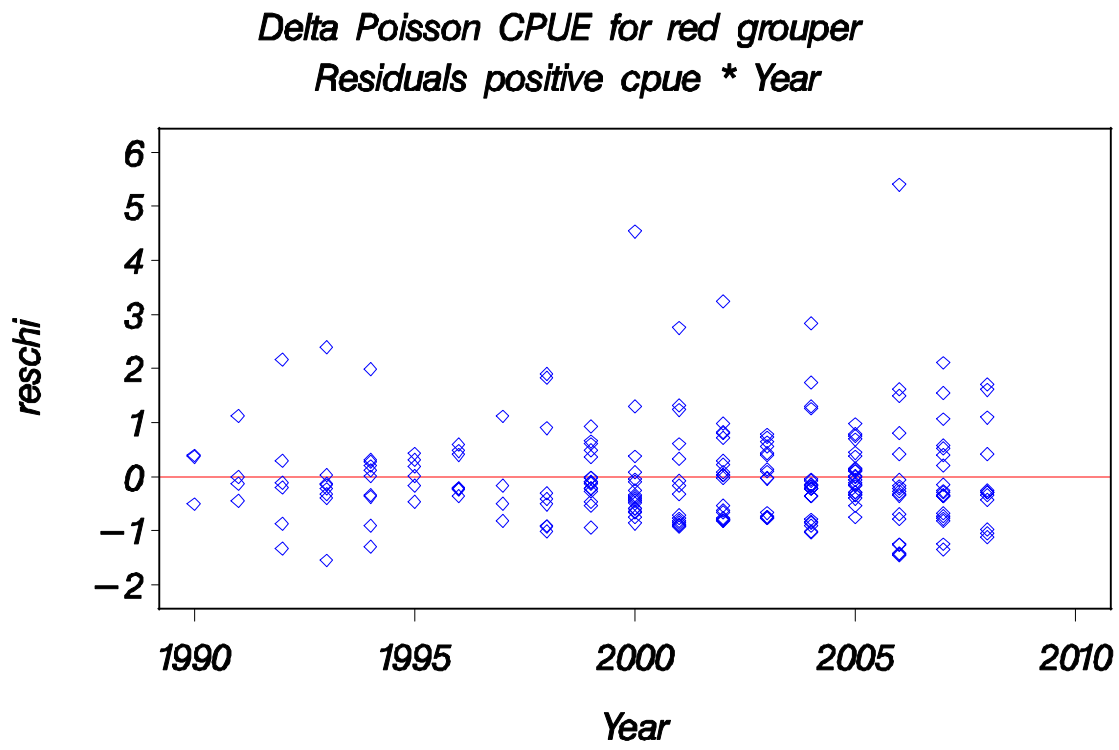
*Type 3 Tests of Fixed Effects*

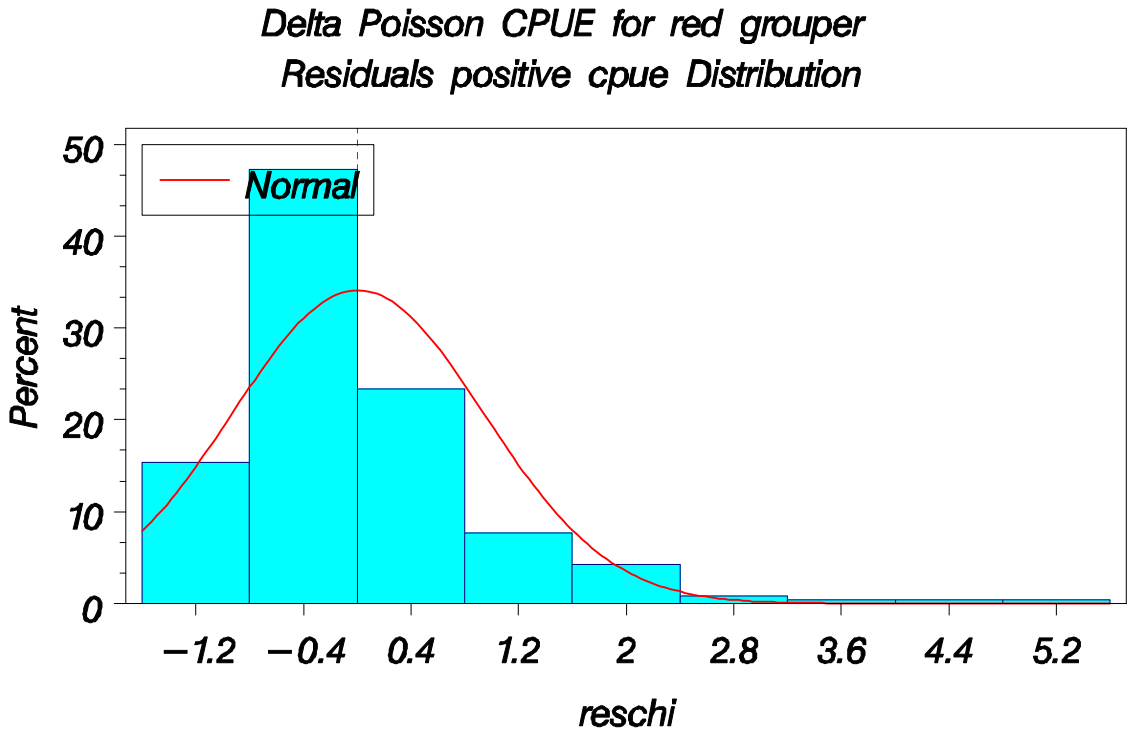
| *Effect* | *Num DF* | *Den DF* | *Chi-Square* | *F Value* | *Pr > ChiSq* | *Pr > F* |
|---|---|---|---|---|---|---|
| *Year* | 18 | 205 | 36.31 | 2.02 | 0.0064 | 0.0103 |
| *LatDeg* | 6 | 205 | 46.45 | 7.74 | <.0001 | <.0001 |
