Patterns of annual abundance of black and red grouper in the Florida Keys and Dry Tortugas based on reef fish visual census conducted by NOAA NMFS.

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Introduction and Methodology

The Reeffish Visual Census (RVC) survey utilizes standard, non-destructive, in situ visual monitoring methods by highly trained and experienced divers using open circuit SCUBA. Visual methods are ideal for assessing reef fishes because of prevailing good visibility and management concerns requiring the use of low impact assessment methods. The method provides reliable quantitative estimates of species composition, abundance (density per plot), frequency-of-occurrence, and individual size composition for the reef fish community. Data are collected by a stationary diver centered in a randomly selected circular plot. Divers sample 7.5 m radius circular plots for 5 minutes attempting to list all fish species observed within each imaginary cylinder extending from the bottom to the limits of vertical visibility (usually the surface). Divers begin each sample by facing in one direction and listing all species within the field of view. When no new species are noted, new sectors are scanned sequentially by rotating in one direction for the 5 min period. Several complete rotations are usually made for each plot. After the initial 5 min, data are then recorded on abundance and minimum and maximum lengths for each species listed. A 30-cm calibration ruler held out perpendicularly at the end of a meter stick was used to reduce apparent magnification errors in size estimates. Divers periodically calibrate their sample radius estimates with either a meter stick or fiberglass tape. The time required to record each sample averages 15-20 min (range 5-30), depending on the habitat. Sampling was conducted at inshore and offshore reef sites along the Florida reef tract from Miami to the Dry Tortugas. Different areas of the reef track have had different levels of protection and different historical management policies. Sampling has been concentrated in the spring and summer when sea conditions are generally calm and water conditions most suitable for visual sampling. Actual sampling intensity has varied on a yearly basis as determined by weather, logistics, funding, scheduling, and personnel consideration. In recent years there have been investigations concerning modifications in the survey design to increase the precision in the estimates. The publication providing more detailed background information for the RVC is NOAA/SEFSC/NMFS Technical Memorandum 427 (Bohnsack et.al. 1999) available online: http://www.sefsc.noaa.gov/PDFdocs/427techmemo.pdf.

For this study, two data sets were analyzed. RVC data was collected on black and red grouper from 1994 to 2008 in the Dry Tortugas Region and included a total of 4,005 individual point counts (Note: There was no Dry Tortugas sampling during 2003 and 2005, and the data is unavailable for years 1999, 2000, 2001, and 2002), and from 1979 to 2007 in the Florida Keys

(Miami thru just west of Key West) and included a total of 15,330 individual point counts. Florida Keys sampling occurred at depths between 1 and 33 m, while Dry Tortugas sampling occurred at depths between 2 and 41 m.

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 σ^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, month, and habitat-type. Several habitats were sampled and habitat type was recorded. In order to aid in analyses in the Florida Keys data, several habitat types were combined or deleted to increase sample size within each habitat type or to remove

habitats where very few or no black or red grouper were observed, respectively (see Appendix 1). 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 $\alpha = 0.05$. Binomial submodel performance was evaluated using AIC, while the performance of the Poisson submodel was evaluated based on analyses of residual scatter and QQ plots. Abundance (density per plot) was modeled using this approach. Initially, length 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

Figures 1 and 2 illustrate the sampling effort and the number of fish observed per sampling plot in both the Dry Tortugas and the Florida Keys over their respective time series. In order to examine effort and fish observations on an annual basis, Appendix 2 may be examined, which would illustrate an increase in sampling effort over time in both sampling areas.

Figures 3 – 6 elucidate the size of fish observed during the RVC in both sampling areas over the corresponding time series. In order to examine year-specific length frequency histograms for each species from each sampling area, Appendix 3 may be examined. During the RVC, 1317 and 785 black grouper lengths were estimated in the Florida Keys and the Dry Tortugas, respectively. Also, 1164 and 489 red grouper lengths were estimated in the Florida Keys and the Dry Tortugas, respectively. Black grouper ranged in length from approximately 10 to 100 cm with a mode of approximately 40 cm in the Florida Keys (Figure 3), while black grouper ranged in length from approximately 10 to 110 cm with a mode of approximately 45 to 55 cm in the Dry Tortugas (Figure 4). Red grouper ranged in length from approximately 10 to 80 cm with a mode of approximately 35 cm in the Florida Keys (Figure 5), while red grouper ranged in length from approximately 10 to 95 cm with a mode of approximately 50 cm in the Dry Tortugas (Figure 6).

Tables 1 – 4 and Figures 7 – 10 summarize the abundance indices resulting from the previously described methods. For detailed results of the model building process for each species in each sampling area, Appendix 4 may be examined. In the case of all four indices both nominal and modeled average non-zero observation per sampling plot was close to one fish per sampling plot, indicating that a presence/absence (i.e. probability of occurrence) model may be more appropriate than the delta-Poisson model.

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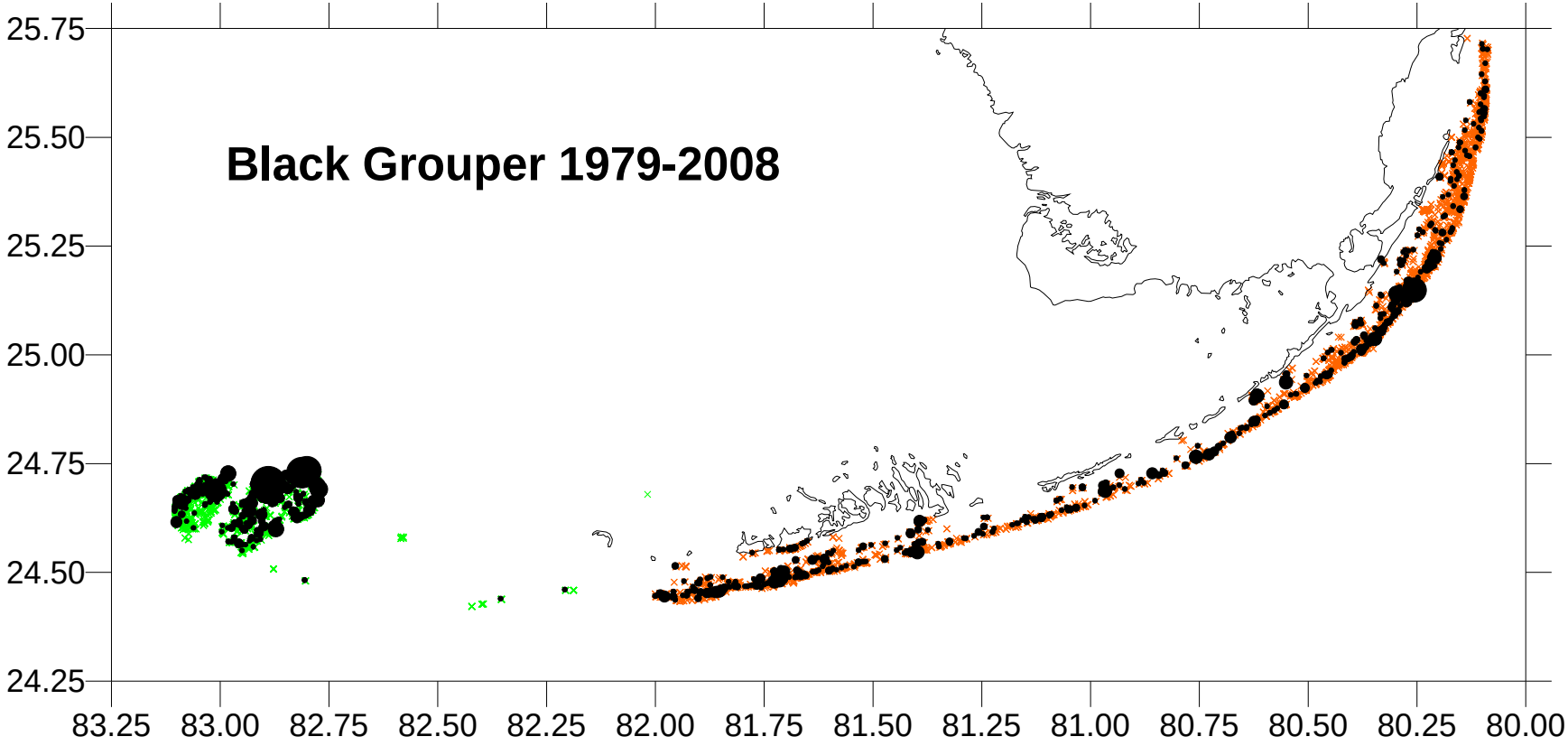


Figure 1. Effort and number of black grouper observed per sampling plot during the RVC for both the Florida Keys (1979 – 2007) and Dry Tortugas (1994 – 2008). Orange crosses represent RVC effort for the Florida Keys sampling area (14715 sampling plots); while green crosses represent RVC effort for the Dry Tortugas sampling area (4005 sampling plots). Black circles indicate plots where black grouper were observed. The diameters of the circles are linearly related to the number of black grouper observed at each sampling plot (non-zero range: 1 – 15 black grouper per sampling plot).

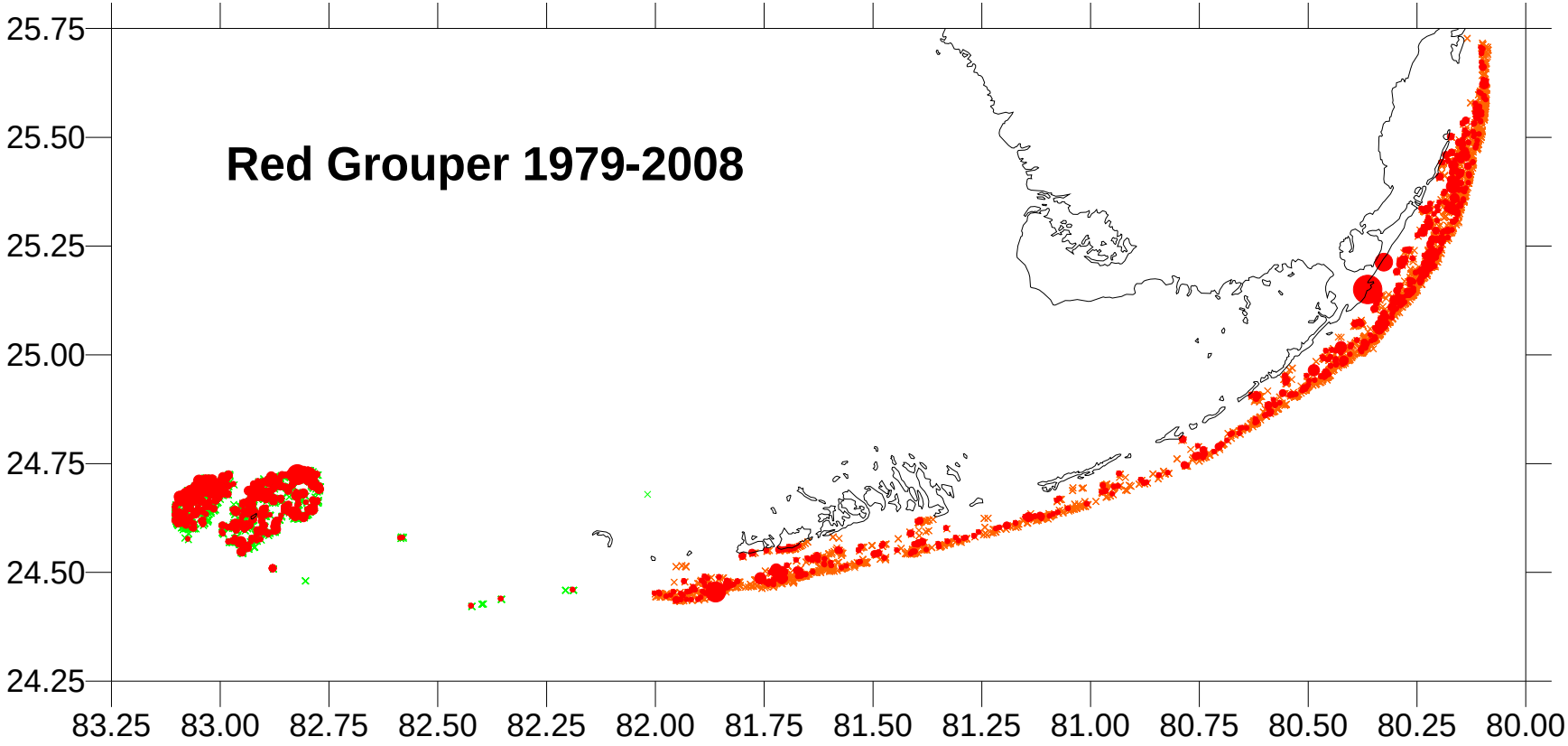


Figure 2. Effort and number of red grouper observed per sampling plot during the RVC for both the Florida Keys (1979 – 2007) and Dry Tortugas (1994 – 2008). Orange crosses represent RVC effort for the Florida Keys sampling area (14715 sampling plots); while green crosses represent RVC effort for the Dry Tortugas sampling area (4005 sampling plots). Red circles indicate plots where red grouper were observed. The diameters of the circles are linearly related to the number of red grouper observed at each sampling plot (non-zero range: 1 – 10 red grouper per sampling plot).

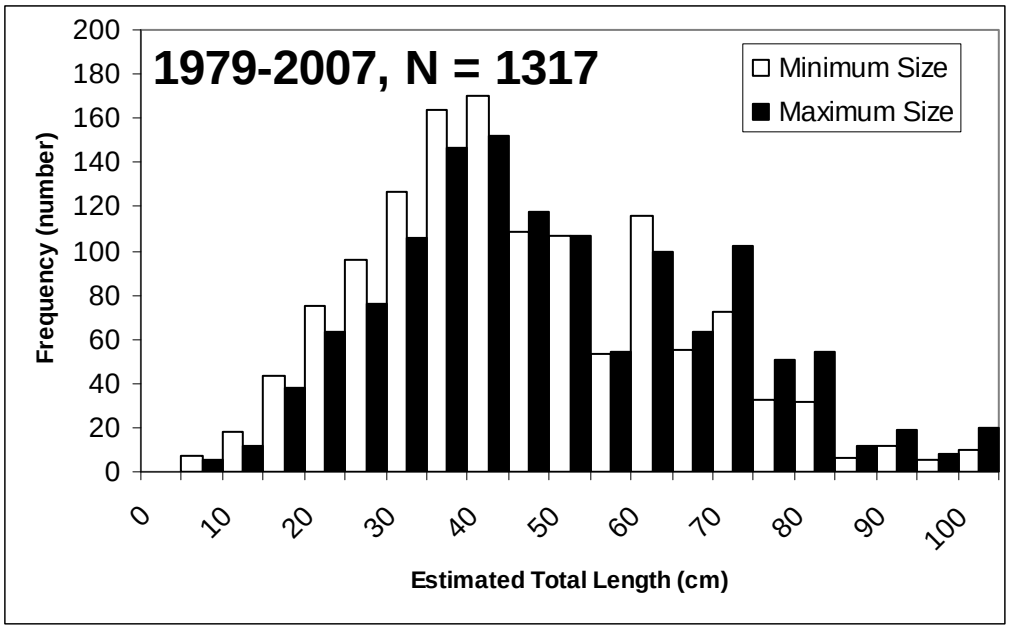


Figure 3. Length frequencies of black grouper observed during the RVC in the Florida Keys (1979 – 2007). Minimum and maximum lengths for each observed fish is recorded. Therefore, each fish has two estimated lengths. Both the minimum and maximum lengths are included on the length frequency histogram, and N is the number of fish for which minimum and maximum lengths were estimated.

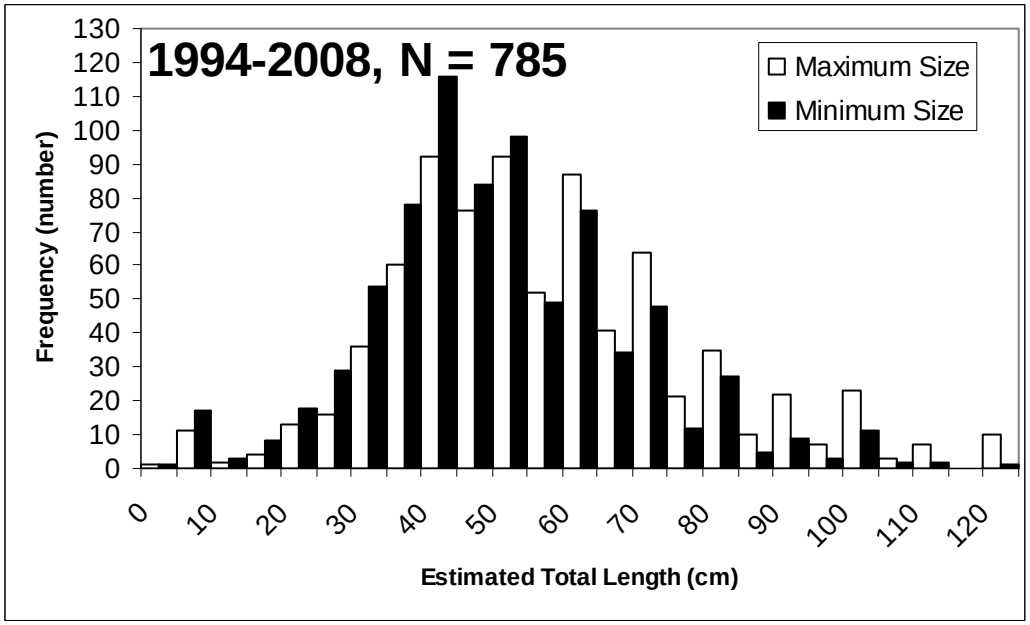


Figure 4. Length frequencies of black grouper observed during the RVC in the Dry Tortugas (1994 – 2008). Minimum and maximum lengths are included on the length frequency histogram, and N is the number of fish for which minimum and maximum lengths were estimated.

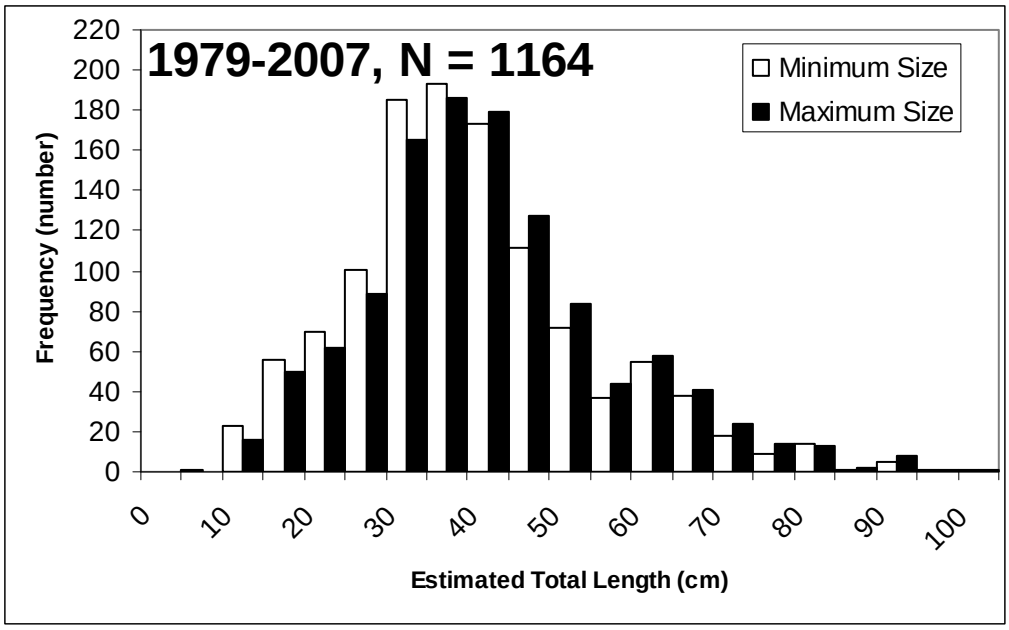


Figure 5. Length frequencies of red grouper observed during the RVC in the Florida Keys (1979 – 2007). Minimum and maximum lengths are included on the length frequency histogram, and N is the number of fish for which minimum and maximum lengths were estimated.

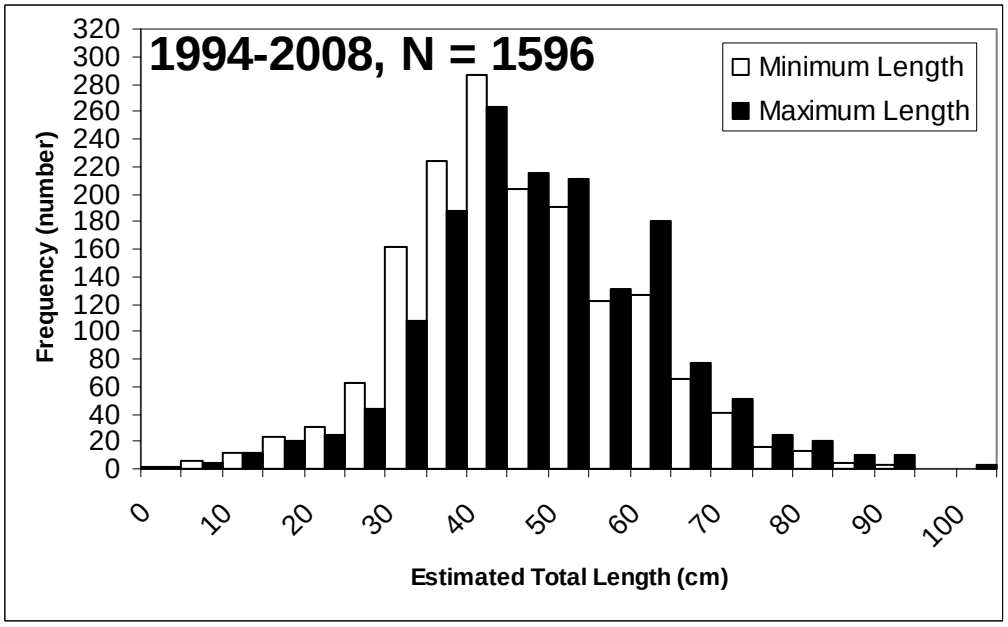


Figure 6. Length frequencies of red grouper observed during the RVC in the Dry Tortugas (1994 – 2008). Minimum and maximum lengths are included on the length frequency histogram, and N is the number of fish for which minimum and maximum lengths were estimated.

Table 1. Model results for black grouper observed during the RVC in the Florida Keys (1979 – 2007). No black grouper were observed in 1979.

Year	*N*	*Index (number per sampling plot)*	*Index (scaled to a mean of 1)*	*CV*	*LCL*	*UCL*	*Nominal Frequency of Occurrence (FO)*	*Modeled FO (MFO)*	*CV MFO*	*LCL MFO*	*UCL MFO*	*Modeled Non-zero Observations*	*Nominal Non-zero Observations*
1980	144	0.007	0.082	2.237	0.006	1.190	0.014	0.004	2.104	0.000	0.210	1.578	1.500
1981	208	0.037	0.455	0.600	0.150	1.380	0.067	0.037	0.533	0.013	0.102	0.995	1.071
1982	189	0.040	0.504	0.610	0.164	1.551	0.079	0.042	0.543	0.014	0.118	0.957	1.000
1983	419	0.060	0.744	0.356	0.373	1.486	0.055	0.062	0.296	0.035	0.110	0.956	1.000
1984	206	0.102	1.272	0.390	0.599	2.700	0.087	0.102	0.322	0.053	0.187	0.998	1.000
1985	85	0.083	1.031	0.601	0.339	3.131	0.106	0.073	0.514	0.026	0.190	1.133	1.111
1986	21	0.038	0.478	0.878	0.105	2.170	0.190	0.040	0.756	0.009	0.163	0.965	1.250
1987	63	0.031	0.381	0.978	0.074	1.960	0.063	0.030	0.843	0.006	0.147	1.007	1.000
1988	259	0.027	0.340	0.616	0.109	1.056	0.042	0.029	0.535	0.010	0.080	0.951	1.000
1989	318	0.001	0.019	2.634	0.001	0.329	0.003	0.001	2.386	0.000	0.137	1.027	1.000
1990	282	0.008	0.099	1.664	0.010	0.988	0.007	0.007	1.482	0.000	0.115	1.146	1.000
1991	275	0.054	0.671	0.554	0.239	1.888	0.098	0.045	0.509	0.016	0.119	1.188	1.185
1992	256	0.038	0.470	0.649	0.144	1.539	0.063	0.034	0.588	0.011	0.105	1.096	1.063
1993	259	0.042	0.529	0.719	0.146	1.922	0.077	0.040	0.665	0.011	0.140	1.060	1.050
1994	273	0.034	0.428	0.618	0.137	1.333	0.081	0.031	0.569	0.010	0.091	1.123	1.182
1995	629	0.007	0.084	1.094	0.014	0.493	0.019	0.007	1.026	0.001	0.050	0.971	1.000
1996	325	0.035	0.433	0.684	0.126	1.495	0.058	0.030	0.633	0.008	0.099	1.170	1.211
1997	784	0.033	0.414	0.556	0.147	1.168	0.064	0.031	0.522	0.011	0.084	1.077	1.060
1998	901	0.062	0.771	0.412	0.349	1.702	0.081	0.054	0.383	0.025	0.112	1.146	1.137
1999	677	0.108	1.351	0.370	0.660	2.768	0.130	0.104	0.342	0.052	0.198	1.041	1.045
2000	842	0.193	2.405	0.227	1.536	3.766	0.151	0.133	0.205	0.088	0.196	1.451	1.465
2001	1185	0.195	2.436	0.232	1.540	3.852	0.154	0.152	0.212	0.099	0.226	1.288	1.339
2002	999	0.225	2.806	0.188	1.935	4.070	0.170	0.162	0.166	0.116	0.221	1.393	1.429
2003	908	0.133	1.653	0.293	0.931	2.936	0.131	0.098	0.270	0.057	0.163	1.355	1.353
2004	796	0.123	1.530	0.254	0.927	2.524	0.122	0.093	0.231	0.059	0.145	1.315	1.433
2005	1124	0.273	3.400	0.184	2.363	4.893	0.144	0.192	0.162	0.138	0.261	1.418	1.414
2006	1039	0.094	1.168	0.304	0.644	2.117	0.095	0.073	0.279	0.042	0.125	1.283	1.303
2007	1236	0.164	2.048	0.252	1.246	3.365	0.115	0.122	0.230	0.076	0.188	1.352	1.352

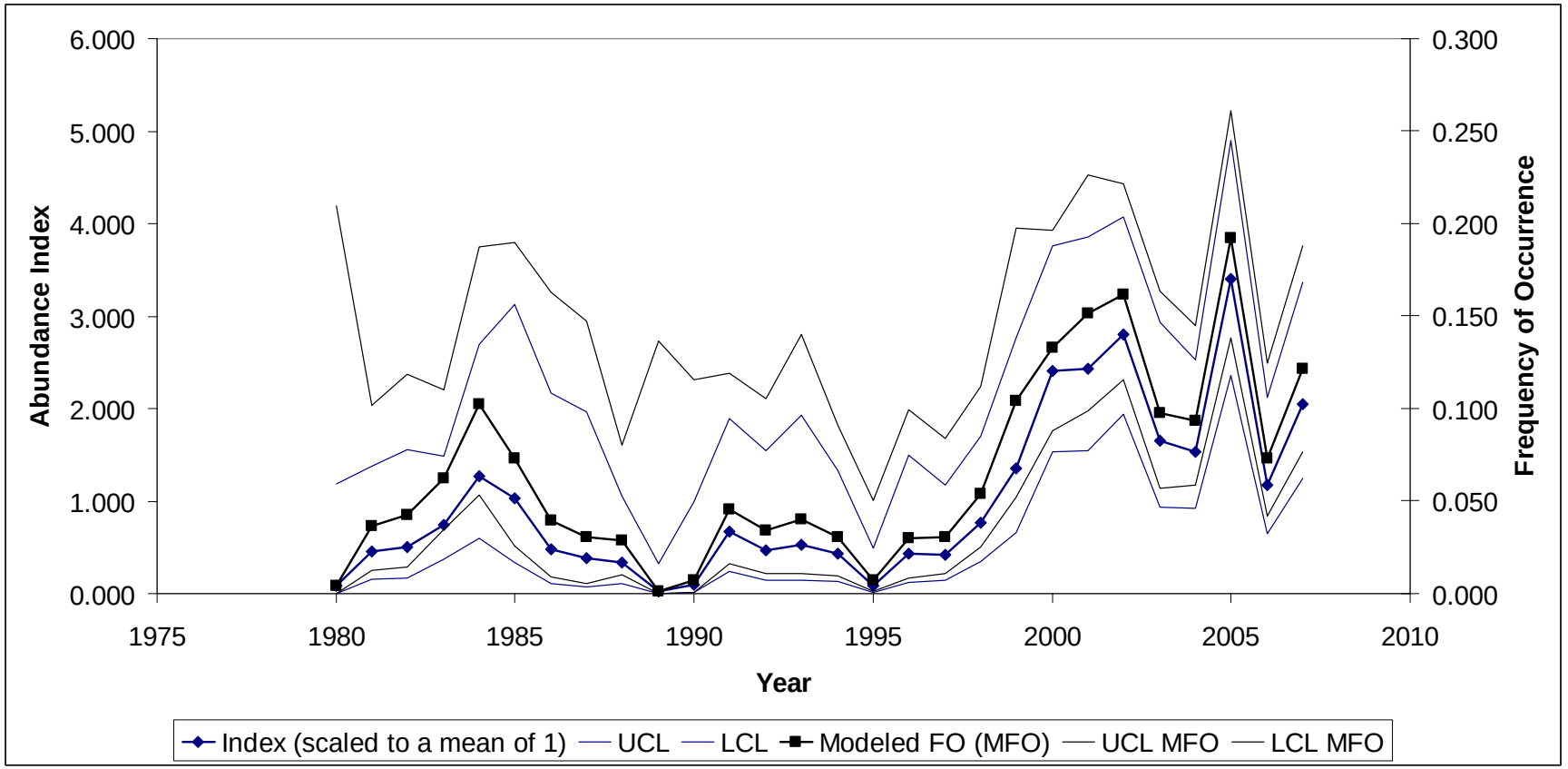


Figure 7. Model results for black grouper observed during the RVC in the Florida Keys (1979 – 2007). No black grouper were observed in 1979.

Table 2. Model results of red grouper observed during the RVC in the Florida Keys (1987 – 2007). Sampling years 1979 – 1986, except for 1983, had zero observations of red grouper.

Year	*N*	*Index (number per sampling plot)*	*Index (scaled to a mean of 1)*	*CV*	*LCL*	*UCL*	*Nominal Frequency of Occurrence (NFO)*	*Modeled FO (MFO)*	*CV MFO*	*LCL MFO*	*UCL MFO*	*Modeled Non-zero Observations*	*Nominal Non-zero Observations*
1987	63	0.052	0.644	0.799	0.158	2.625	0.016	0.054	0.462	0.021	0.130	0.964	1.000
1988	259	0.007	0.082	2.798	0.004	1.578	0.004	0.001	2.702	0.000	0.233	4.822	5.000
1989	318	0.002	0.027	2.289	0.002	0.399	0.006	0.002	2.128	0.000	0.136	0.964	1.000
1990	282	0.024	0.293	0.913	0.062	1.393	0.043	0.021	0.850	0.004	0.107	1.132	1.167
1991	275	0.017	0.210	1.013	0.039	1.126	0.011	0.017	0.864	0.003	0.093	0.964	1.000
1992	256	0.005	0.057	1.900	0.005	0.672	0.008	0.005	1.734	0.000	0.133	0.964	1.000
1993	259	0.002	0.028	2.321	0.002	0.425	0.004	0.002	2.080	0.000	0.130	0.964	1.000
1994	273	0.061	0.765	0.840	0.177	3.302	0.026	0.042	0.764	0.009	0.179	1.448	1.429
1995	629	0.147	1.828	0.379	0.879	3.801	0.041	0.127	0.329	0.064	0.236	1.154	1.115
1996	325	0.050	0.628	0.842	0.145	2.715	0.031	0.041	0.773	0.009	0.178	1.216	1.200
1997	784	0.043	0.537	0.511	0.205	1.407	0.038	0.039	0.465	0.015	0.095	1.118	1.033
1998	901	0.145	1.807	0.369	0.884	3.693	0.065	0.122	0.337	0.061	0.229	1.191	1.169
1999	677	0.254	3.169	0.346	1.616	6.213	0.097	0.167	0.318	0.086	0.301	1.519	1.500
2000	842	0.136	1.698	0.273	0.993	2.903	0.169	0.119	0.250	0.071	0.193	1.140	1.169
2001	1187	0.129	1.604	0.265	0.952	2.701	0.161	0.113	0.243	0.069	0.180	1.139	1.152
2002	1002	0.128	1.596	0.248	0.980	2.601	0.138	0.107	0.225	0.068	0.165	1.198	1.174
2003	908	0.114	1.426	0.279	0.824	2.466	0.153	0.102	0.255	0.061	0.167	1.118	1.130
2004	796	0.195	2.427	0.218	1.578	3.732	0.161	0.164	0.193	0.110	0.237	1.188	1.203
2005	1124	0.089	1.107	0.279	0.641	1.914	0.132	0.083	0.255	0.049	0.136	1.075	1.081
2006	1039	0.037	0.455	0.432	0.199	1.041	0.068	0.035	0.402	0.016	0.077	1.045	1.070
2007	1236	0.049	0.612	0.372	0.298	1.257	0.073	0.045	0.345	0.022	0.087	1.103	1.122

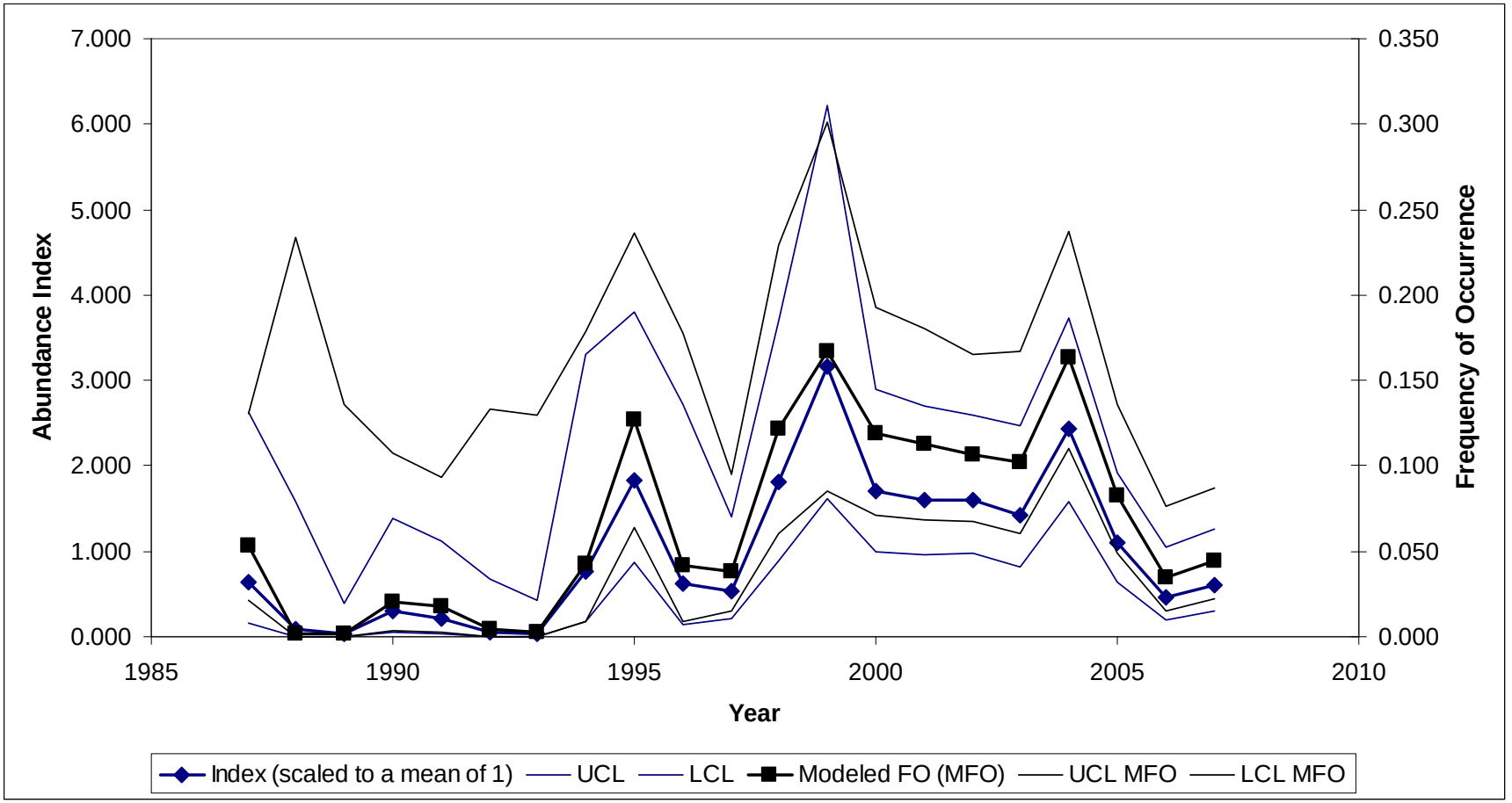


Figure 8. Model results of red grouper observed during the RVC in the Florida Keys (1987 – 2007). Sampling years 1979 – 1986, except for 1983, had zero observations of red grouper.

Table 3. Model results for black grouper observed during the RVC in the Dry Tortugas (1994 – 2008).

Year	*N*	*Index (number per sampling plot)*	*Index (scaled to a mean of 1)*	*CV*	*LCL*	*UCL*	*Nominal Frequency of Occurrence (NFO)*	*Modeled FO (MFO)*	*CV MFO*	*LCL MFO*	*UCL MFO*	*Modeled Non-zero Observations*	*Nominal Non-zero Observations*
1994	188	0.033	0.207	1.187	0.032	1.352	0.069	0.031	0.964	0.004	0.191	1.077	1.077
1995	75	0.015	0.092	1.629	0.009	0.895	0.053	0.015	1.200	0.001	0.148	1.000	1.000
1996	100	0.060	0.375	1.173	0.058	2.409	0.070	0.047	0.889	0.007	0.243	1.286	1.286
1997	209	0.076	0.476	0.866	0.107	2.125	0.148	0.070	0.724	0.015	0.264	1.097	1.097
1998	146	0.128	0.801	0.878	0.177	3.634	0.123	0.100	0.704	0.023	0.351	1.278	1.278
1999													
2000													
2001													
2002													
2003													
2004	1137	0.389	2.432	0.619	0.779	7.594	0.254	0.202	0.585	0.054	0.526	1.931	1.931
2005													
2006	952	0.219	1.368	0.731	0.370	5.061	0.166	0.124	0.683	0.029	0.406	1.766	1.766
2007													
2008	1198	0.360	2.249	0.983	0.434	11.643	0.189	0.240	0.940	0.025	0.793	1.502	1.502

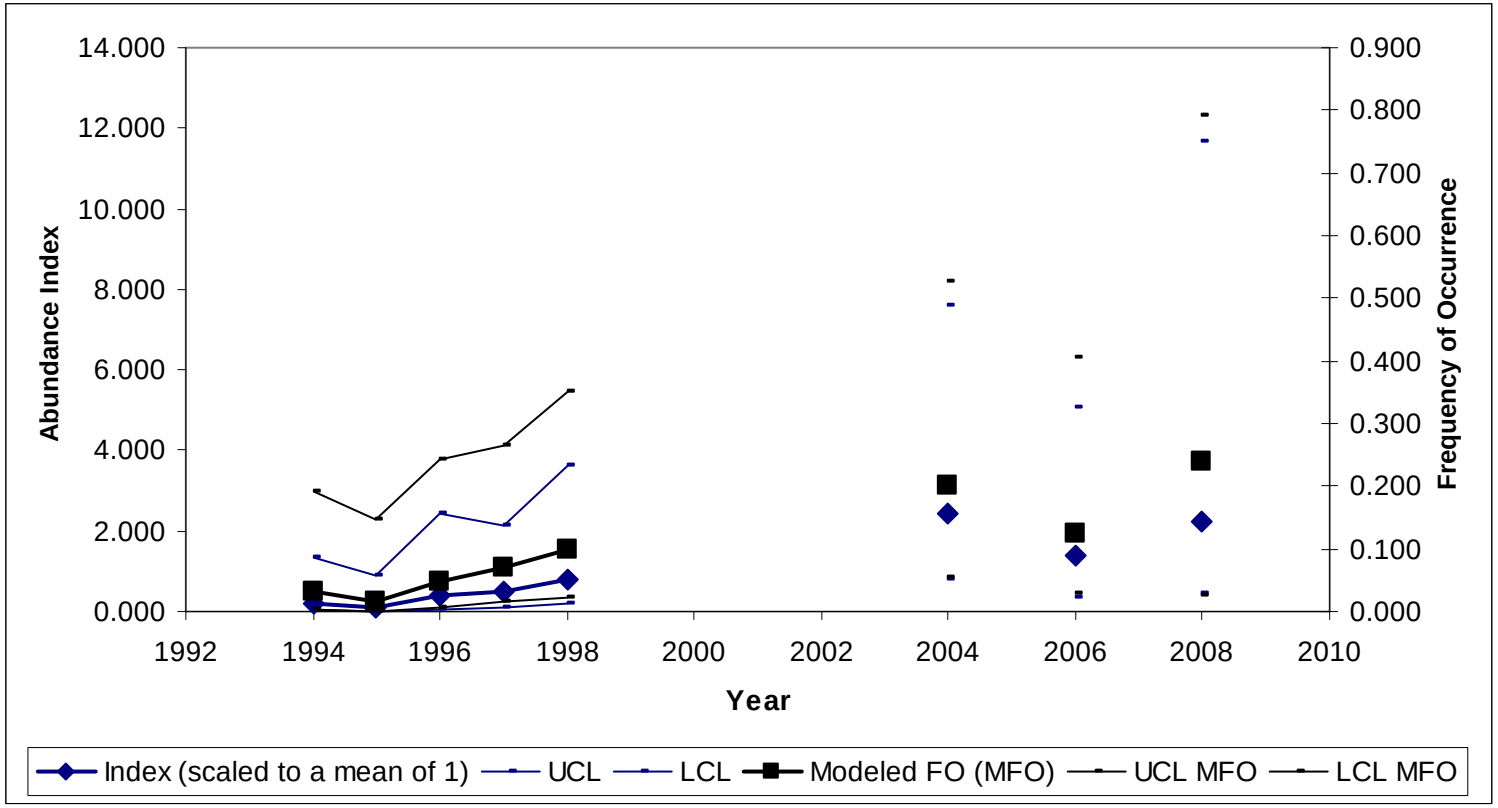


Figure 9. Model results for black grouper observed during the RVC in the Dry Tortugas (1994 – 2008).

Table 4. Model results for red grouper observed during the RVC in the Dry Tortugas (1994 – 2008).

Year	*N*	*Index (number per sampling plot)*	*Index (scaled to a mean of 1)*	*CV*	*LCL*	*UCL*	*Nominal Frequency of Occurrence (NFO)*	*Modeled FO (MFO)*	*CV MFO*	*LCL MFO*	*UCL MFO*	*Modeled Non-zero Observations*	*Nominal Non-zero Observations*
1994	188	0.083	0.314	0.801	0.077	1.284	0.144	0.083	0.717	0.018	0.303	0.998	1.222
1995	75	0.074	0.281	0.903	0.060	1.318	0.187	0.094	0.803	0.017	0.383	0.784	1.000
1996	100	0.107	0.407	0.734	0.109	1.514	0.190	0.126	0.641	0.032	0.388	0.846	1.053
1997	209	0.168	0.639	0.558	0.226	1.811	0.191	0.175	0.476	0.062	0.403	0.961	1.175
1998	146	0.468	1.783	0.468	0.732	4.343	0.288	0.357	0.387	0.142	0.651	1.312	1.595
1999													
2000													
2001													
2002													
2003													
2004	1137	0.354	1.348	0.434	0.588	3.094	0.471	0.314	0.361	0.137	0.569	1.130	1.327
2005													
2006	952	0.413	1.573	0.436	0.682	3.625	0.471	0.377	0.364	0.157	0.662	1.096	1.283
2007													
2008	1198	0.435	1.654	0.717	0.456	5.995	0.371	0.263	0.593	0.066	0.644	1.650	1.239

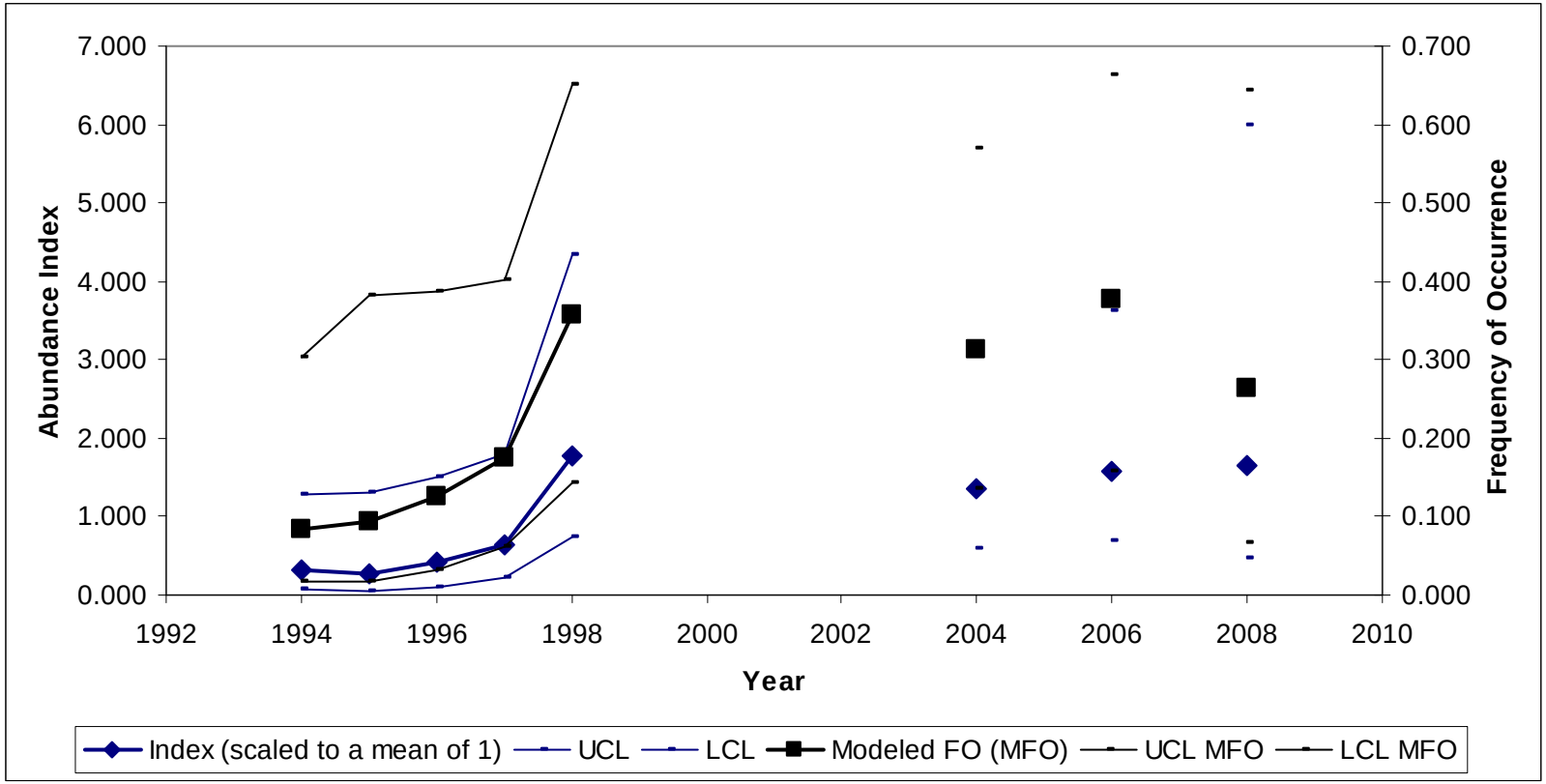


Figure 10. Model results for red grouper observed during the RVC in the Dry Tortugas (1994 – 2008).

Appendix 1:
Habitat consolidation for the Florida Keys RVC data.