| *Month* | 4 | 205 | 9.28 | 2.32 | 0.0544 | 0.0581 |
| *Duration* | 1 | 205 | 3.07 | 3.07 | 0.0800 | 0.0815 |

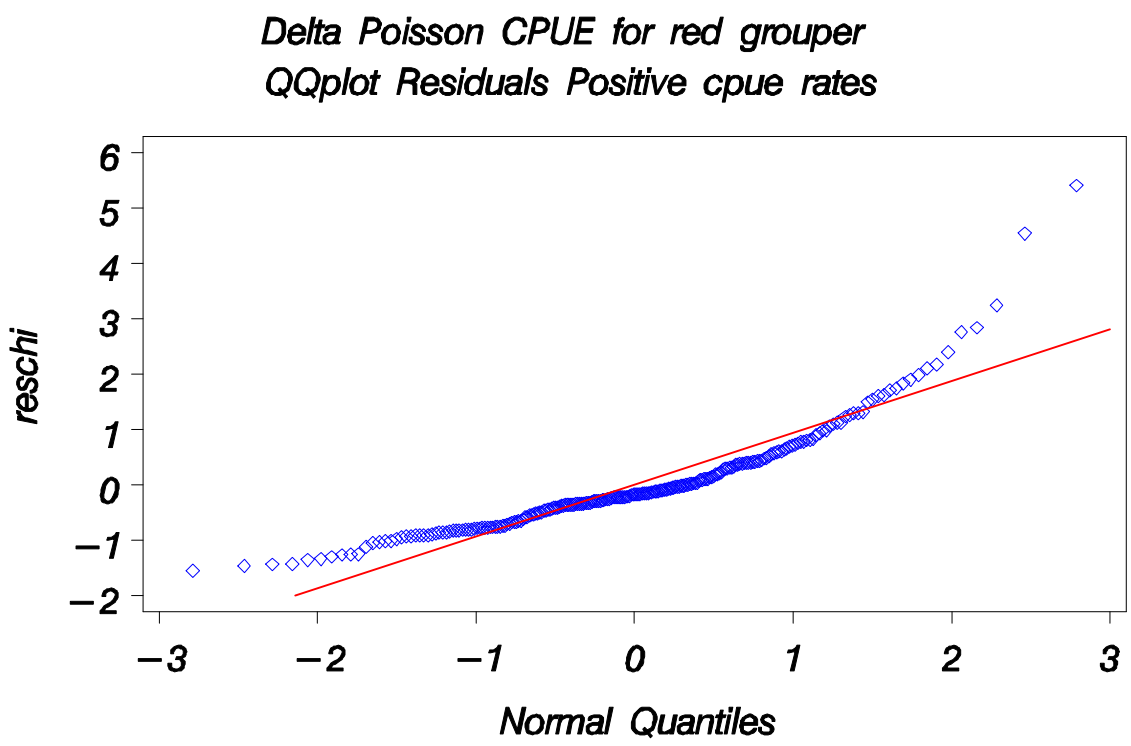
| *Description* | *Value* |
|---|---|
| Deviance | 149.4549 |
| Scaled Deviance | 176.2744 |
| Pearson Chi-Square | 173.8100 |
| Scaled Pearson Chi-Square | 205.0000 |
| Extra-Dispersion Scale | 0.8479 |