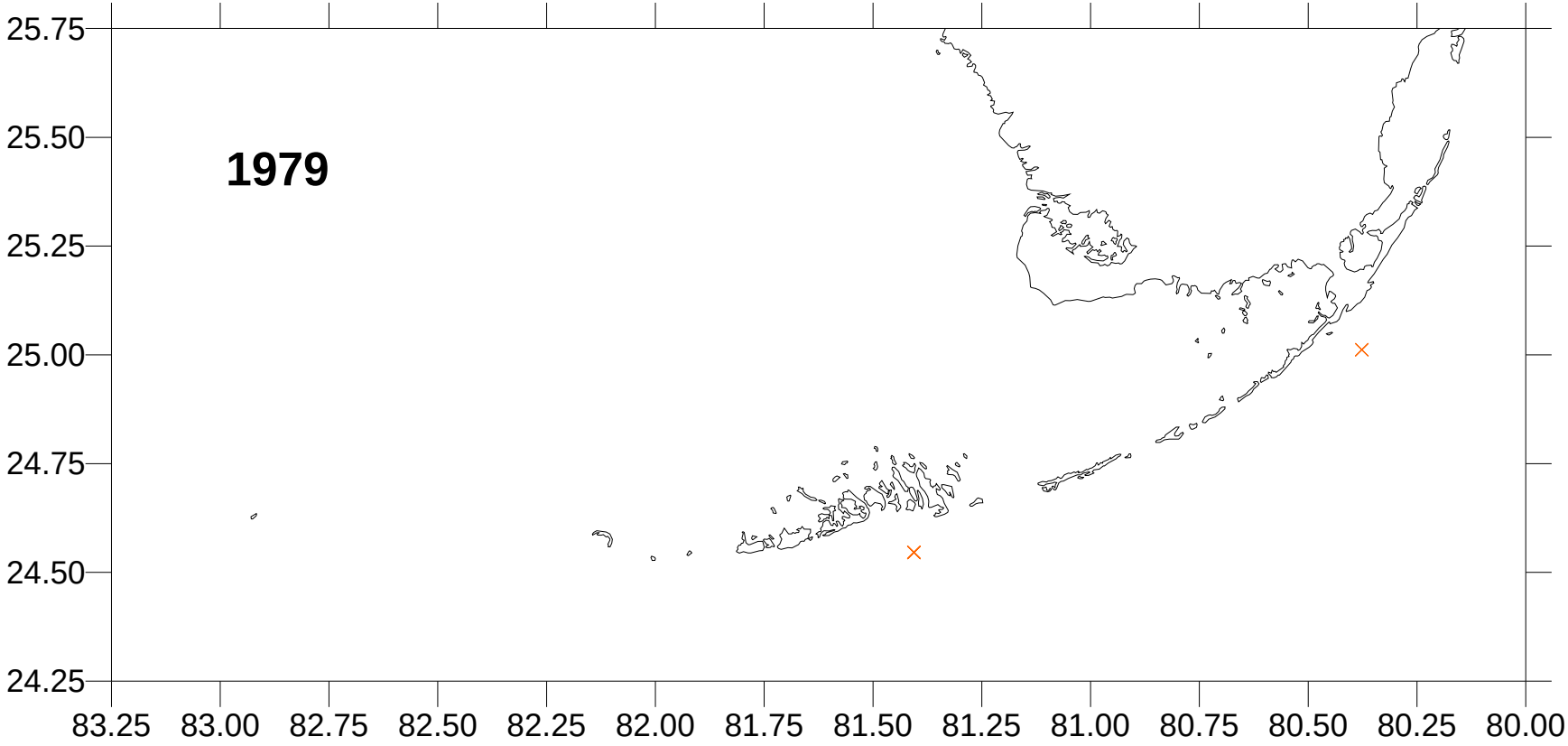
The following is the SAS code used to consolidate habitats in the Florida Keys RVC.

```
if Habitat_Name='Patchy Hardbottom in Sand'     then Habitat='Patchy Hardbottom in Sand';
if Habitat_Name='High Relief Spur-Groove'       then Habitat='High Relief Spur-Groove';
if Habitat_Name='Inner Line Reef'               then Habitat='High Relief Spur-Groove';
if Habitat_Name='Low Relief Hardbottom'         then Habitat='Low Relief Hardbottom';
if Habitat_Name='Low Relief Spur-Groove'        then Habitat='Low Relief Spur-Groove';
if Habitat_Name='Medium Profile Reef'           then Habitat='Medium Profile Reef';
if Habitat_Name='Inshore Reef'                  then Habitat='Patch Reefs';
if Habitat_Name='Mid Channel Patch Reef'        then Habitat='Patch Reefs';
if Habitat_Name='Offshore Patch Reef'           then Habitat='Patch Reefs';
if Habitat_Name='Patch Reefs'                   then Habitat='Patch Reefs';
if Habitat_Name='Isolated reef structure(s)'    then Habitat='Patch Reefs';
if Habitat_Name='Rocky Outcrops'                then Habitat='Patch Reefs';
if Habitat_Name='Reef Rubble/Back Reef'         then Habitat='Reef Rubble/Back Reef';
if Habitat_Name='Reef Terrace'                  then Habitat='Reef Terrace';
if Habitat_Name='Sand'                          then delete;
if Habitat_Name='Sand-Seagrass-HB matrix'       then delete;
if Habitat_Name='TBD'                           then delete;
if Habitat_Name='Wellwood Damaged'              then delete;
if Habitat_Name='Artificial Reef'               then delete;
if Habitat_Name='Iselin Damaged'                then delete;
```

Appendix 2:

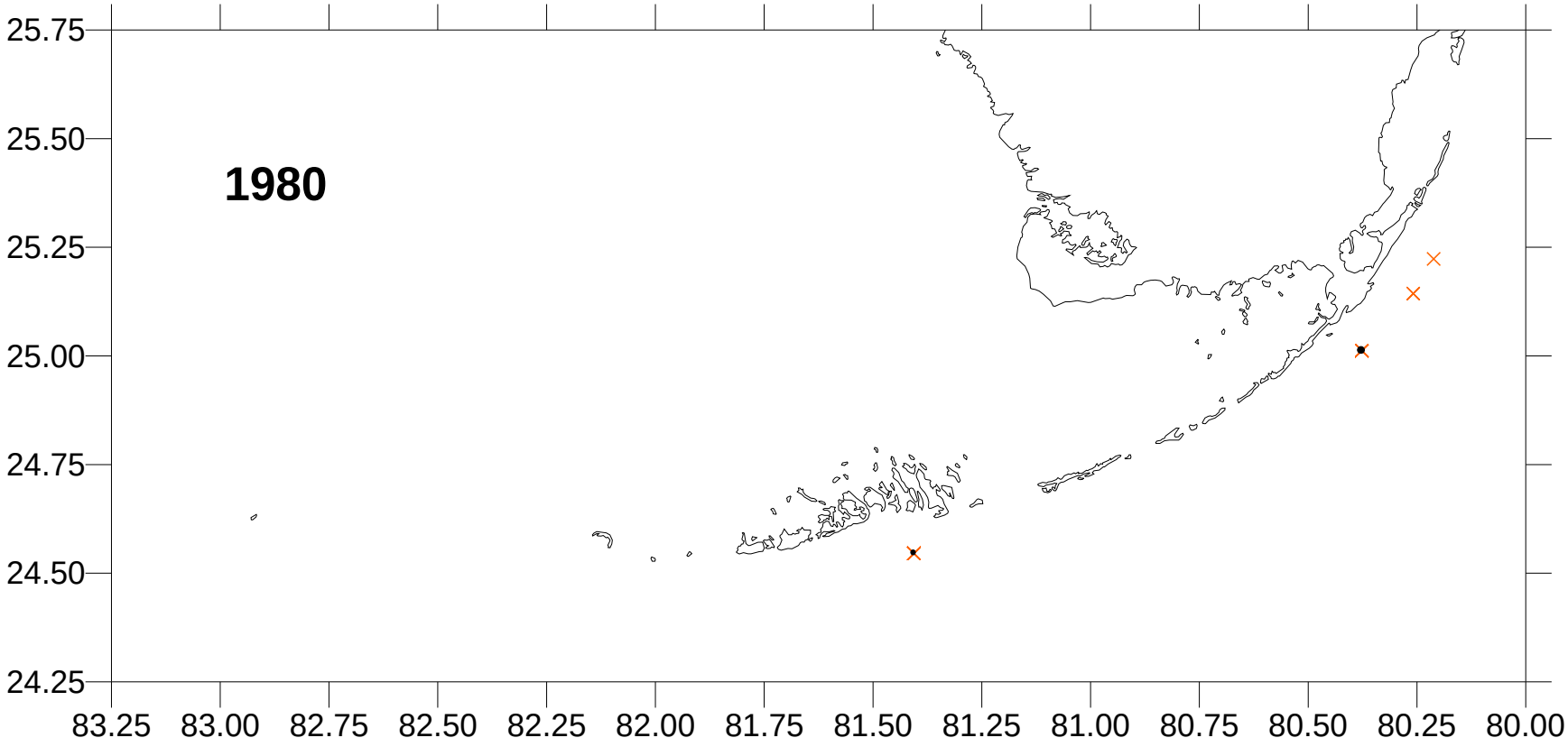
Effort and number observed data from the RVC for both the Florida Keys (1979 – 2007) and Dry Tortugas (1994 – 2008).

Yearly effort and number of black and red grouper observed per sampling plot during the RVC for both the Florida Keys (1979 – 2007) and Dry Tortugas (1994 – 2008) are charted below. Orange crosses represent RVC effort for the Florida Keys sampling area; while green crosses represent RVC effort for the Dry Tortugas sampling area. Black circles indicate plots where black grouper were observed. Red circles indicate plots where red grouper were observed. The diameters of the black and red circles are linearly related to the number of black or red grouper observed at each sampling plot, respectively. Under each chart, the area-specific effort (i.e. number of plots sampled) and the range of non-zero observations for each species are reported.



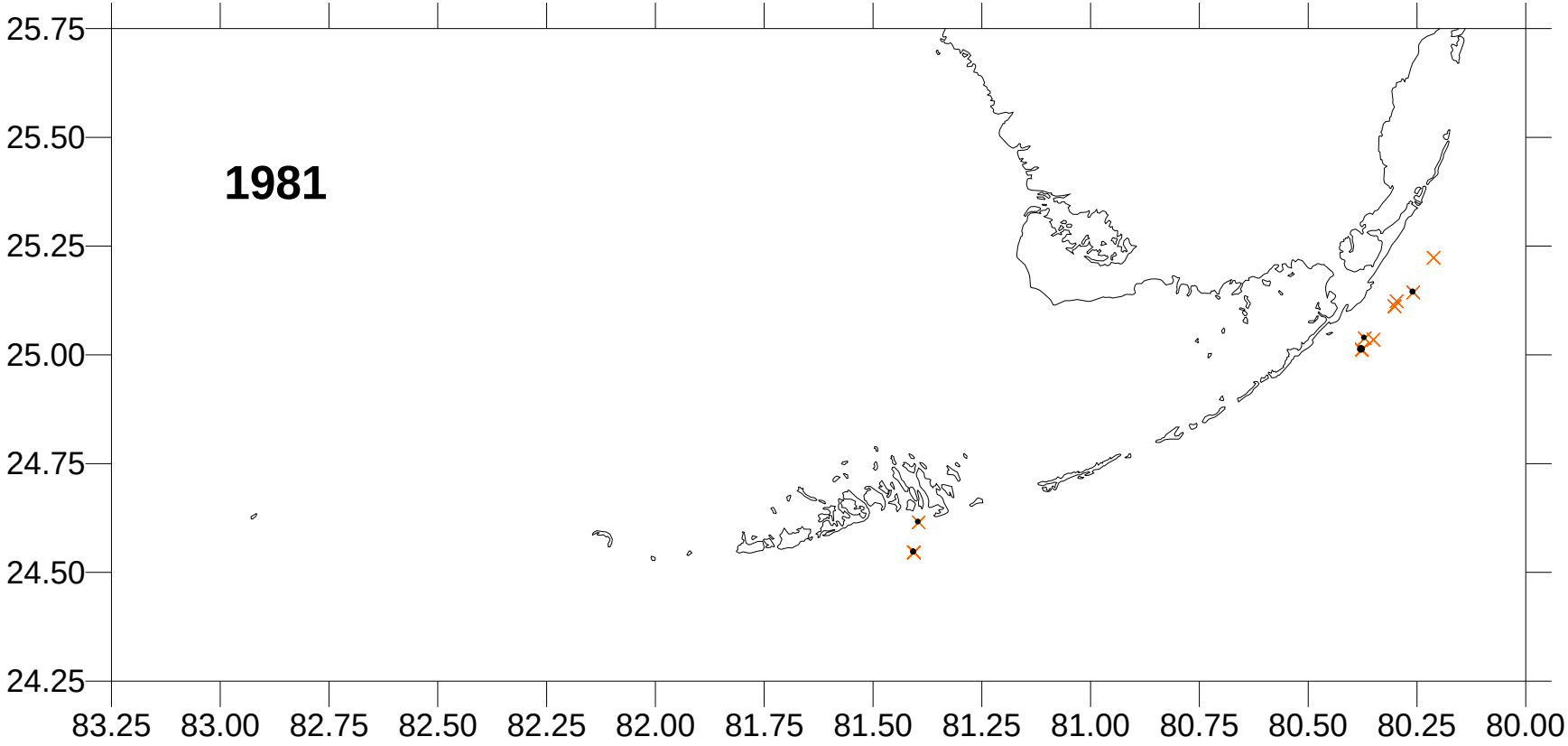
Florida Keys

Effort: 13 plots
Range of non-zero black grouper observations: 0
Range of non-zero red grouper observations: 0



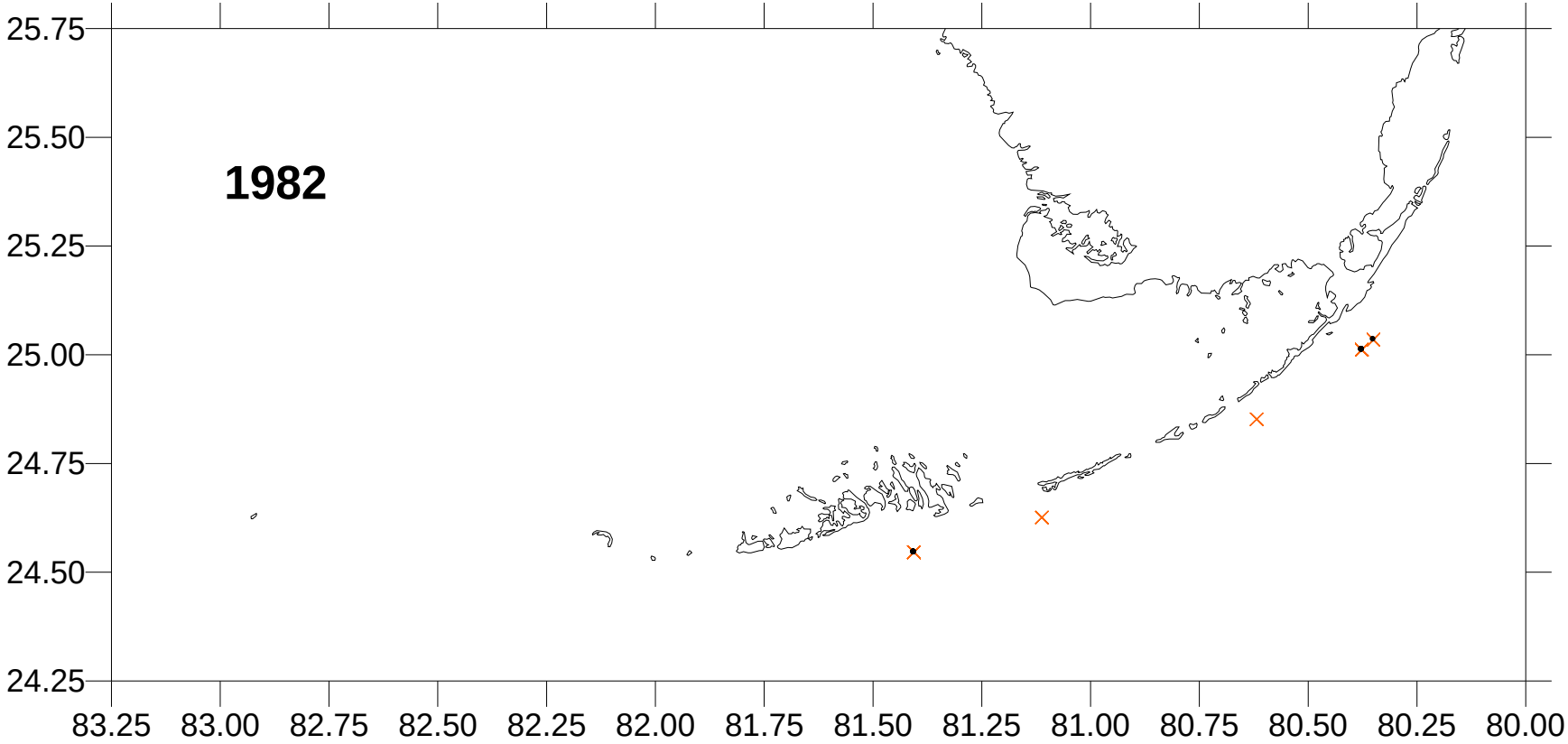
Florida Keys

Effort: 144 plots
Range of non-zero black grouper observations: 1 – 2
Range of non-zero red grouper observations: 0



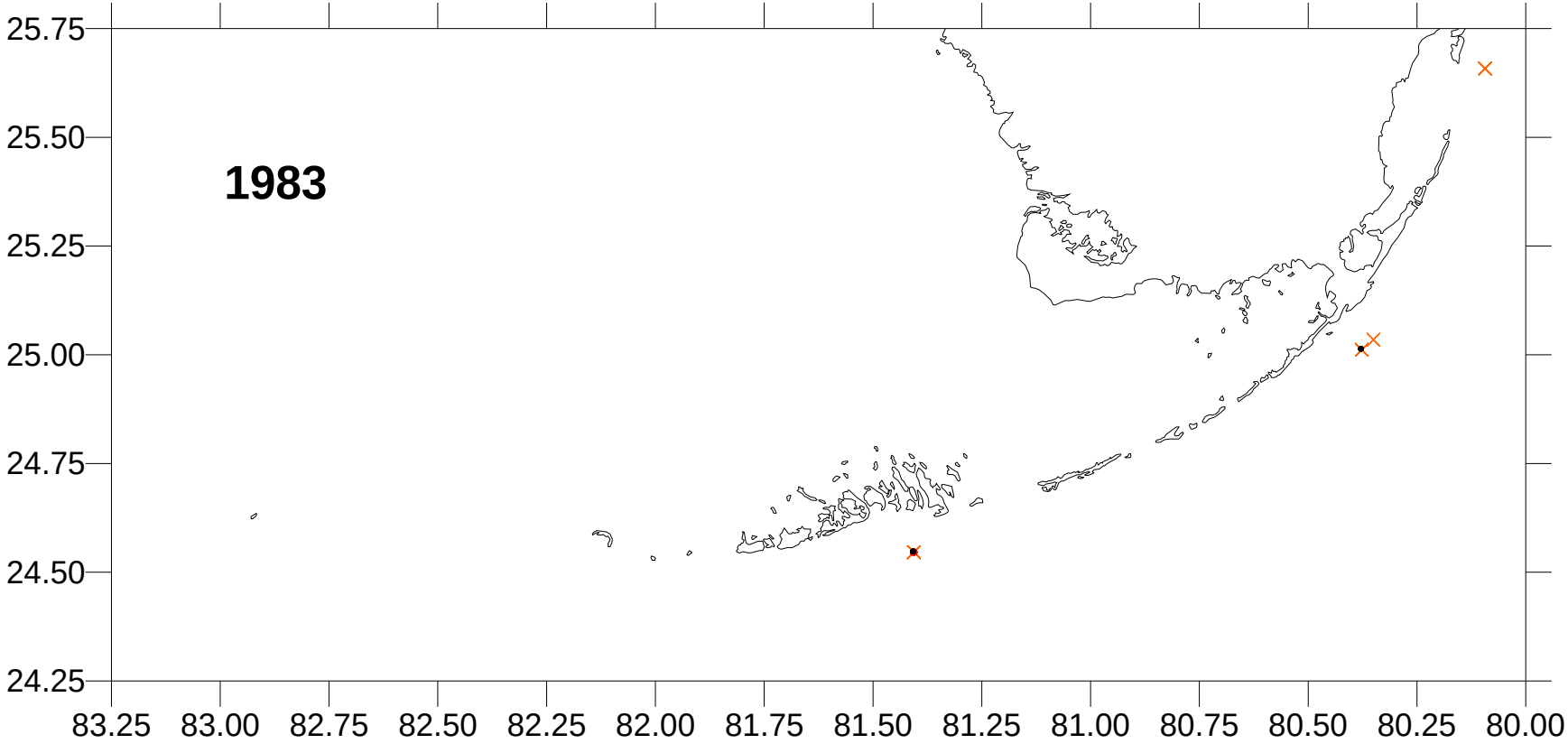
Florida Keys

Effort: 208 plots
Range of non-zero black grouper observations: 1 – 2
Range of non-zero red grouper observations: 0



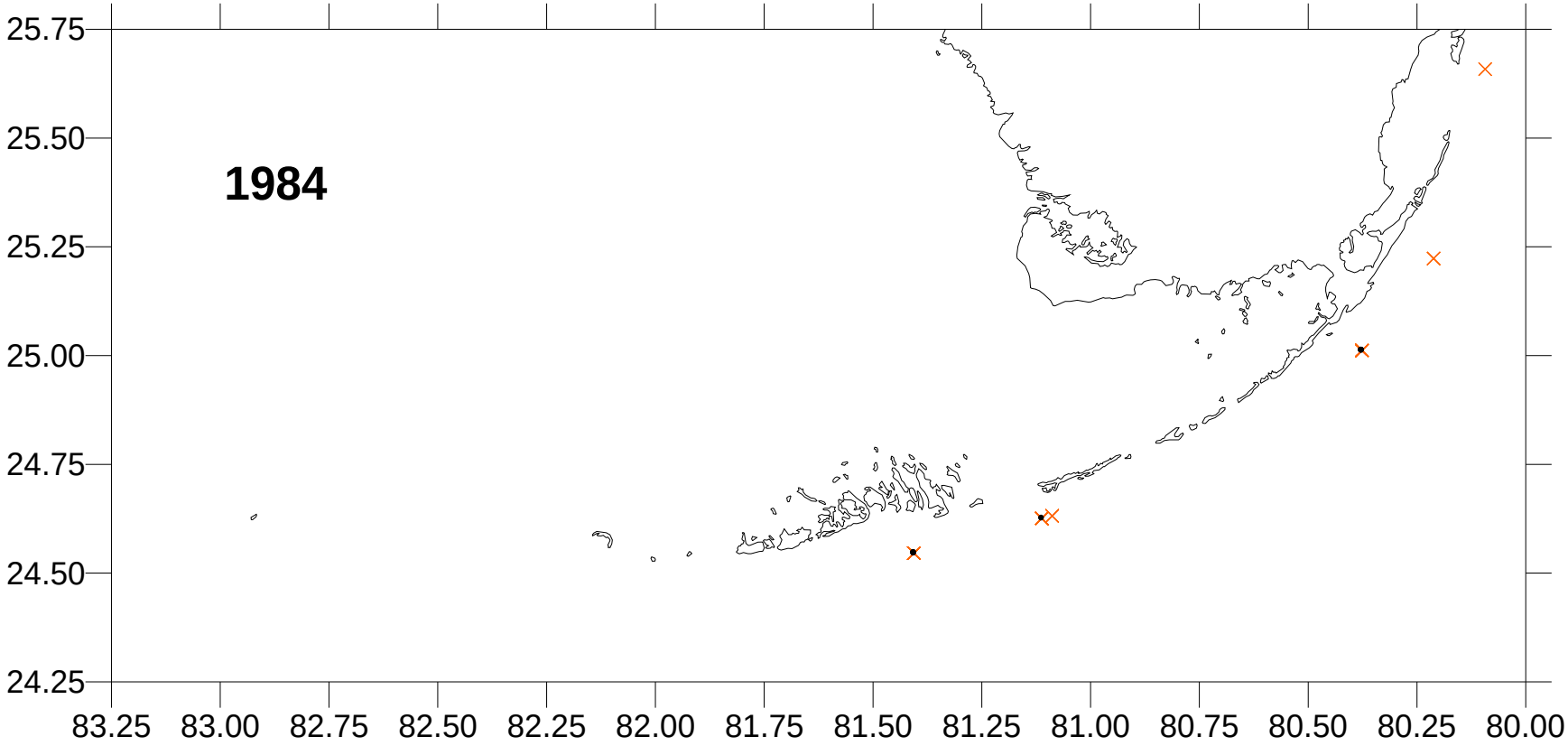
Florida Keys

Effort: 189 plots
Range of non-zero black grouper observations: 1
Range of non-zero red grouper observations: 0



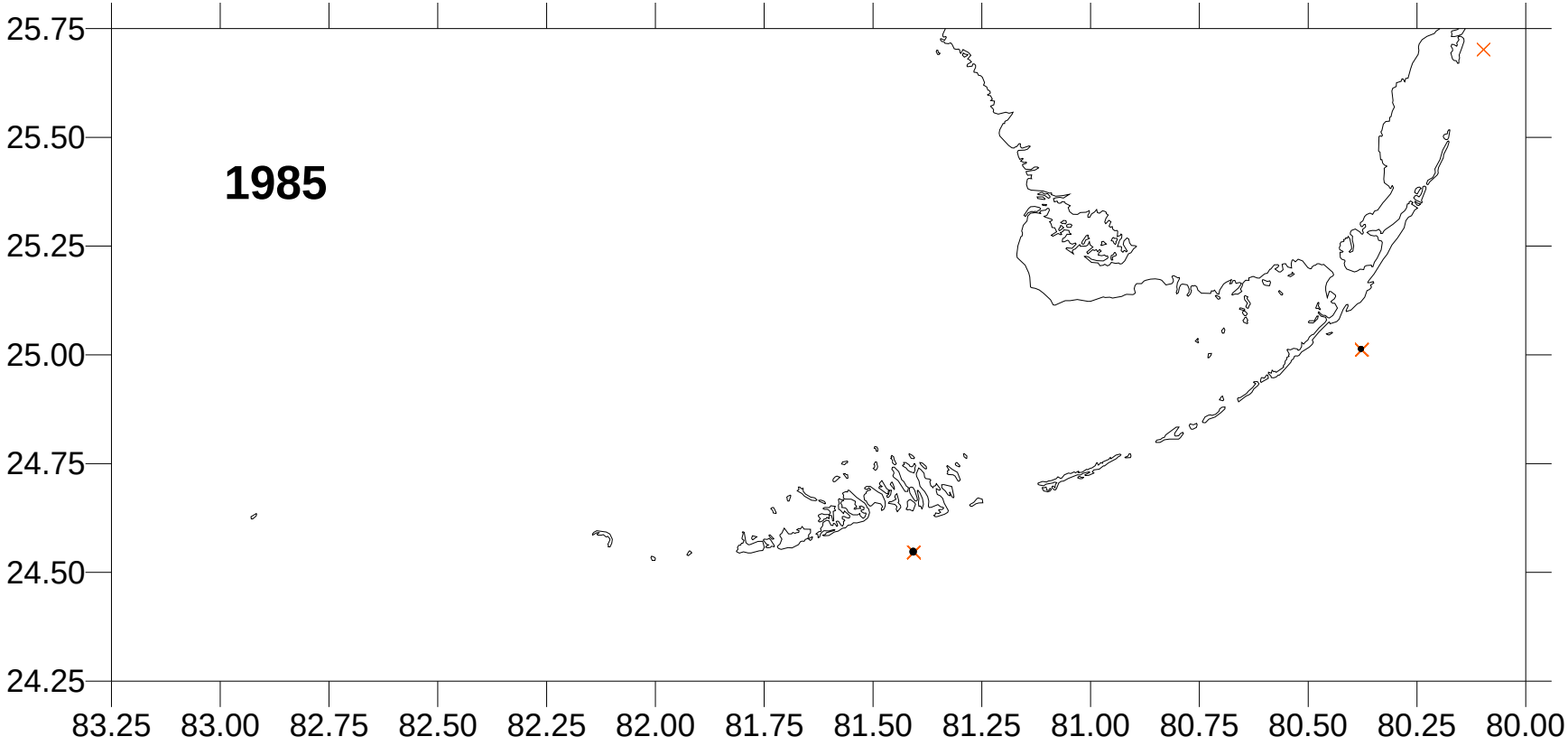
Florida Keys

Effort: 419 plots
Range of non-zero black grouper observations: 1
Range of non-zero red grouper observations: 1



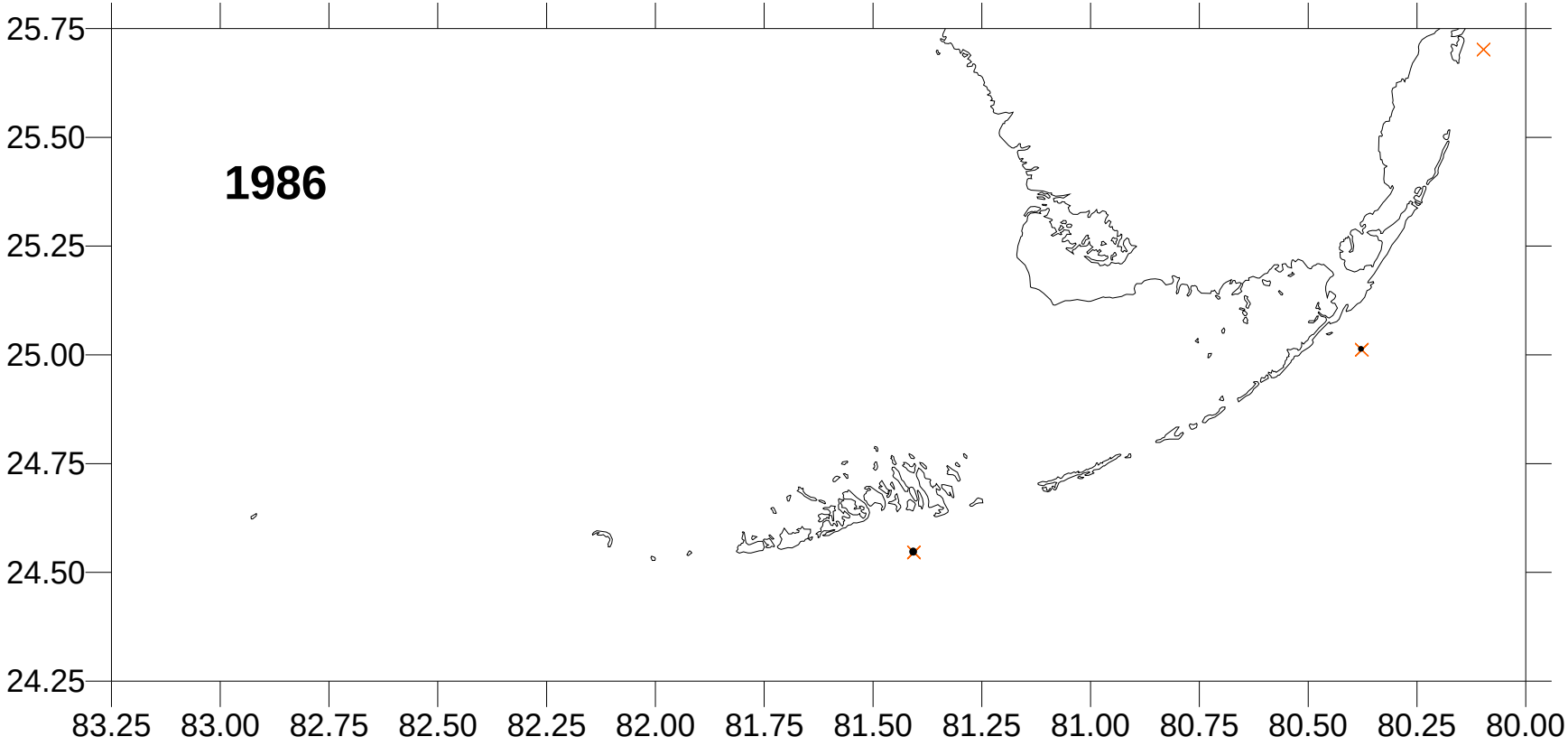
Florida Keys

Effort: 206 plots
Range of non-zero black grouper observations: 1
Range of non-zero red grouper observations: 0



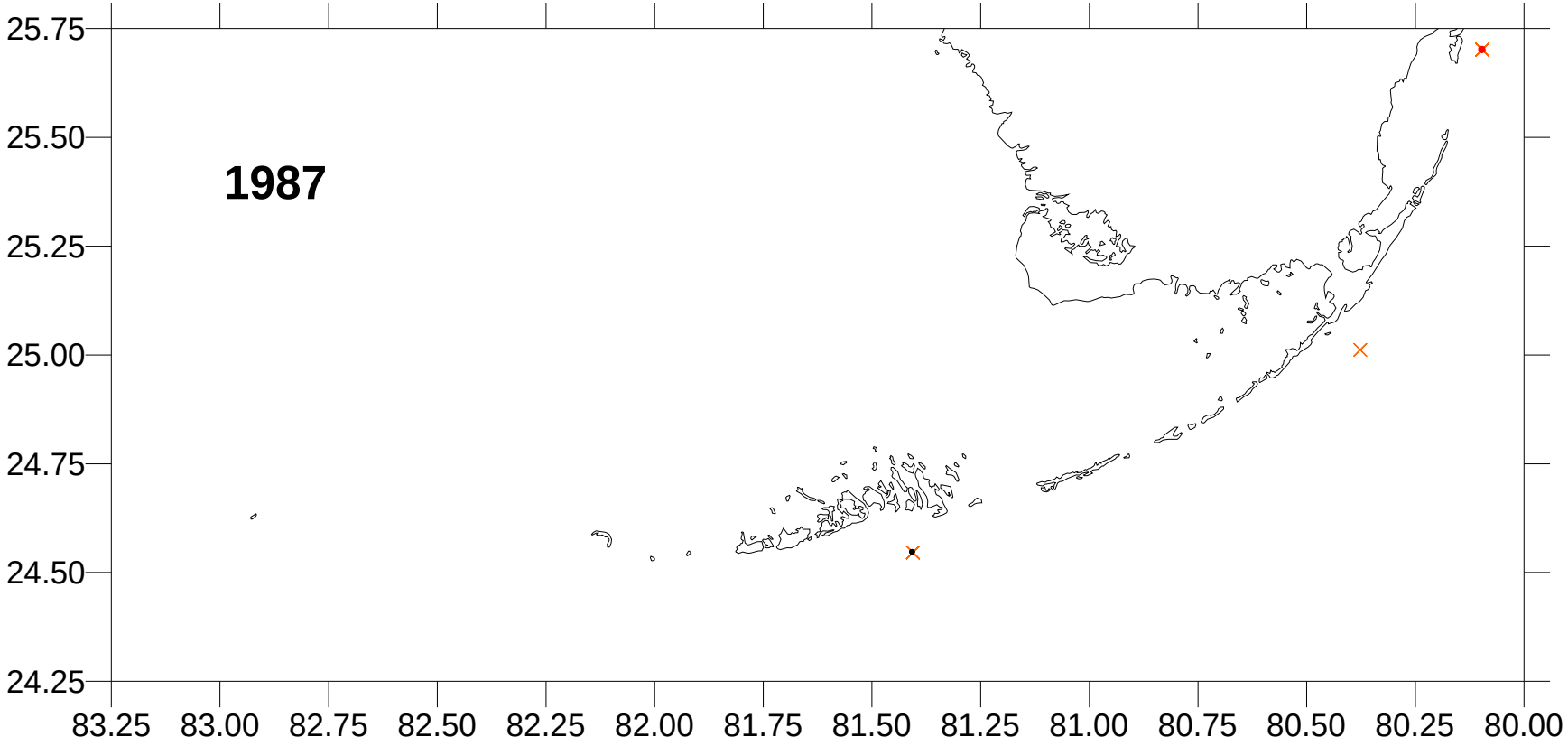
Florida Keys

Effort: 85 1 – 2 plots
Range of non-zero black grouper observations: 1 – 2
Range of non-zero red grouper observations: 0



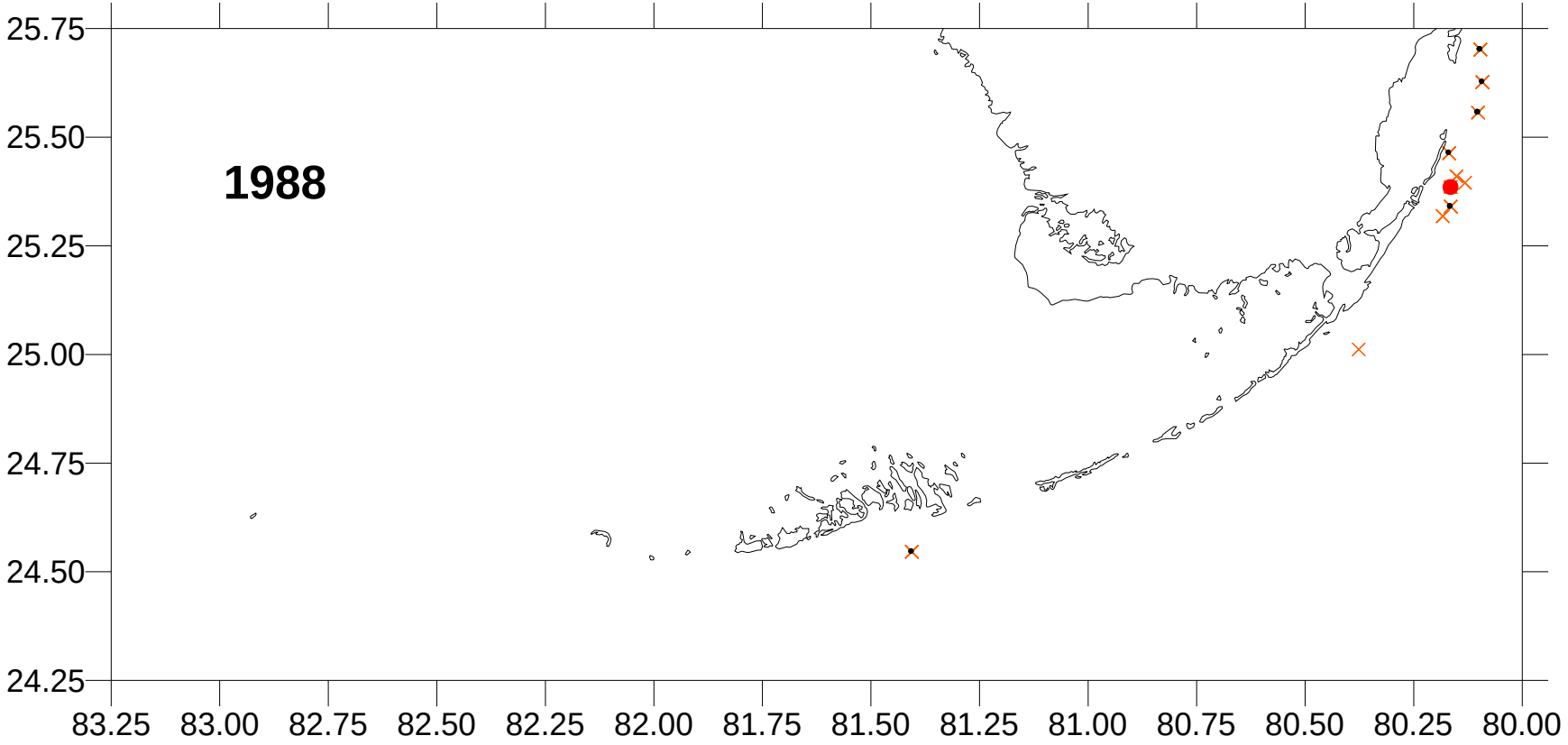
Florida Keys

Effort: 21 plots
Range of non-zero black grouper observations: 1 – 2
Range of non-zero red grouper observations: 0



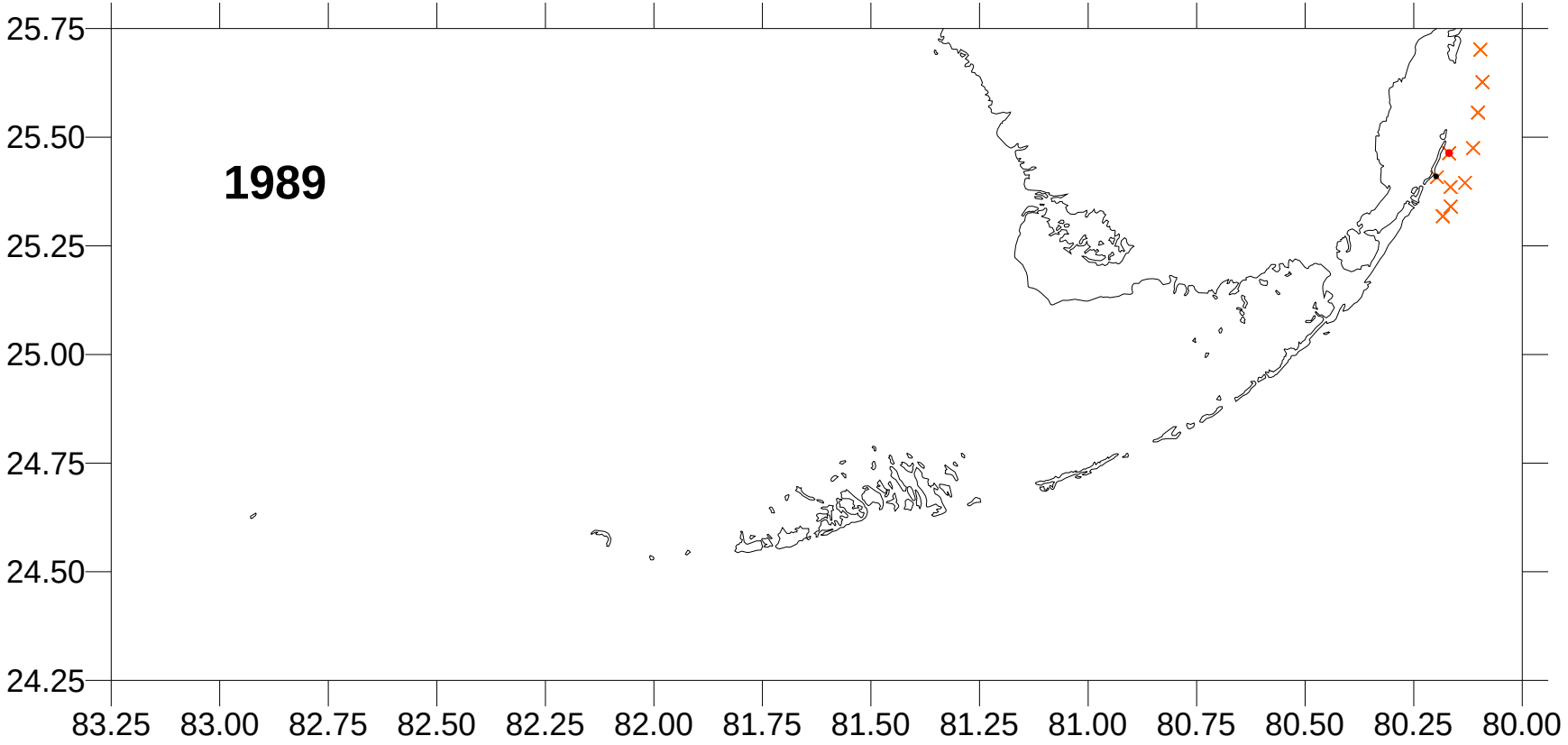
Florida Keys

Effort: 63 plots
Range of non-zero black grouper observations: 1
Range of non-zero red grouper observations: 1



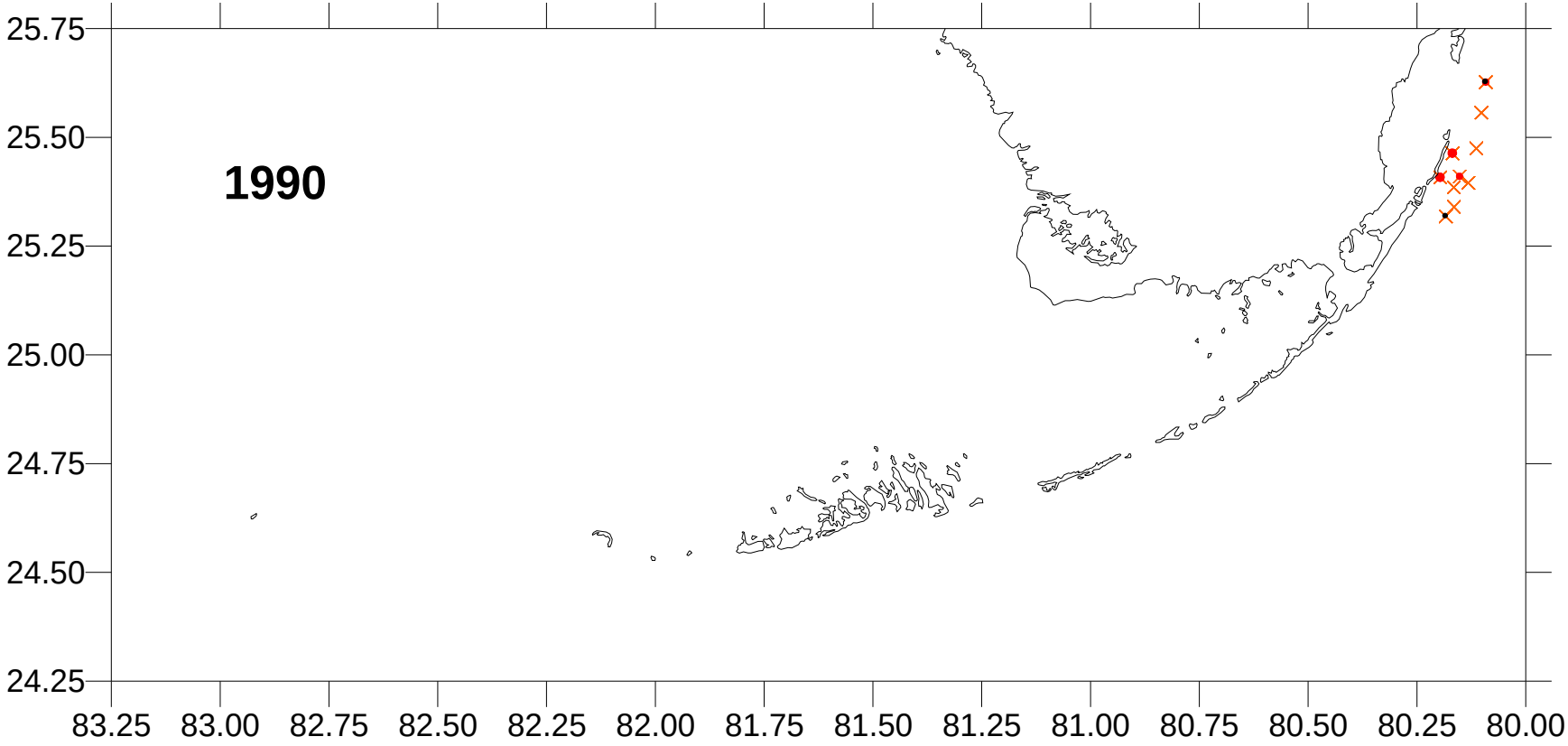
Florida Keys

Effort: 259 plots
Range of non-zero black grouper observations: 1
Range of non-zero red grouper observations: 5



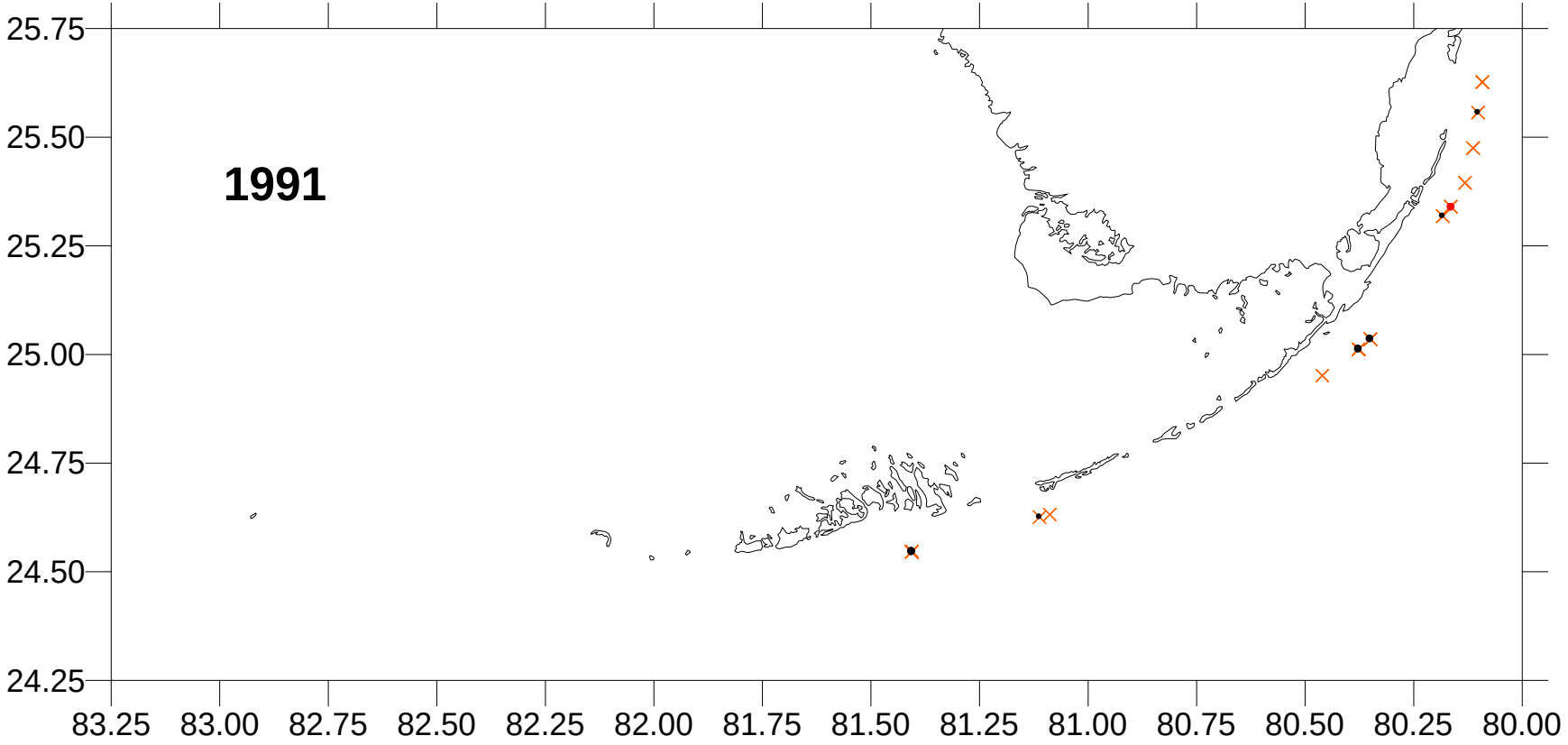
Florida Keys

Effort: 318 plots
Range of non-zero black grouper observations: 1
Range of non-zero red grouper observations: 1



Florida Keys

Effort: 282 plots
Range of non-zero black grouper observations: 1
Range of non-zero red grouper observations: 1 – 2