Delta Poisson CPUE for red grouper
Chisq Residuals proportion positive
reschi
16
14
12
10
8
6
4
2
0
−2
1990
1995
2000
2005
2010
Year

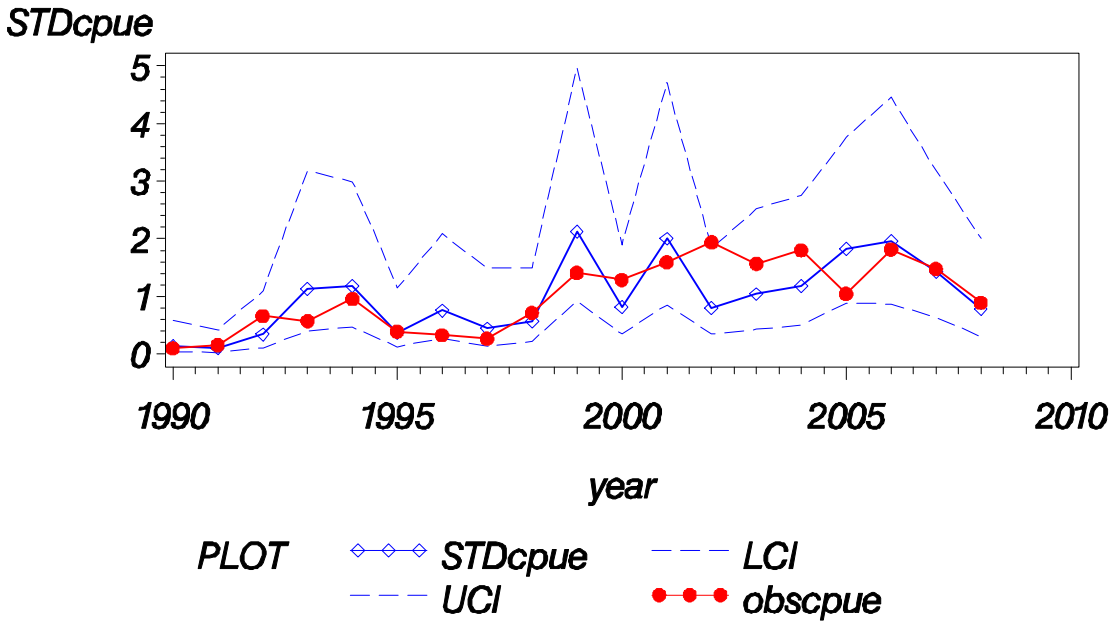

Delta Poisson CPUE for red grouper
QQplot Residuals proportion positive
reschi
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0
−2.5
−4
−2
0
2
4
Normal Quantiles


Delta Poisson CPUE for red grouper
Residuals positive cpue * Year
reschi
6
5
4
3
2
1
0
−1
−2
1990
1995
2000
2005
2010
Year