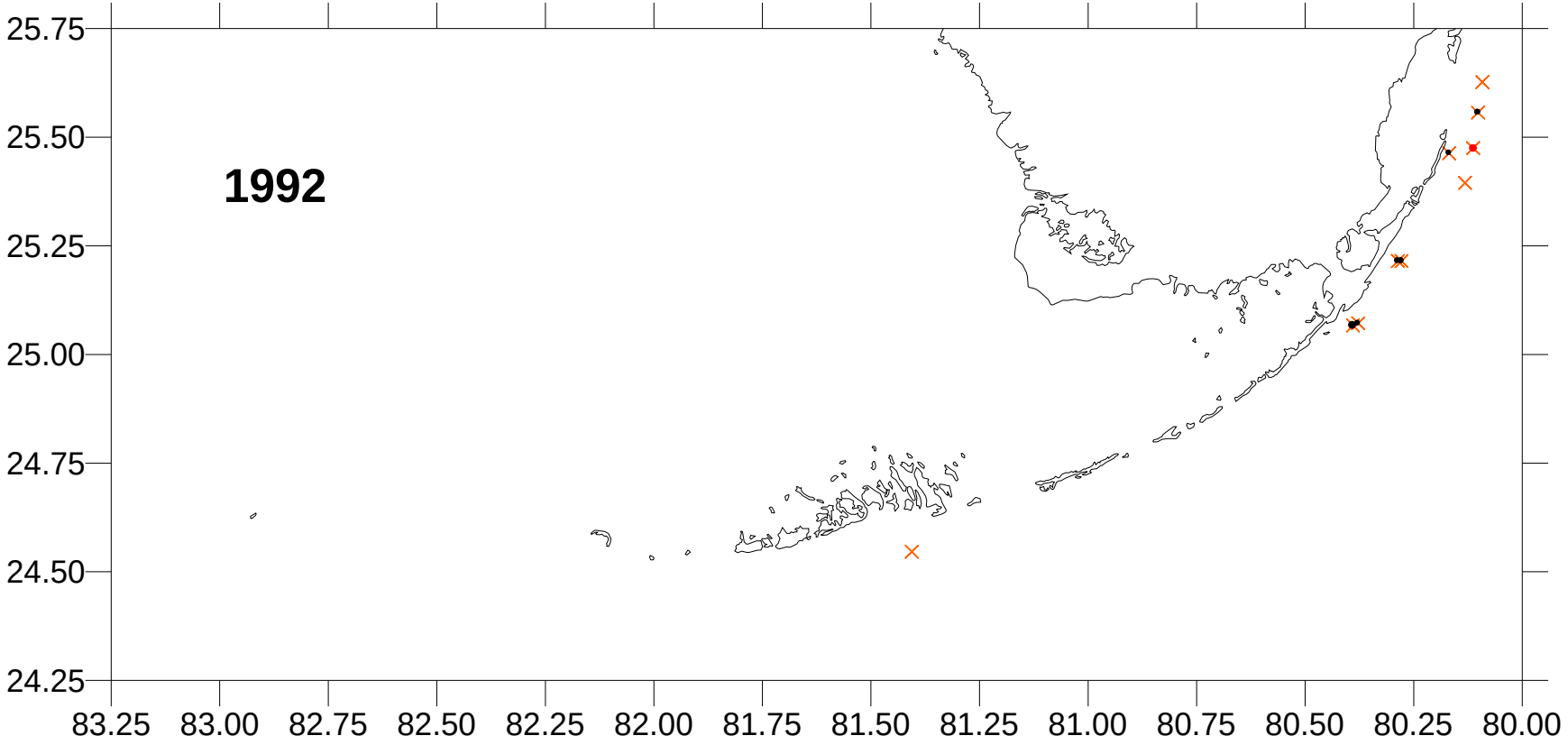


Florida Keys

Effort: 275 plots

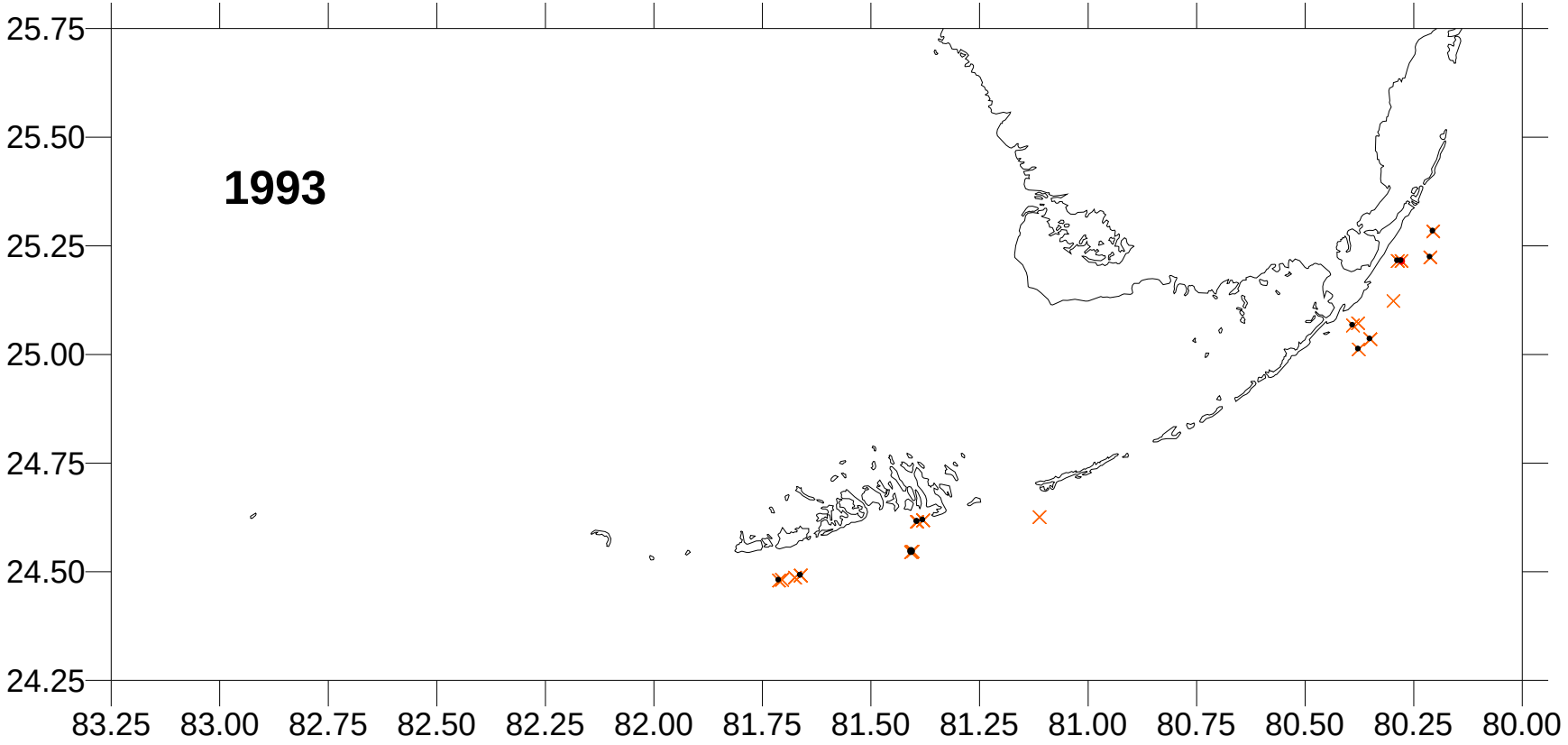
Range of non-zero black grouper observations: 1 – 2

Range of non-zero red grouper observations: 1



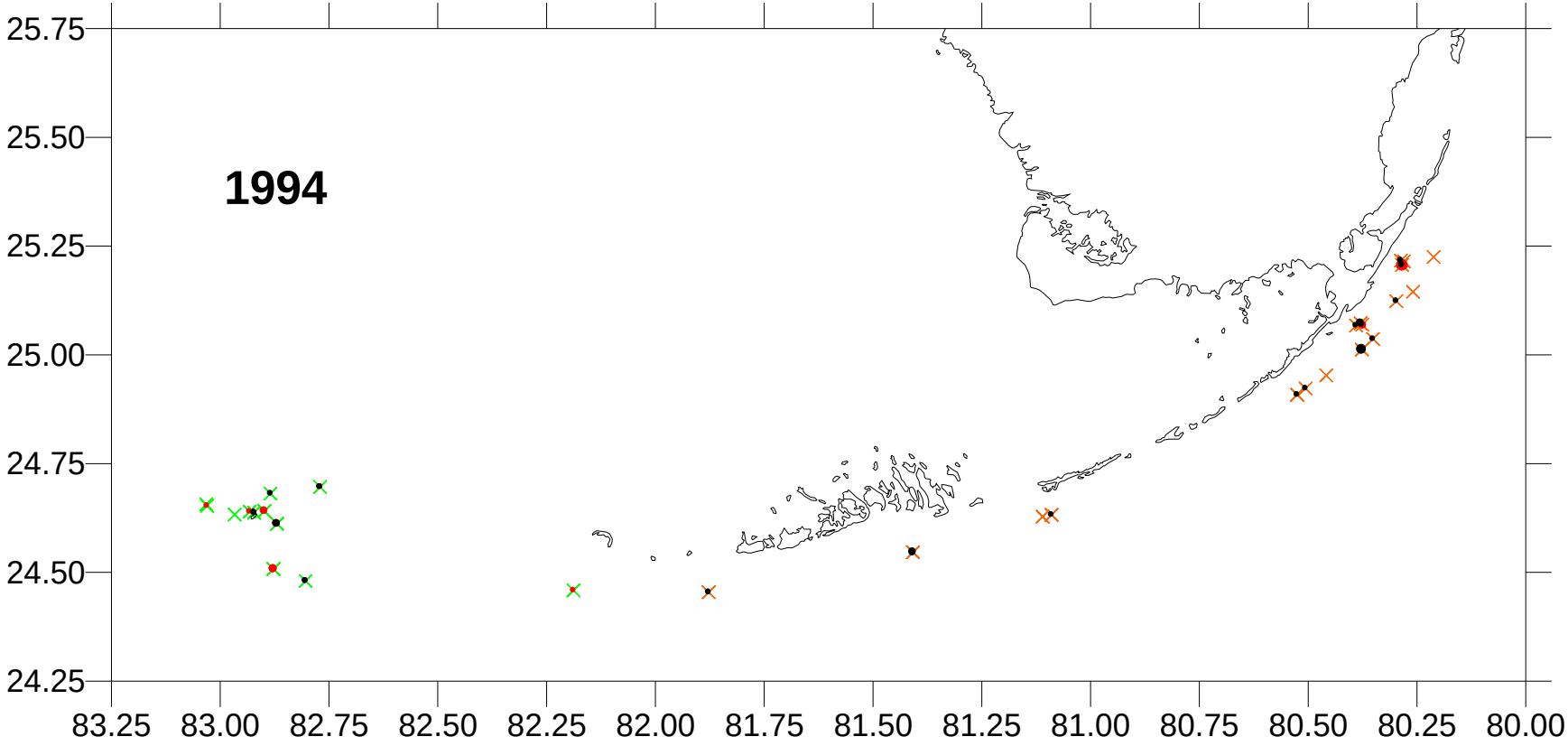
Florida Keys

Effort: 256 plots
Range of non-zero black grouper observations: 1 – 2
Range of non-zero red grouper observations: 1 – 2



Florida Keys

Effort: 259 plots
Range of non-zero black grouper observations: 1 – 2
Range of non-zero red grouper observations: 1



Florida Keys

Effort: 273 plots

Range of non-zero black grouper observations: 1 – 3

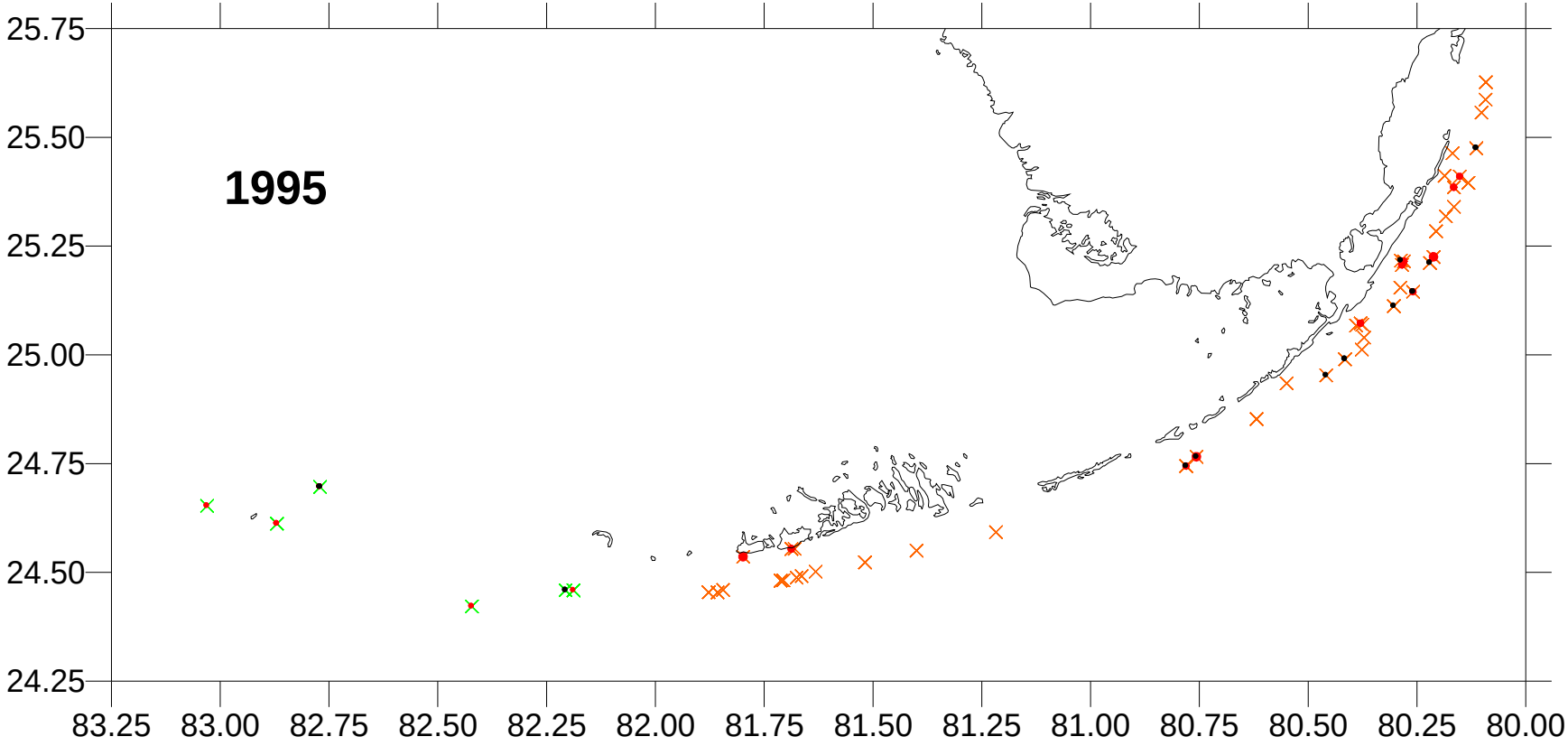
Range of non-zero red grouper observations: 1 – 3

Dry Tortugas

Effort: 188 plots

Range of non-zero black grouper observations: 1 – 2

Range of non-zero red grouper observations: 1 – 2

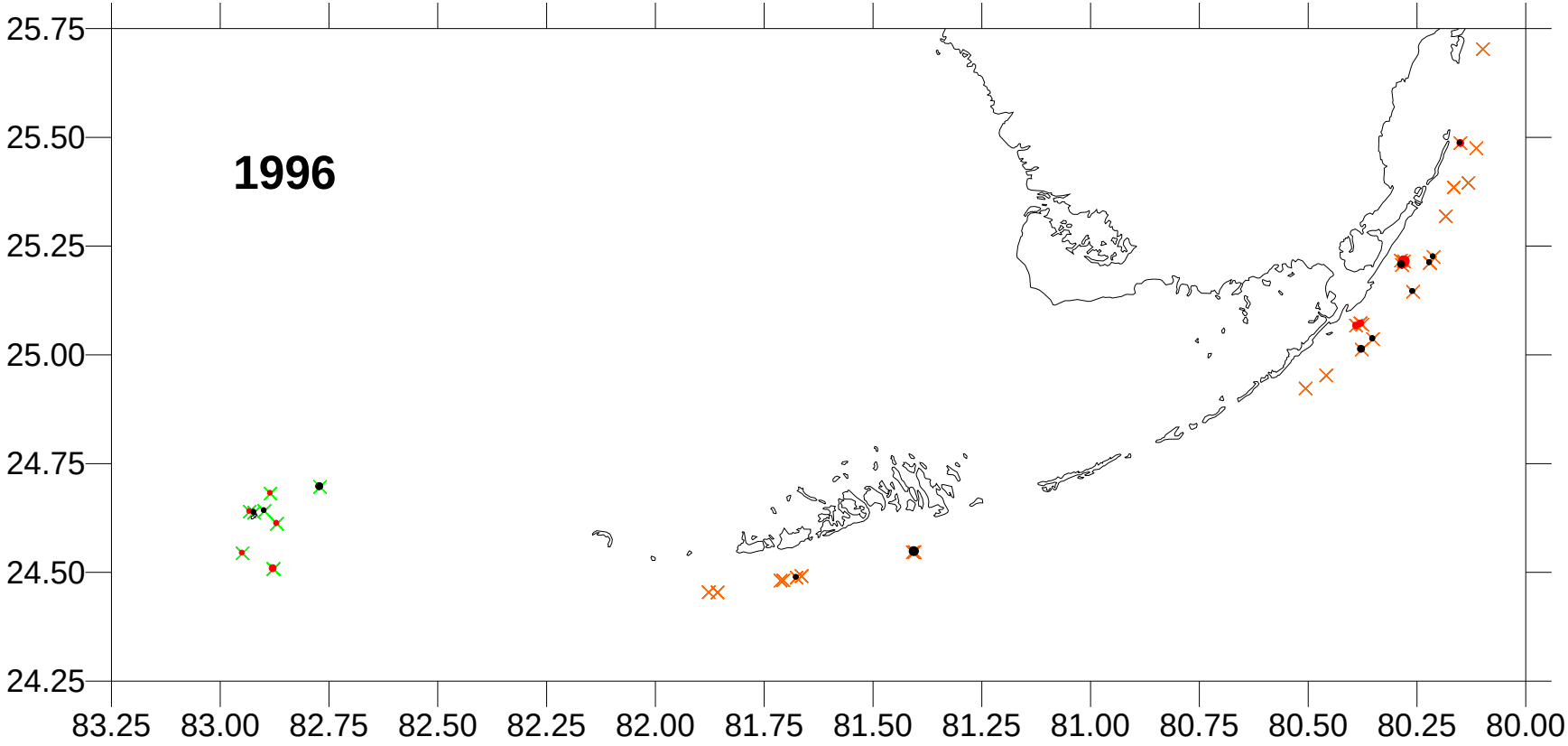


Florida Keys

Effort: 629 plots
Range of non-zero black grouper observations: 1
Range of non-zero red grouper observations: 1 – 2

Dry Tortugas

Effort: 75 plots
Range of non-zero black grouper observations: 1
Range of non-zero red grouper observations: 1



Florida Keys

Effort: 325 plots

Range of non-zero black grouper observations: 1 – 3

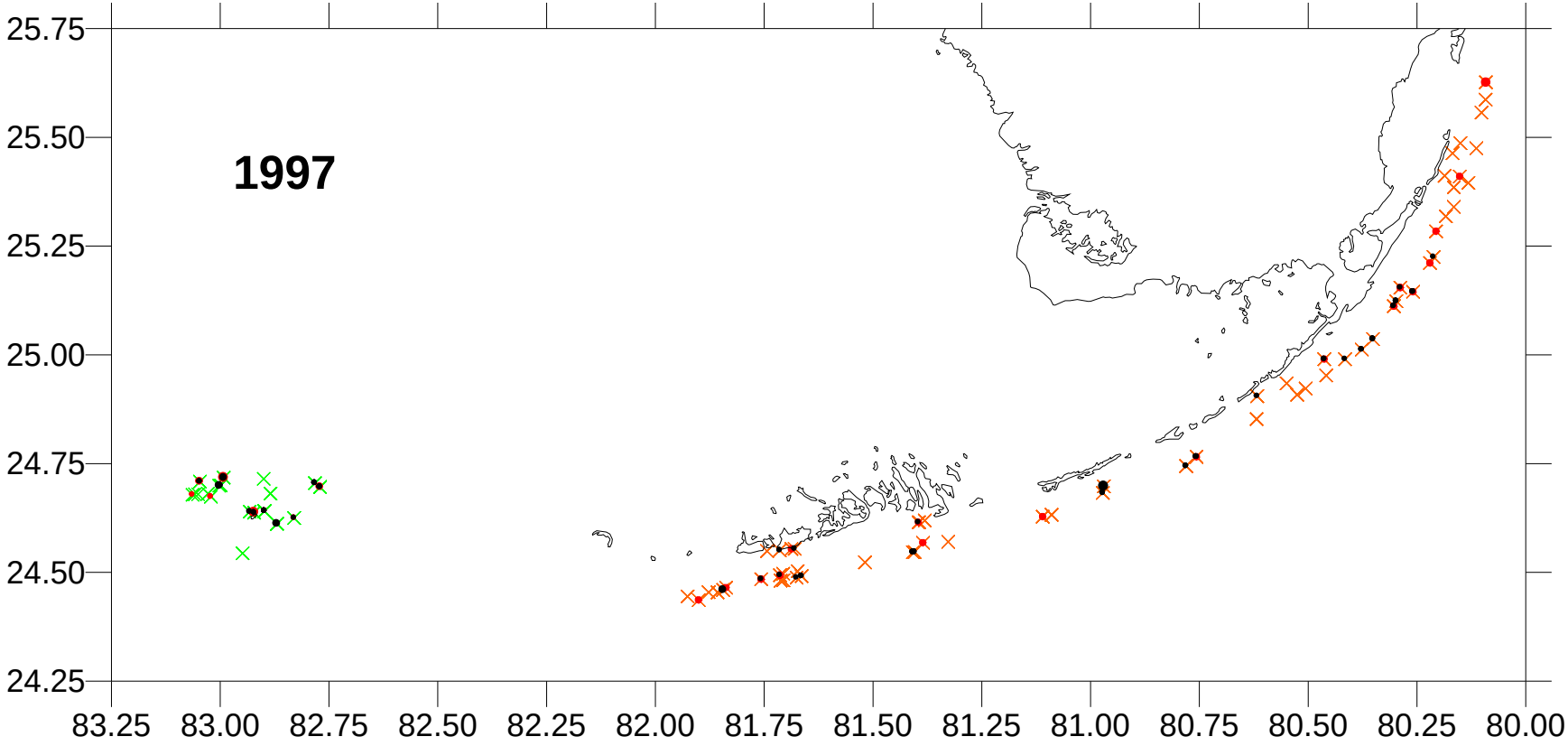
Range of non-zero red grouper observations: 1 – 3

Dry Tortugas

Effort: 100 plots

Range of non-zero black grouper observations: 1 – 2

Range of non-zero red grouper observations: 1 – 2



Florida Keys

Effort: 784 plots

Range of non-zero black grouper observations: 1 – 3

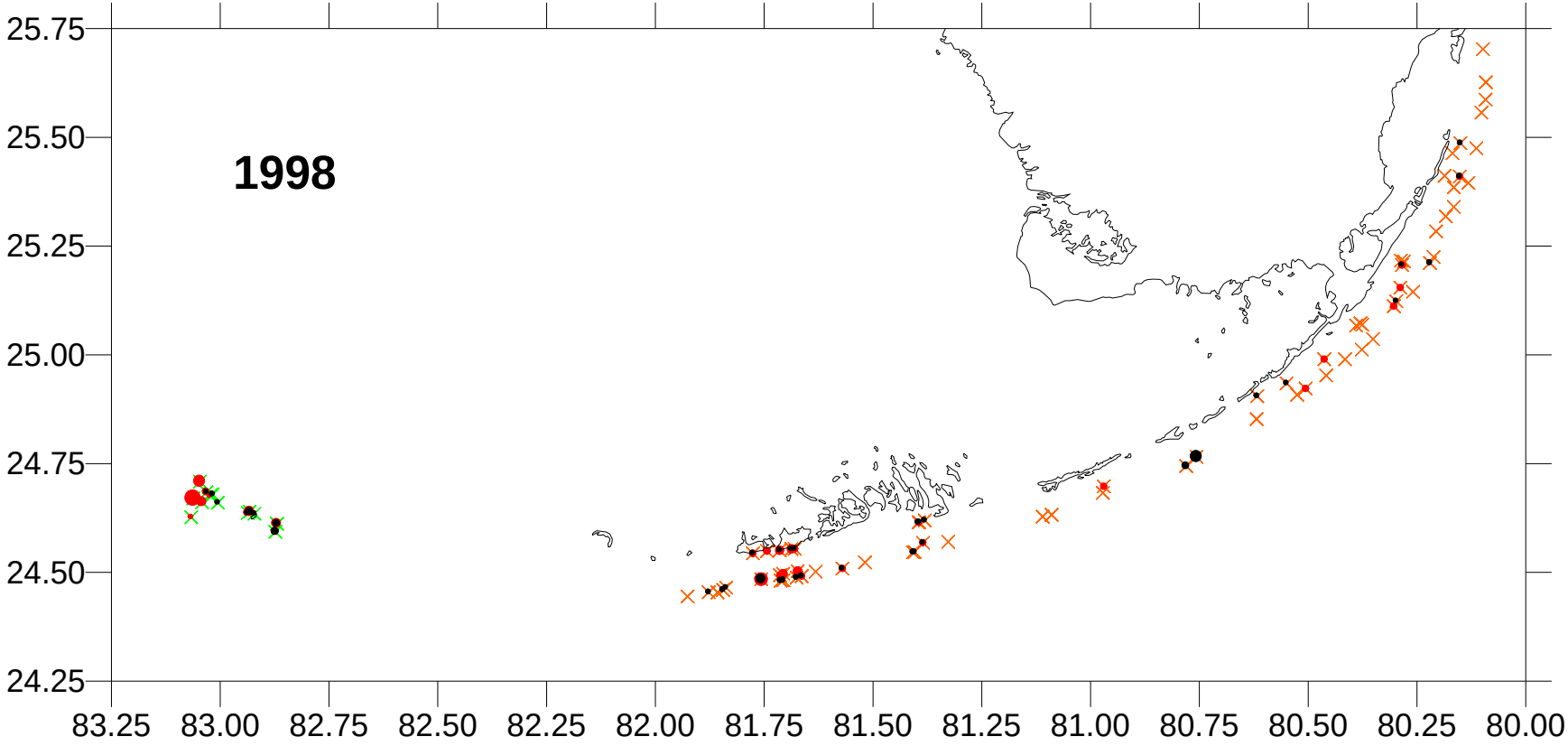
Range of non-zero red grouper observations: 1 – 2

Dry Tortugas

Effort: 209 plots

Range of non-zero black grouper observations: 1 – 2

Range of non-zero red grouper observations: 1 – 3



Florida Keys

Effort: 901 plots

Range of non-zero black grouper observations: 1 – 4

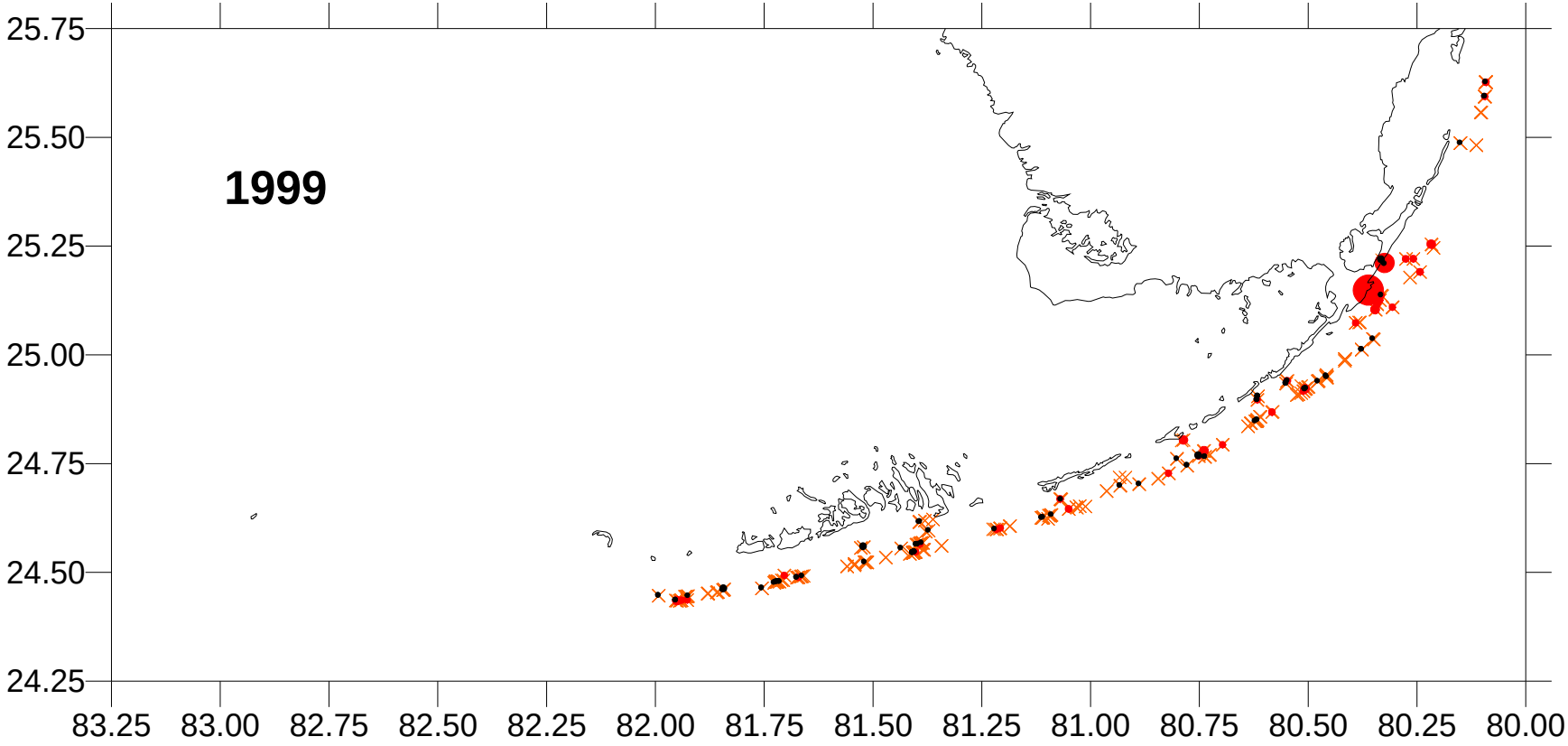
Range of non-zero red grouper observations: 1 – 4

Dry Tortugas

Effort: 146 plots

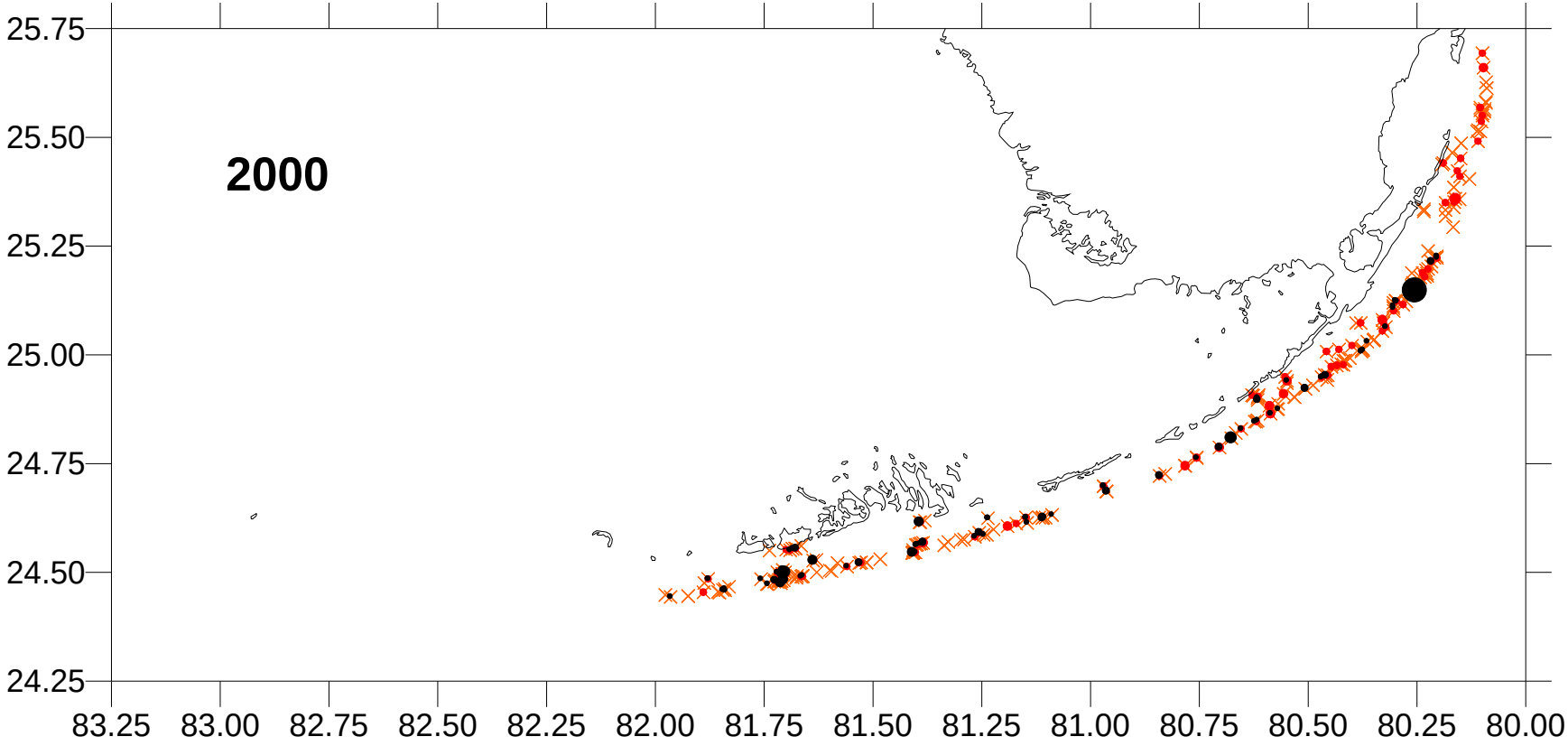
Range of non-zero black grouper observations: 1 – 2

Range of non-zero red grouper observations: 1 – 6



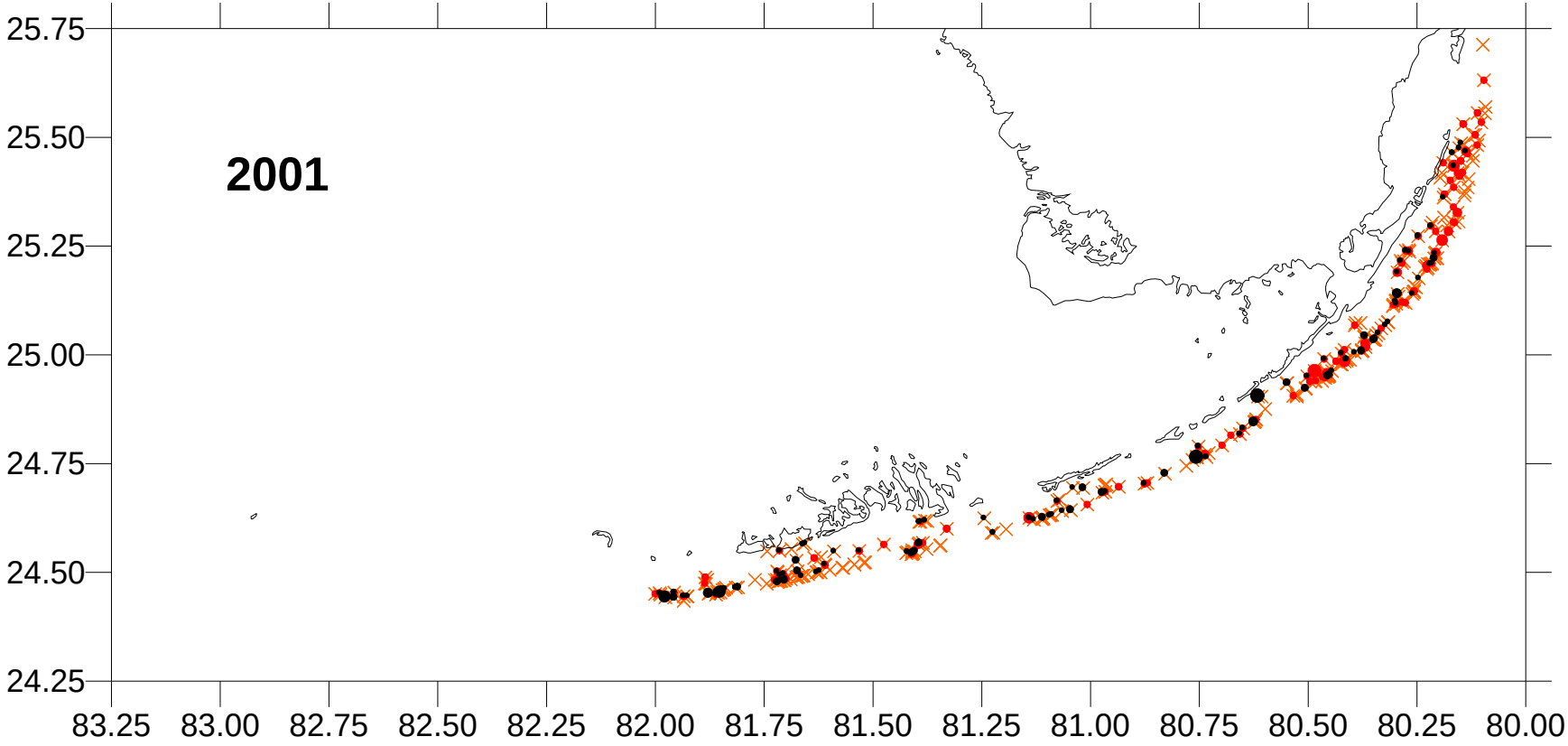
Florida Keys

Effort: 677 plots
Range of non-zero black grouper observations: 1 – 2
Range of non-zero red grouper observations: 1 – 12



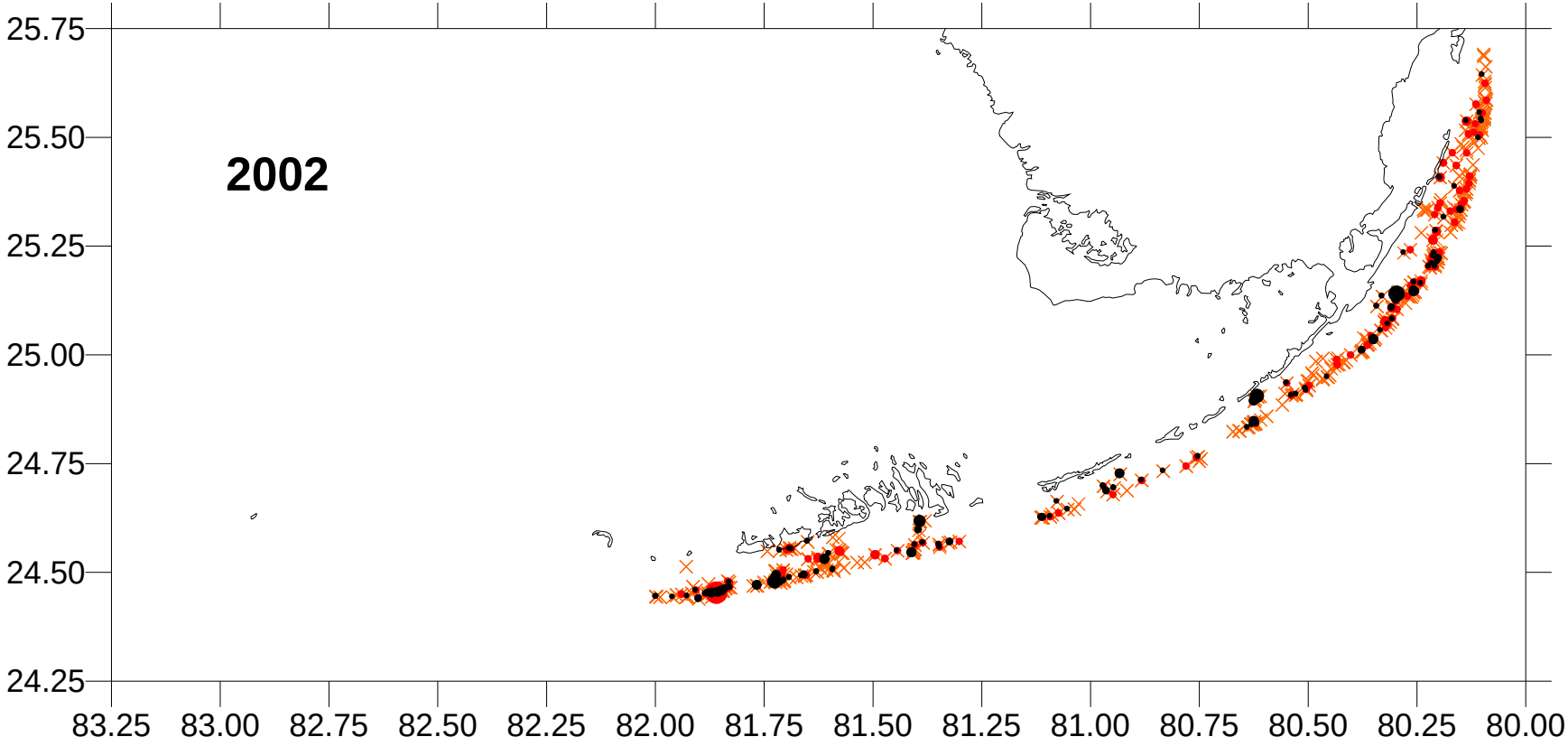
Florida Keys

Effort: 842 plots
Range of non-zero black grouper observations: 1 – 10
Range of non-zero red grouper observations: 1 – 3



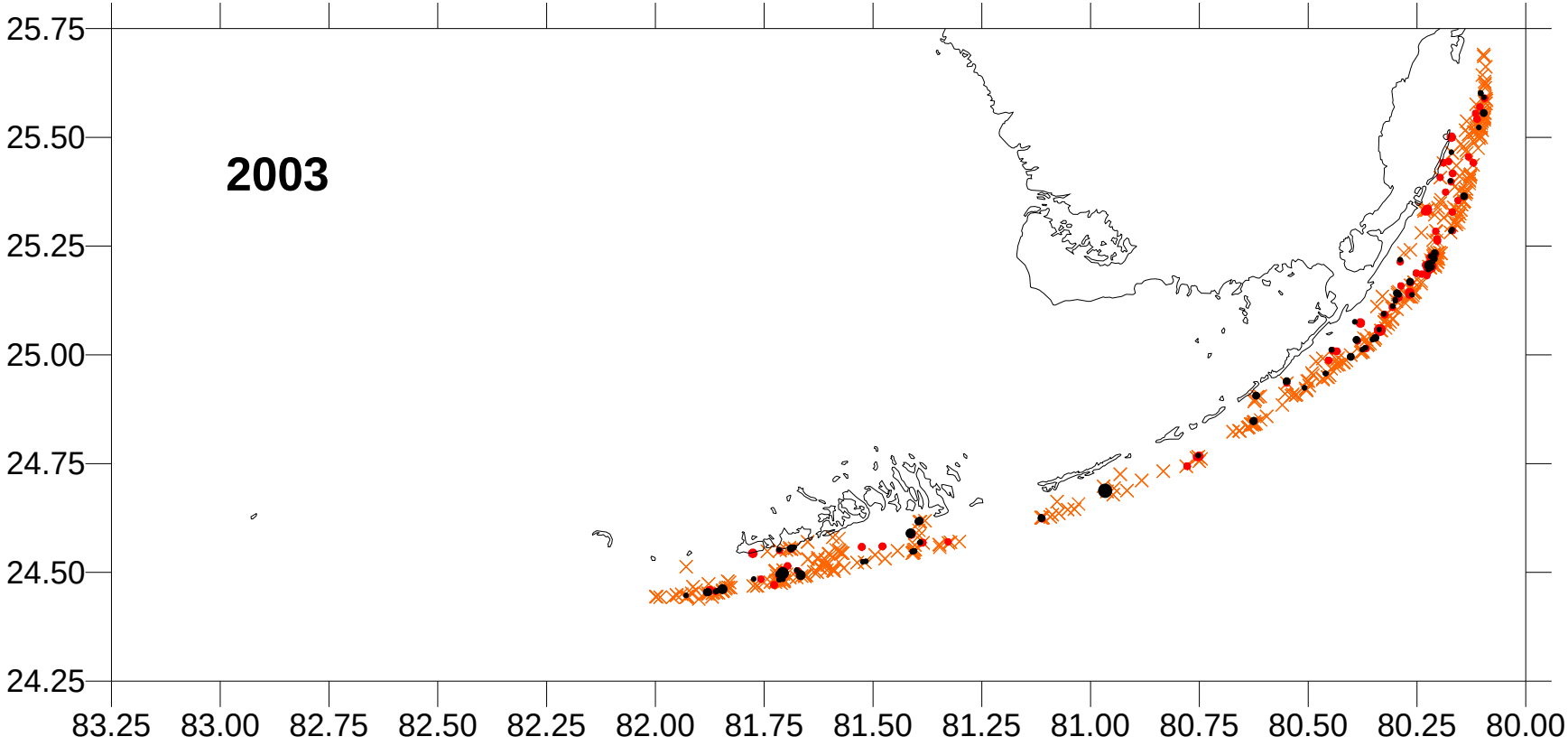
Florida Keys

Effort: 1185 plots
Range of non-zero black grouper observations: 1 – 5
Range of non-zero red grouper observations: 1 – 4



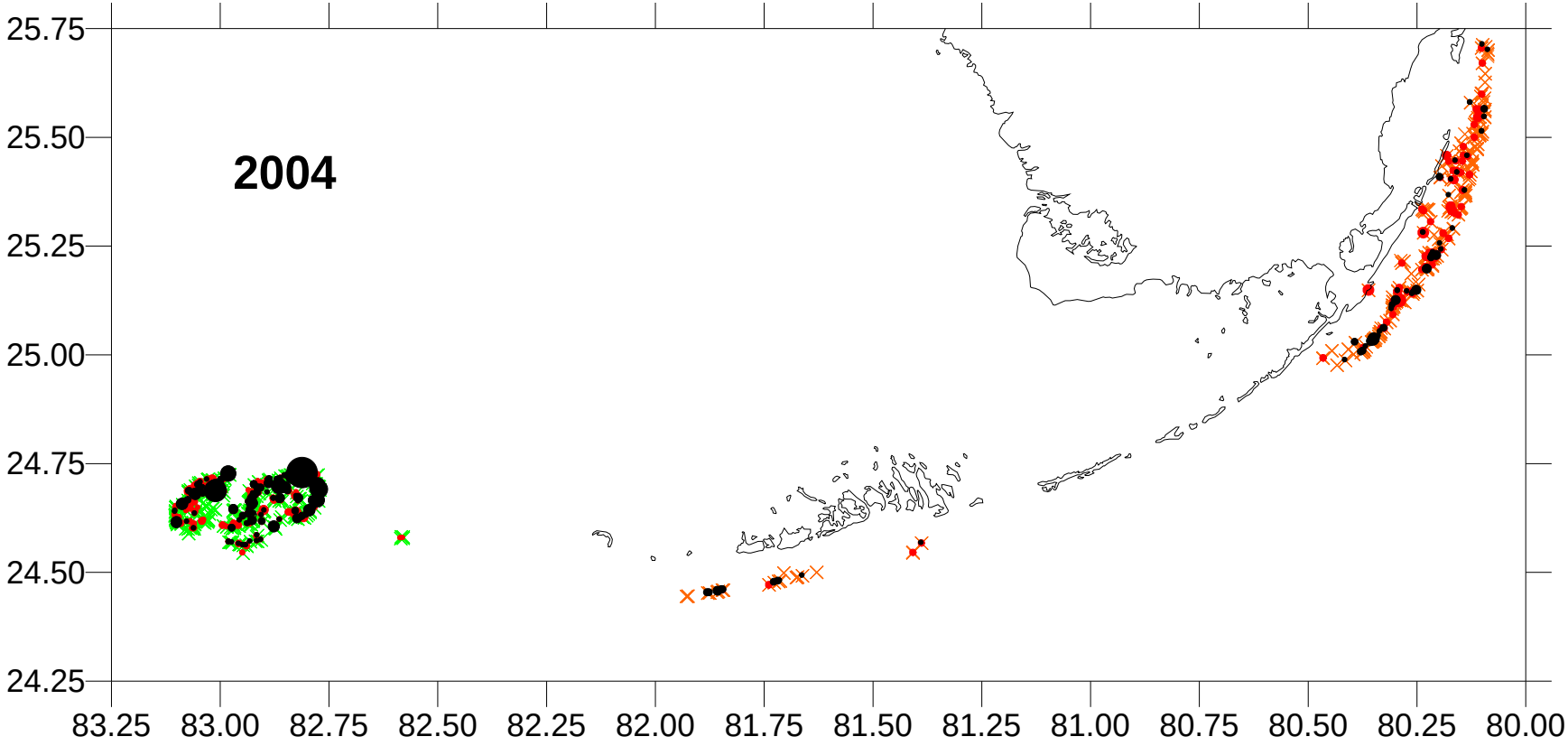
Florida Keys

Effort: 999 plots
Range of non-zero black grouper observations: 1 – 6
Range of non-zero red grouper observations: 1 – 8



Florida Keys

Effort: 908 plots
Range of non-zero black grouper observations: 1 – 5
Range of non-zero red grouper observations: 1 – 4



Florida Keys

Effort: 796 plots

Range of non-zero black grouper observations: 1 – 4

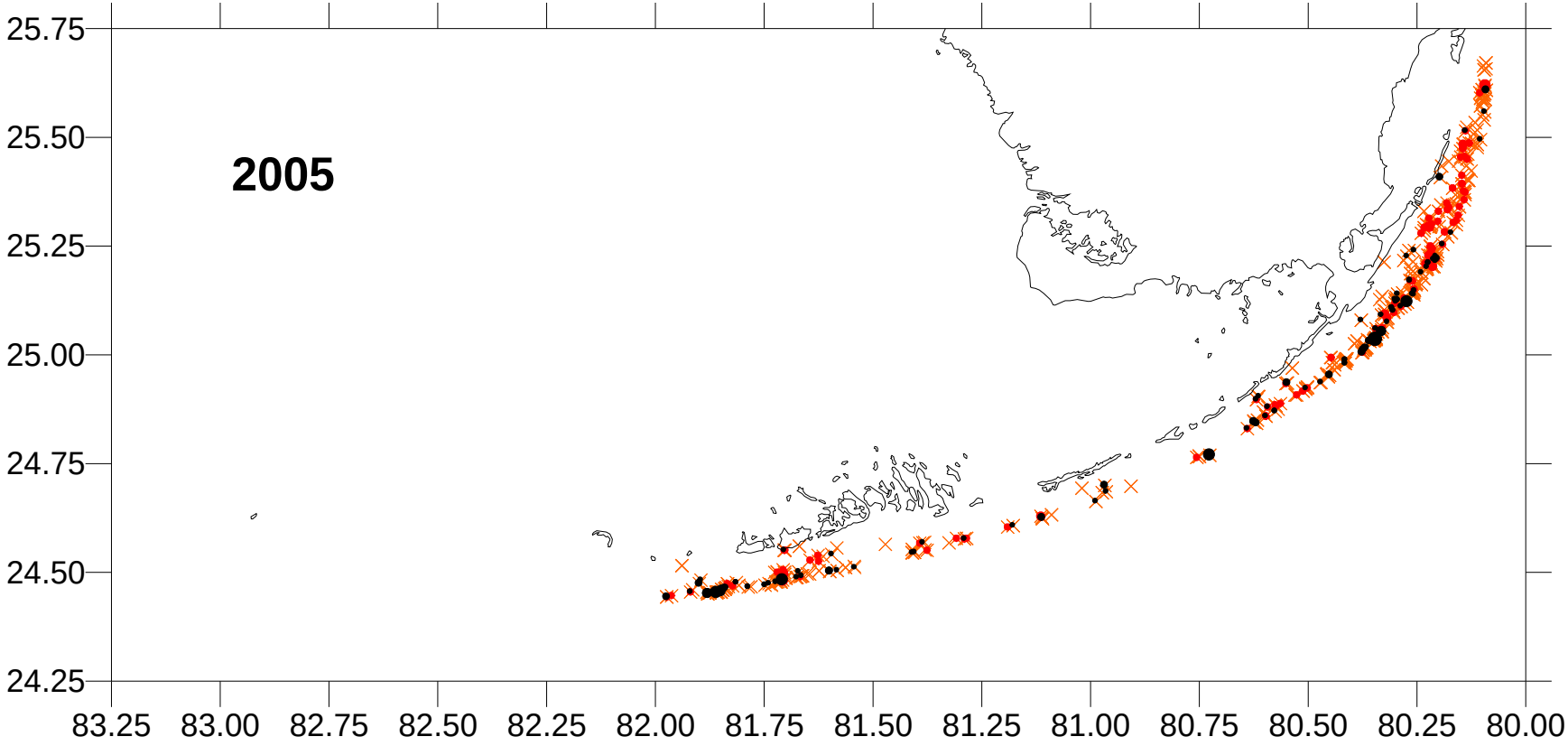
Range of non-zero red grouper observations: 1 – 4