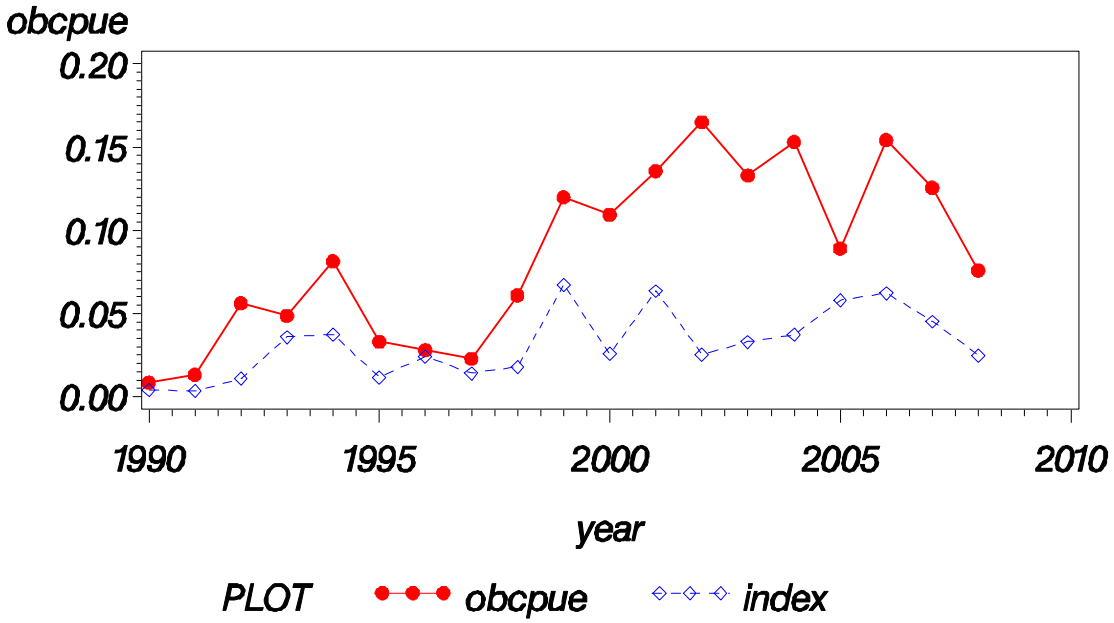

Delta Poisson CPUE for red grouper
Residuals positive cpue Distribution
Normal
Percent
50
40
30
20
10
0
−1.2
−0.4
0.4
1.2
2
2.8
3.6
4.4
5.2
reschi


Delta Poisson CPUE for red grouper
QQplot Residuals Positive cpue rates
reschi
6
5
4
3
2
1
0
−1
−2
−3
−2
−1
0
1
2
3
Normal Quantiles

Delta Poisson CPUE for red grouper
Observed and Standardized CPUE (95% CI)



*Delta Poisson CPUE for red grouper*
*Diagnostic plots: 3) Obs vs Pred CPUE Input units*



***Delta Poisson CPUE for red grouper***
***Index Output***

| SurveyYear | Frequency | N | LoIndex | StdIndex | CV | LCL | UCL |
|---|---|---|---|---|---|---|---|
| 1990 | 0.008547 | 351 | 0.004263 | 0.13444 | 0.84287 | 0.03106 | 0.58194 |
| 1991 | 0.013289 | 301 | 0.003371 | 0.10630 | 0.77402 | 0.02700 | 0.41848 |
| 1992 | 0.018750 | 320 | 0.010893 | 0.34351 | 0.63105 | 0.10791 | 1.09351 |
| 1993 | 0.019465 | 411 | 0.035881 | 1.13145 | 0.55314 | 0.40260 | 3.17982 |
| 1994 | 0.027174 | 368 | 0.037406 | 1.17953 | 0.49171 | 0.46507 | 2.99161 |
| 1995 | 0.022059 | 272 | 0.011749 | 0.37048 | 0.61019 | 0.12026 | 1.14139 |
| 1996 | 0.024922 | 321 | 0.024074 | 0.75913 | 0.53974 | 0.27614 | 2.08690 |
| 1997 | 0.011429 | 350 | 0.014086 | 0.44416 | 0.66571 | 0.13227 | 1.49150 |
| 1998 | 0.027439 | 328 | 0.018062 | 0.56954 | 0.51371 | 0.21636 | 1.49925 |
| 1999 | 0.071111 | 225 | 0.067363 | 2.12417 | 0.44465 | 0.90836 | 4.96732 |
| 2000 | 0.067925 | 265 | 0.025808 | 0.81380 | 0.44299 | 0.34901 | 1.89754 |
| 2001 | 0.063559 | 236 | 0.063577 | 2.00479 | 0.44678 | 0.85412 | 4.70565 |
| 2002 | 0.091743 | 218 | 0.025406 | 0.80114 | 0.43342 | 0.34940 | 1.83691 |
| 2003 | 0.068807 | 218 | 0.033032 | 1.04161 | 0.46580 | 0.42935 | 2.52697 |
| 2004 | 0.080460 | 261 | 0.037356 | 1.17796 | 0.44450 | 0.50386 | 2.75392 |
| 2005 | 0.075908 | 303 | 0.057908 | 1.82604 | 0.37299 | 0.88721 | 3.75829 |
| 2006 | 0.063158 | 285 | 0.062294 | 1.96433 | 0.42756 | 0.86559 | 4.45777 |
| 2007 | 0.058282 | 326 | 0.045151 | 1.42377 | 0.41855 | 0.63746 | 3.17995 |
| 2008 | 0.039604 | 303 | 0.024858 | 0.78385 | 0.49785 | 0.30585 | 2.00888 |