Dry Tortugas

Effort: 1137 plots

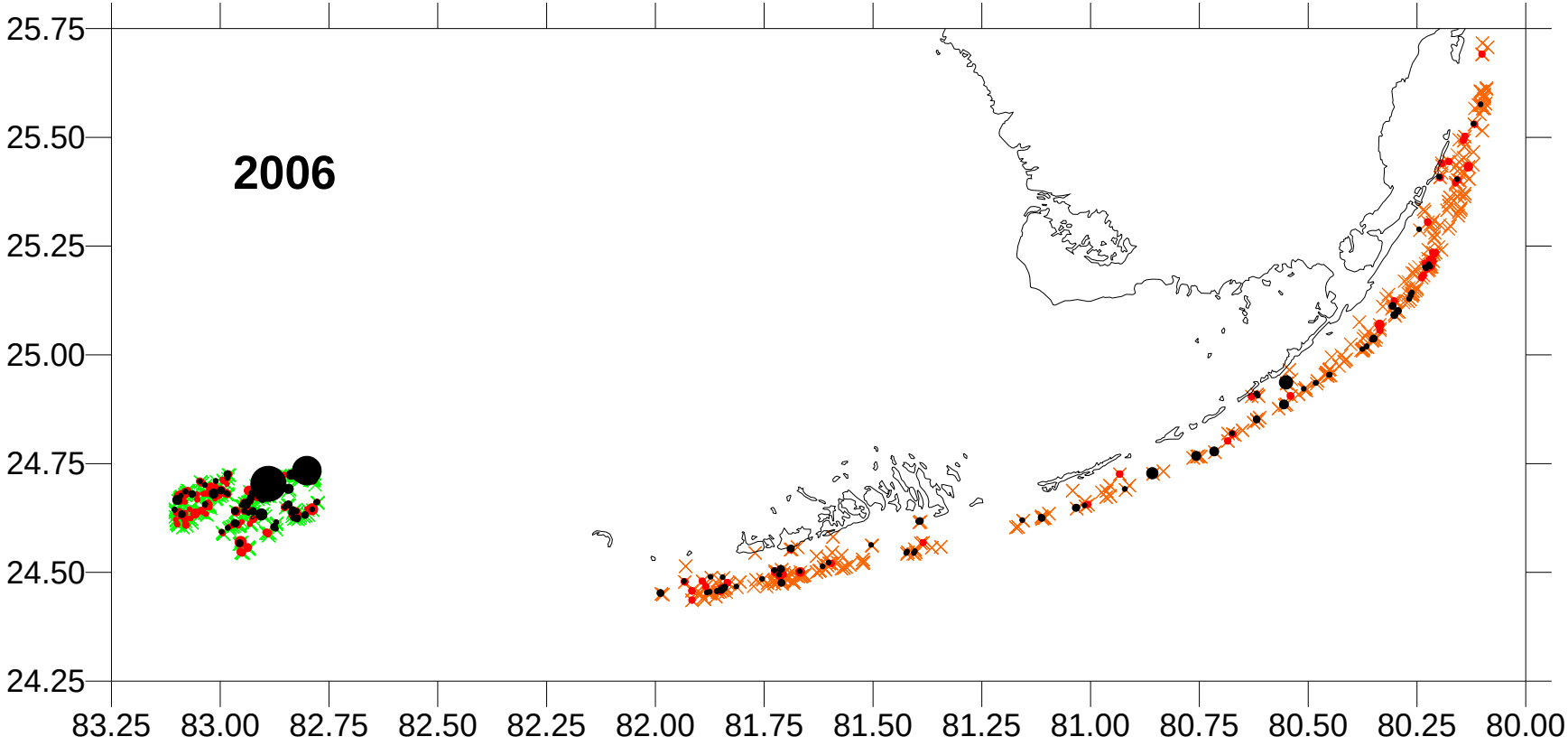
Range of non-zero black grouper observations: 1 – 13

Range of non-zero red grouper observations: 1 – 8



Florida Keys

Effort: 1124 plots
Range of non-zero black grouper observations: 1 – 5
Range of non-zero red grouper observations: 1 – 3



Florida Keys

Effort: 1039 plots

Range of non-zero black grouper observations: 1 – 5

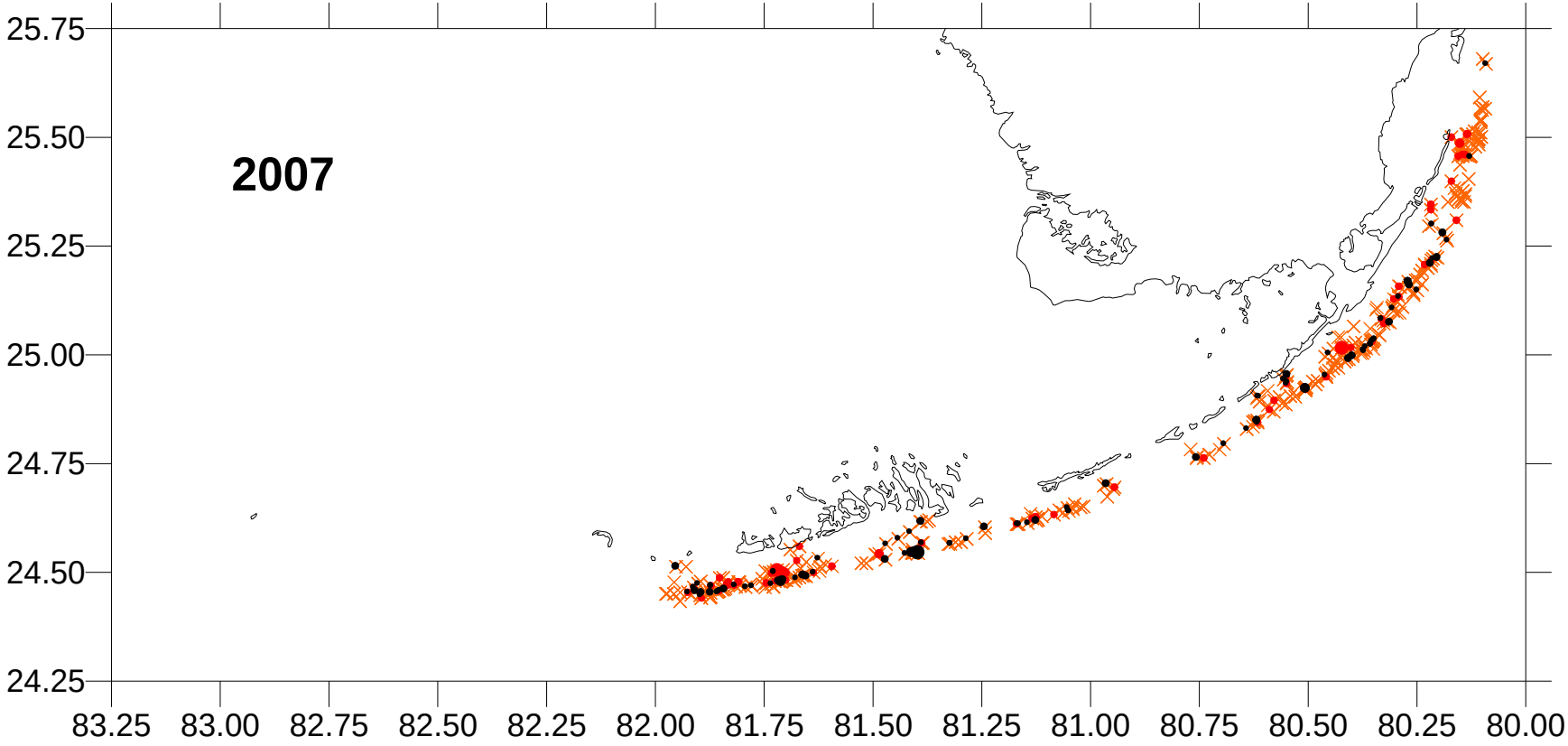
Range of non-zero red grouper observations: 1 – 2

Dry Tortugas

Effort: 952 plots

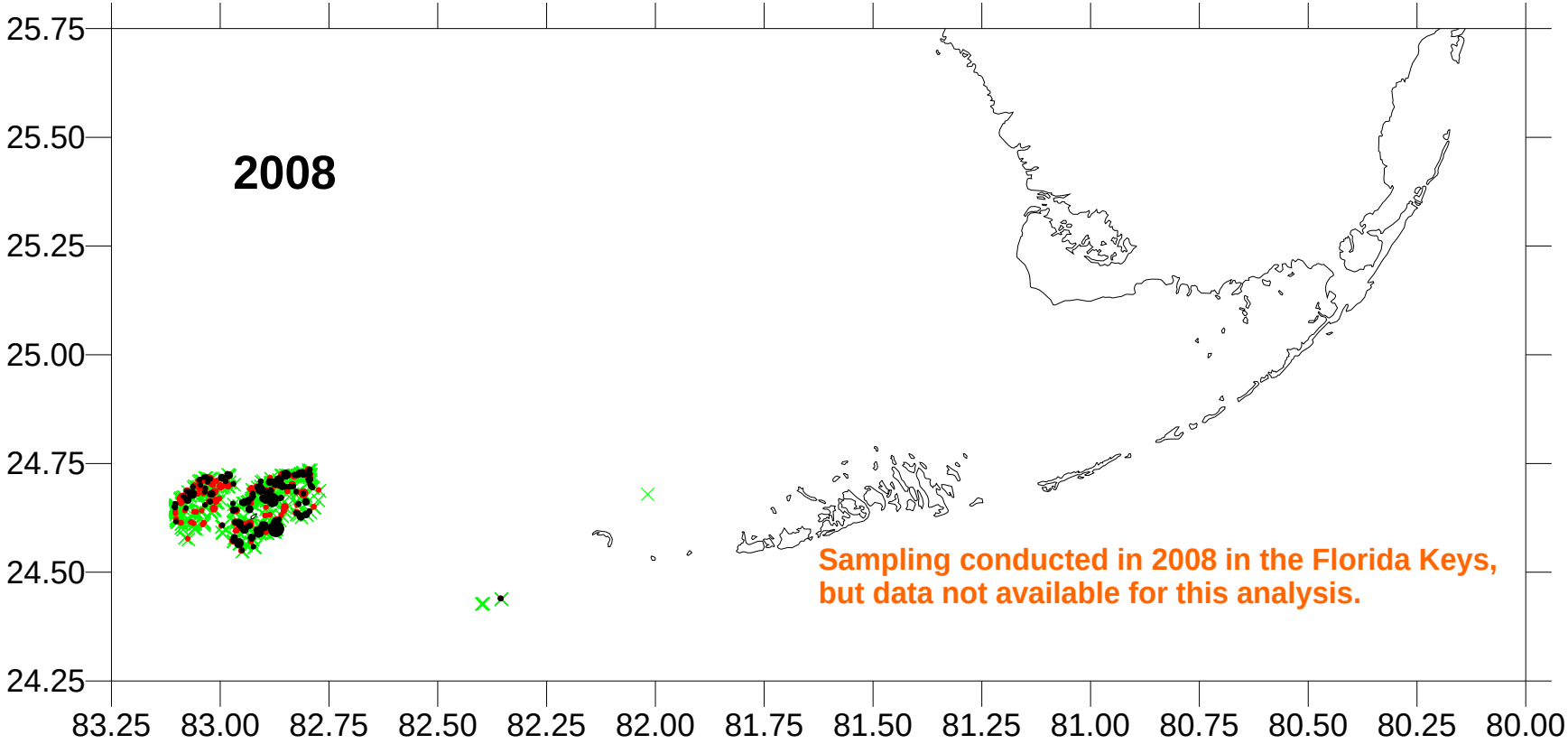
Range of non-zero black grouper observations: 1 – 15

Range of non-zero red grouper observations: 1 – 4



Florida Keys

Effort: 1236 plots
Range of non-zero black grouper observations: 1 – 5
Range of non-zero red grouper observations: 1 – 4



Florida Keys

Effort: not available
Range of non-zero black grouper observations: not available
Range of non-zero red grouper observations: not available

Dry Tortugas

Effort: 1198 plots
Range of non-zero black grouper observations: 1 – 6
Range of non-zero red grouper observations: 1 – 3

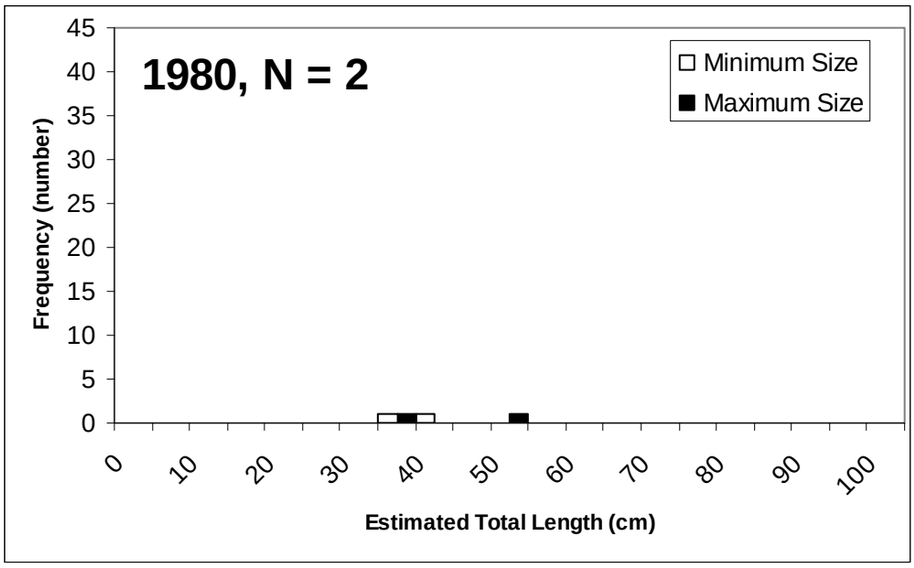
Appendix 3:

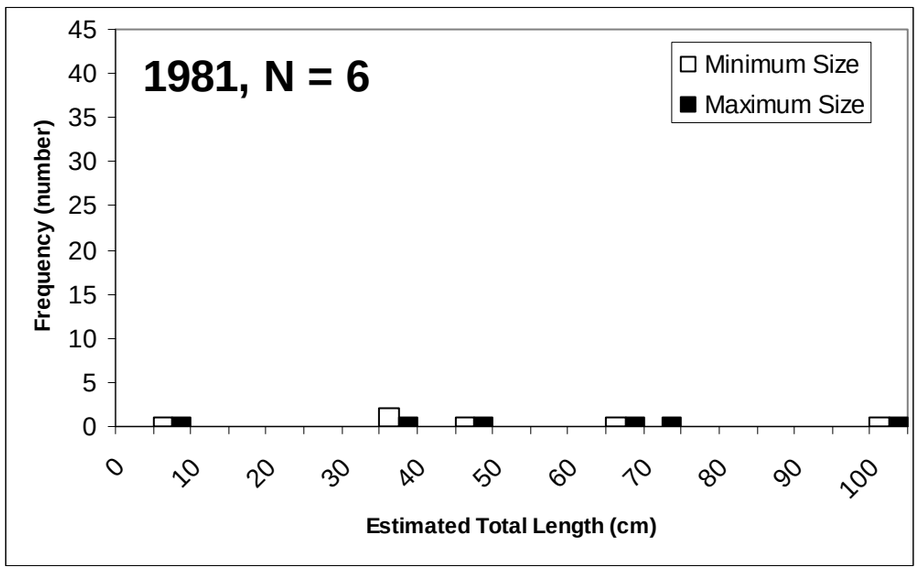
Length frequencies of black and red grouper observed during the RVC for both the Florida Keys (1979 – 2007) and Dry Tortugas (1994 – 2008).

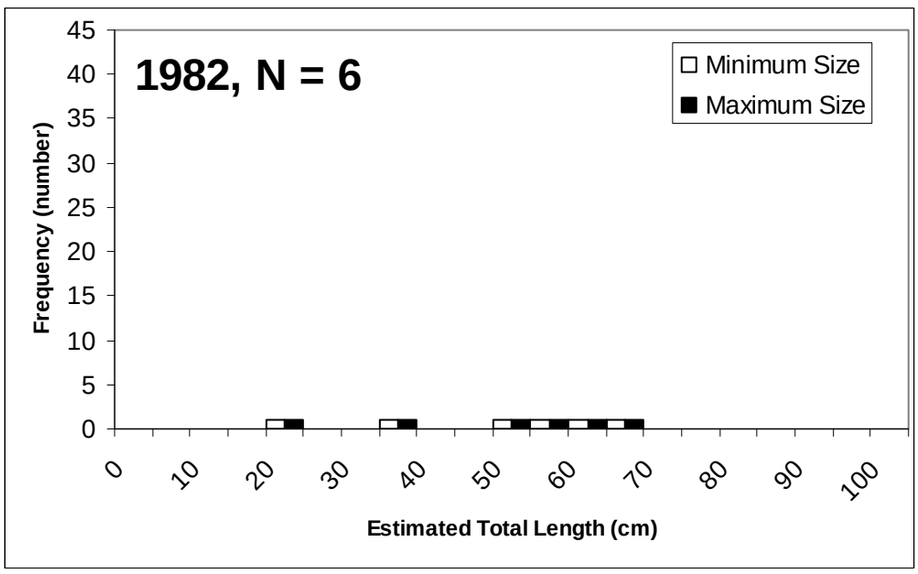
Minimum and maximum lengths for each observed fish is recorded. Therefore, each fish has two estimated lengths. Both the minimum and maximum lengths are included on the following length frequency histograms, and N is the number of fish for which minimum and maximum lengths were estimated per year.

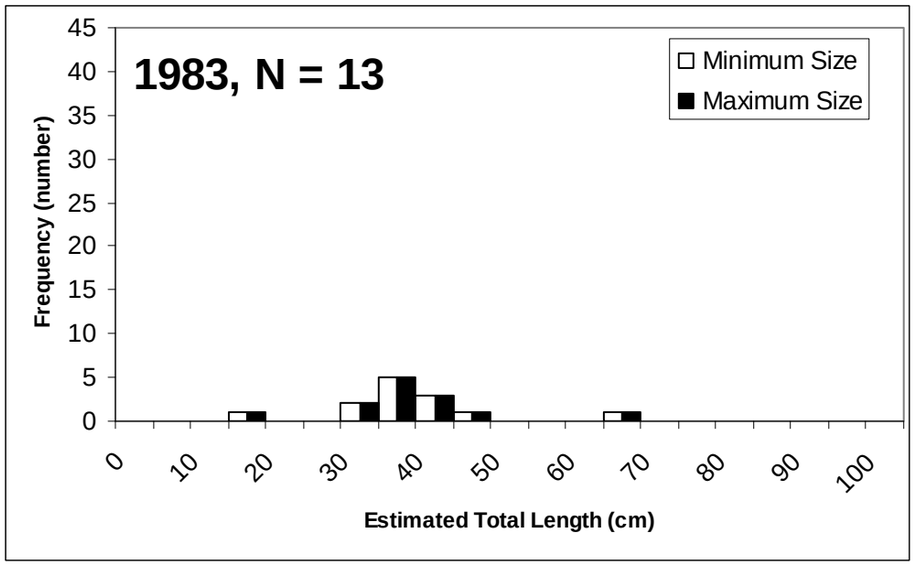
Appendix 3a:

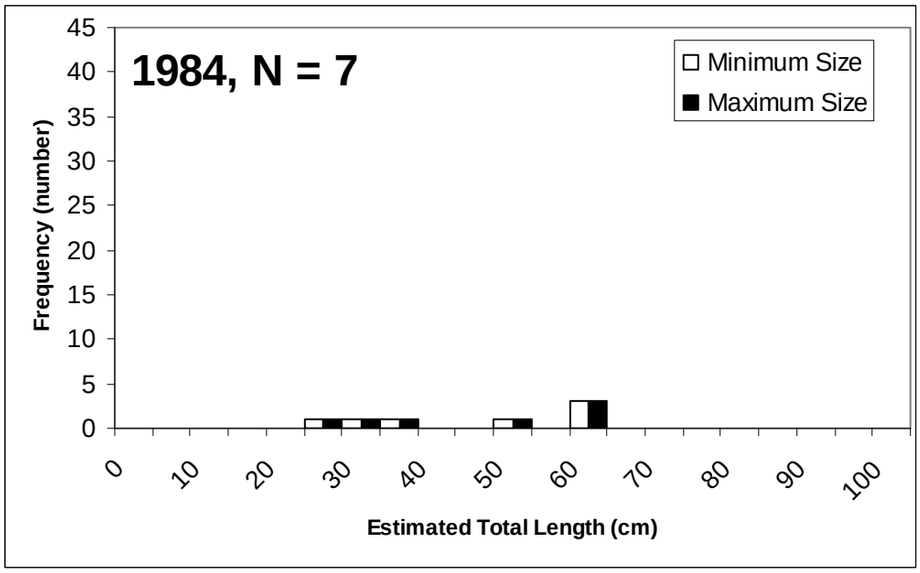
Length frequencies of black grouper observed in the Florida Keys during the RVC (1979 – 2007).