***Delta Poisson CPUE for red grouper***
***Modeled Frequency of Occurrence Index Output***

| *MFO* | *CVMFO* | *LCLMFO* | *UCLMFO* | *year* | *MNZCPUE* | *NFO* | *NNZCPUE* |
|---|---|---|---|---|---|---|---|
| 0.005047 | 0.58157 | 0.001610 | 0.015705 | 1990 | 0.84482 | 0.008547 | 1.00000 |
| 0.006446 | 0.55238 | 0.002177 | 0.018933 | 1991 | 0.52295 | 0.013289 | 1.00000 |
| 0.006187 | 0.53149 | 0.002177 | 0.017453 | 1992 | 1.76082 | 0.018750 | 3.00000 |
| 0.016523 | 0.44828 | 0.006827 | 0.039442 | 1993 | 2.17164 | 0.019465 | 2.50000 |
| 0.023444 | 0.37332 | 0.011218 | 0.048343 | 1994 | 1.59554 | 0.027174 | 3.00000 |
| 0.012659 | 0.46647 | 0.005052 | 0.031361 | 1995 | 0.92809 | 0.022059 | 1.50000 |
| 0.021613 | 0.38436 | 0.010122 | 0.045547 | 1996 | 1.11388 | 0.024922 | 1.12500 |
| 0.007858 | 0.52434 | 0.002802 | 0.021837 | 1997 | 1.79241 | 0.011429 | 2.00000 |
| 0.022460 | 0.38437 | 0.010517 | 0.047319 | 1998 | 0.80416 | 0.027439 | 2.22222 |
| 0.053159 | 0.31768 | 0.028260 | 0.097790 | 1999 | 1.26719 | 0.071111 | 1.68750 |
| 0.032157 | 0.31277 | 0.017326 | 0.058920 | 2000 | 0.80255 | 0.067925 | 1.61111 |
| 0.052500 | 0.32528 | 0.027489 | 0.097975 | 2001 | 1.21100 | 0.063559 | 2.13333 |
| 0.037430 | 0.31203 | 0.020180 | 0.068398 | 2002 | 0.67876 | 0.091743 | 1.80000 |
| 0.037658 | 0.33273 | 0.019479 | 0.071562 | 2003 | 0.87717 | 0.068807 | 1.93333 |
| 0.034868 | 0.33211 | 0.018068 | 0.066234 | 2004 | 1.07136 | 0.080460 | 1.90476 |
| 0.057943 | 0.27059 | 0.033837 | 0.097489 | 2005 | 0.99940 | 0.075908 | 1.17391 |
| 0.033626 | 0.32174 | 0.017792 | 0.062650 | 2006 | 1.85257 | 0.063158 | 2.44444 |
| 0.038558 | 0.30819 | 0.020944 | 0.069928 | 2007 | 1.17100 | 0.058282 | 2.15789 |
| 0.020461 | 0.38277 | 0.009616 | 0.043009 | 2008 | 1.21488 | 0.039604 | 1.91667 |

Delta Poisson CPUE for red grouper
Observed and Standardized Frequency of Occurrence (95% CI)