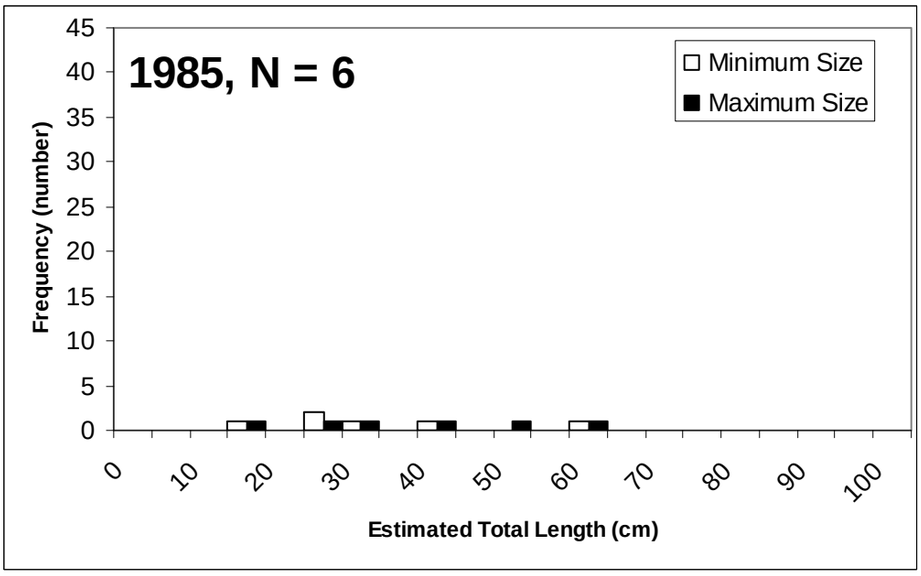


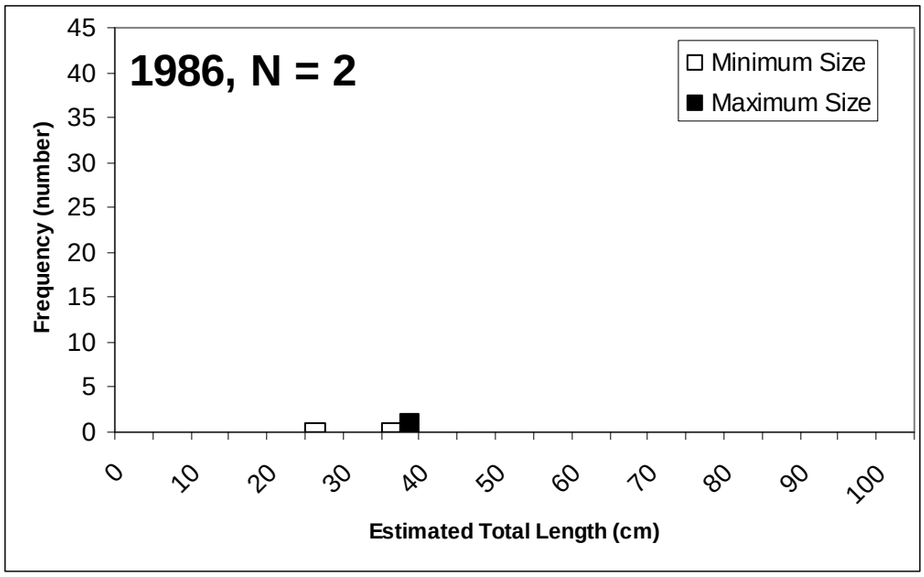


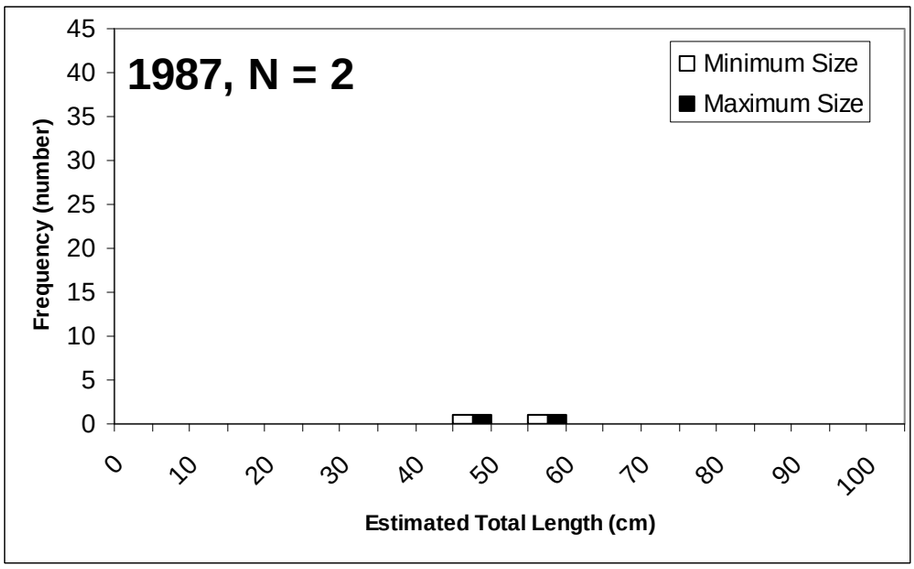


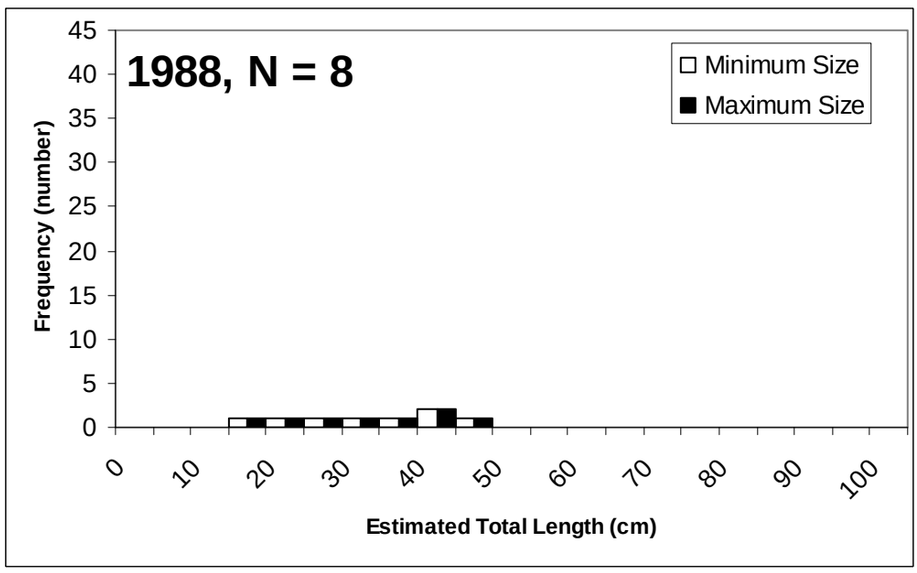

1983, N = 13
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

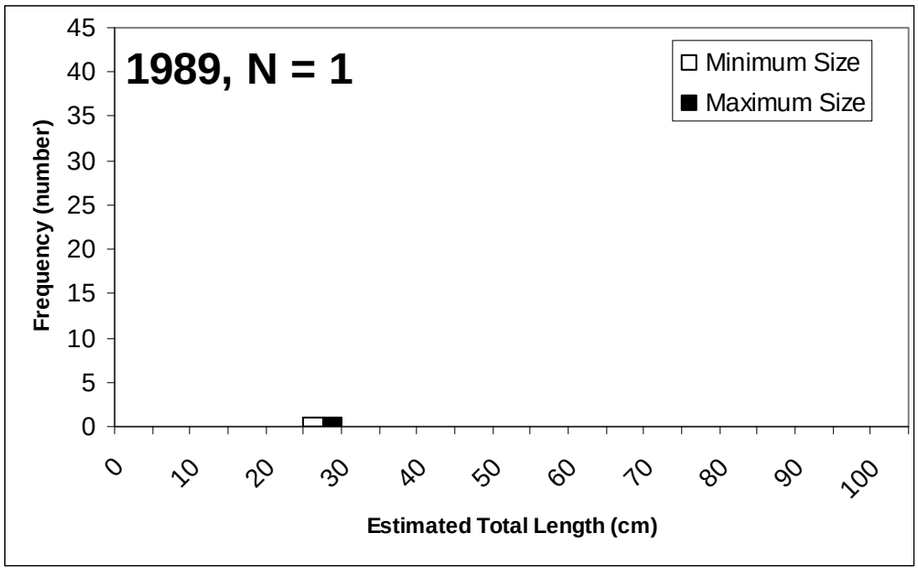

1984, N = 7
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

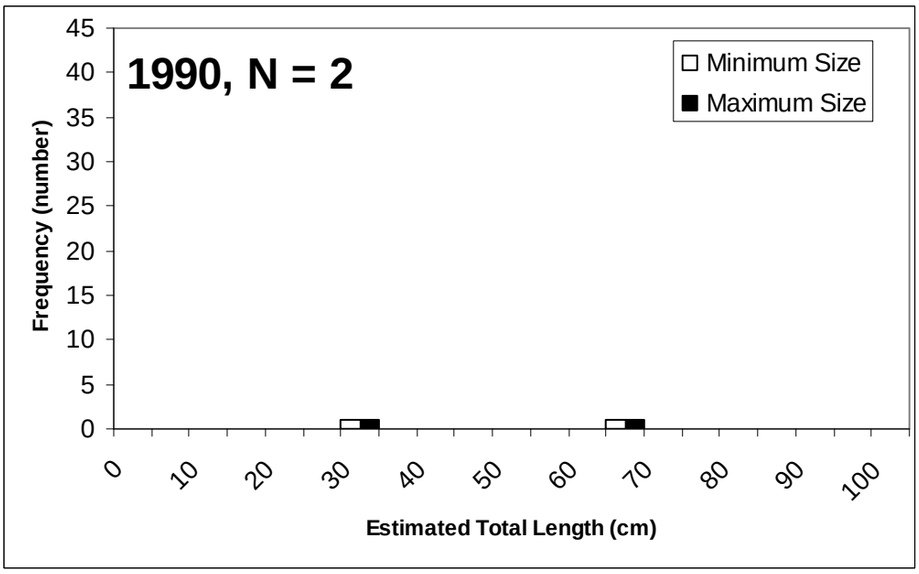

1985, N = 6
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

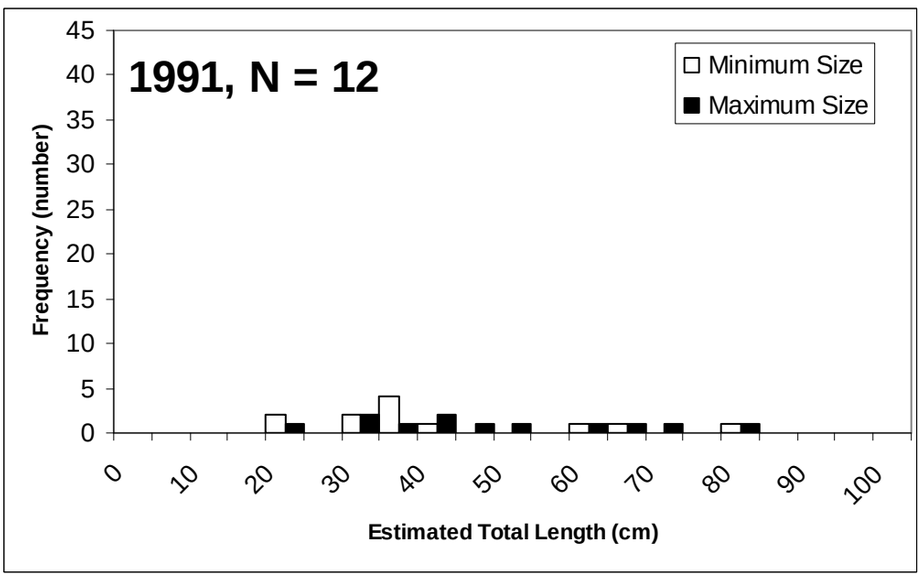

1986, N = 2
Minimum Size
Maximum Size
Frequency (number)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100
Estimated Total Length (cm)

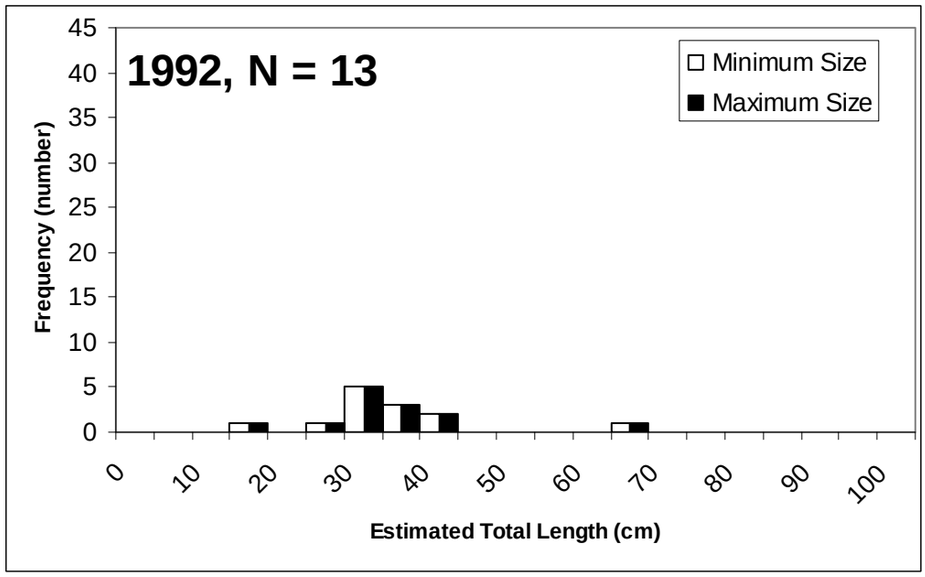

1987, N = 2
Minimum Size
Maximum Size
Frequency (number)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100
Estimated Total Length (cm)

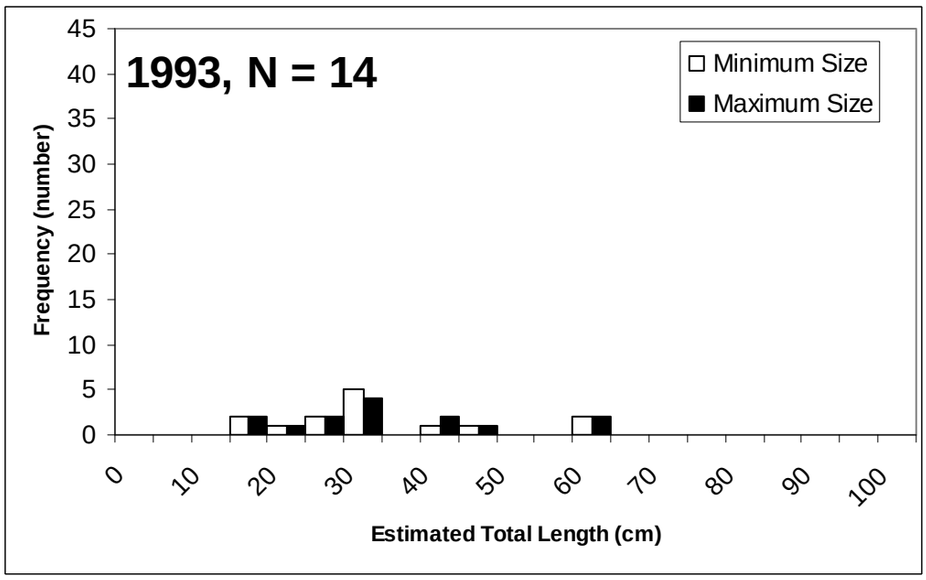

1988, N = 8
Minimum Size
Maximum Size
Frequency (number)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100
Estimated Total Length (cm)

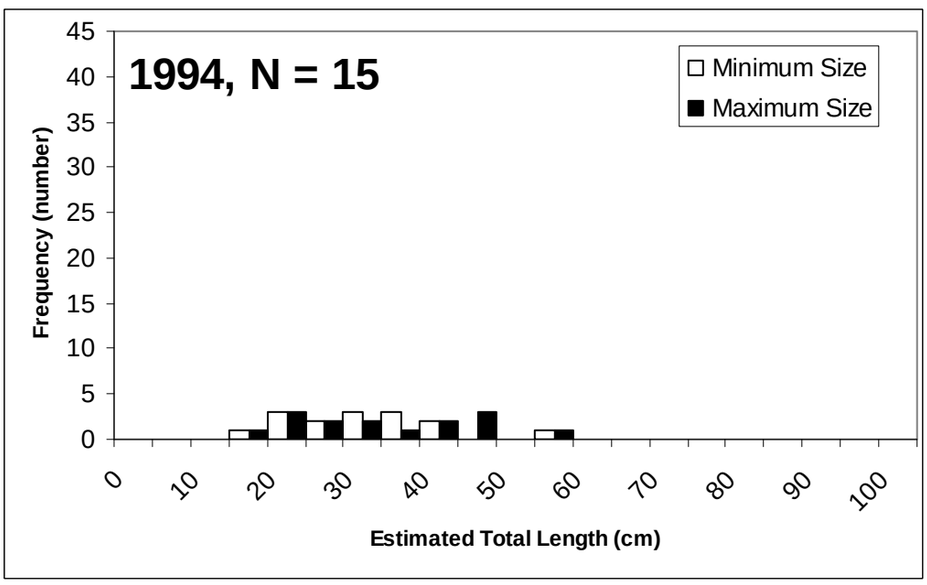

1989, N = 1
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

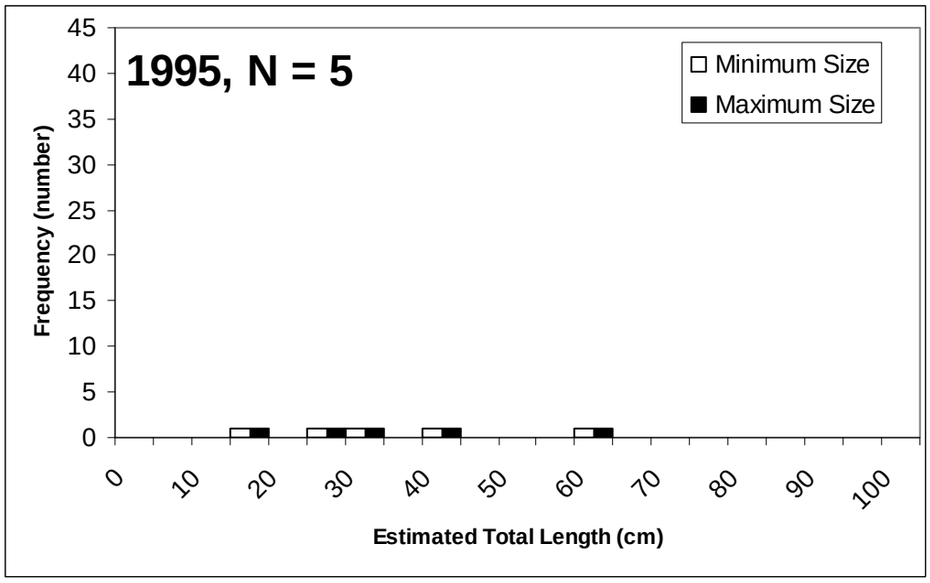

1990, N = 2
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

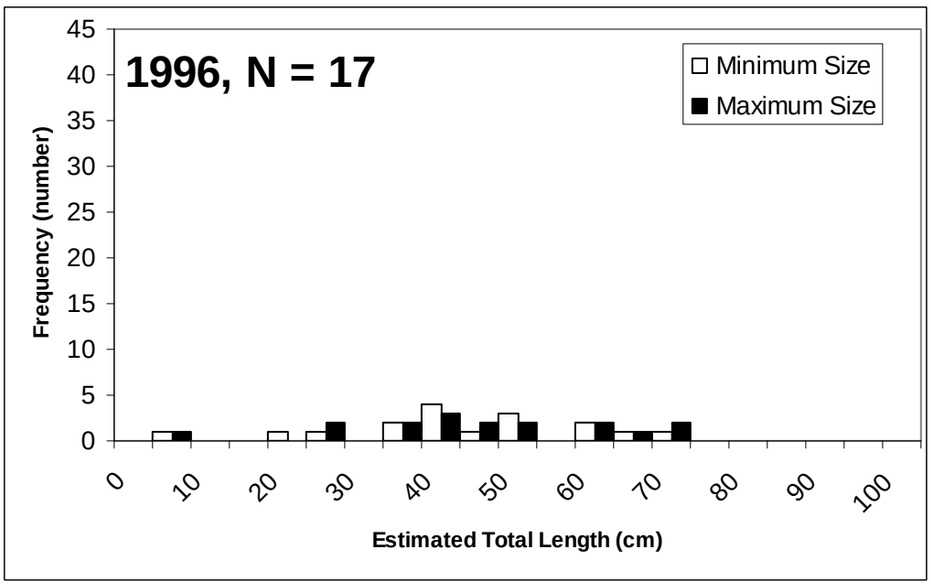

1991, N = 12
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

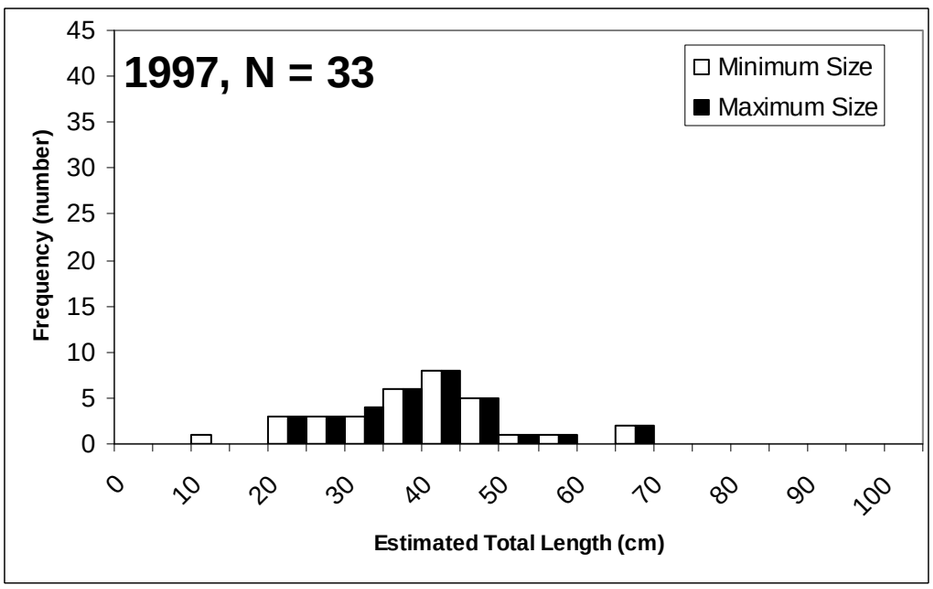

1992, N = 13
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

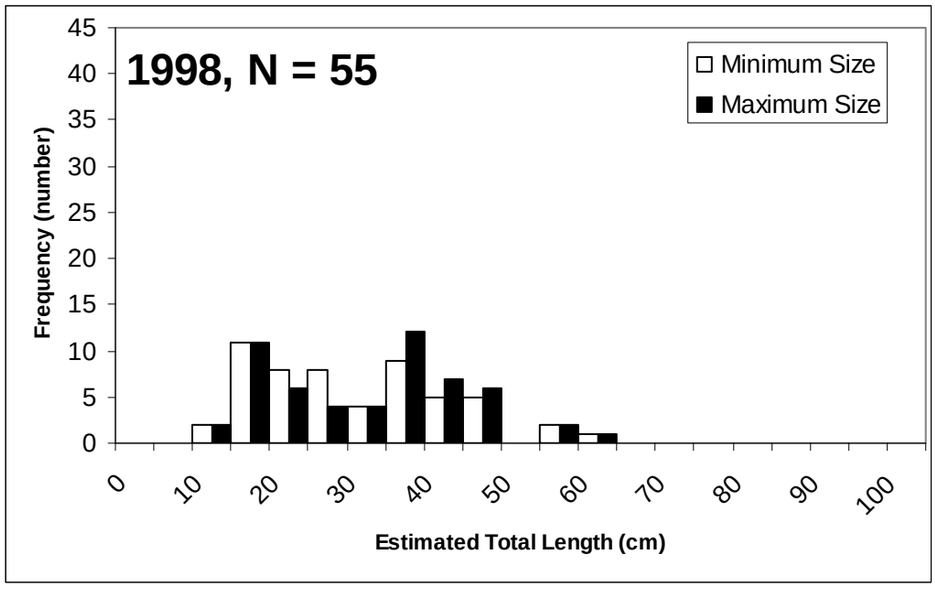

1993, N = 14
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

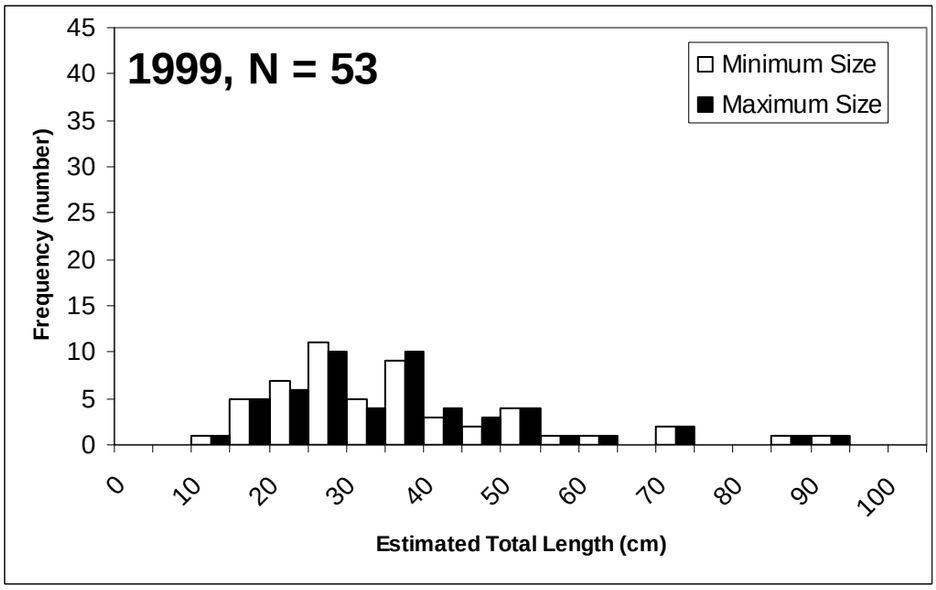

1994, N = 15
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

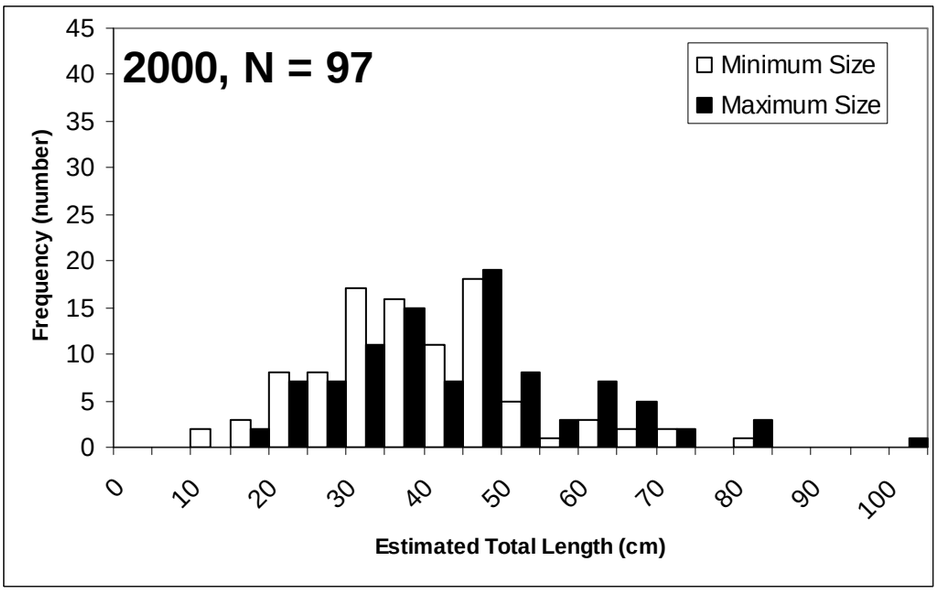

1995, N = 5
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

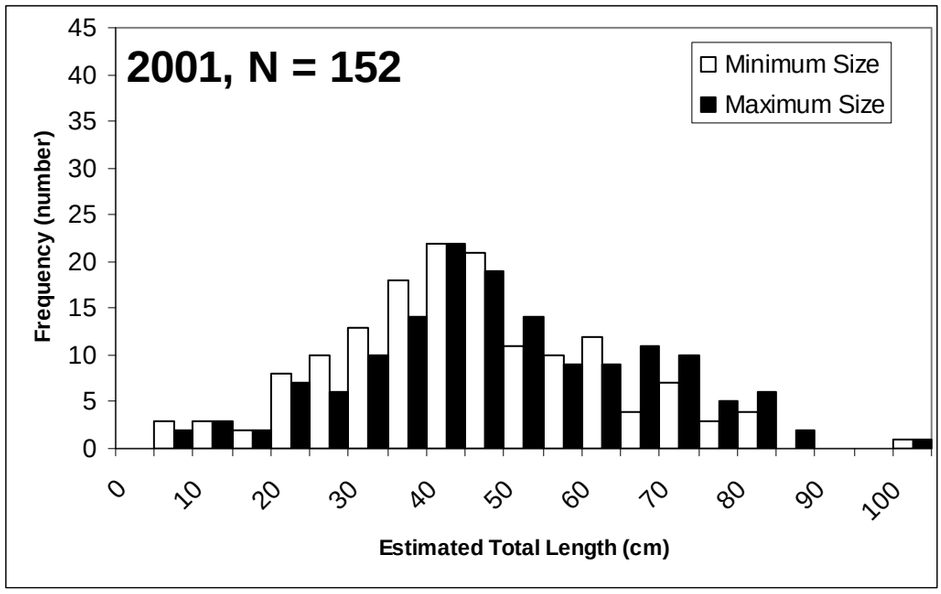

1996, N = 17
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

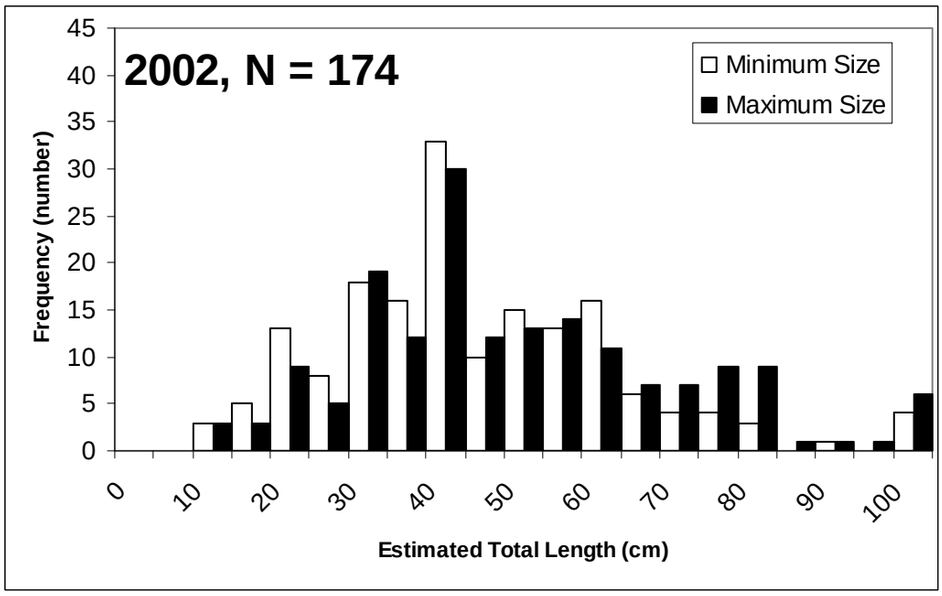

1997, N = 33
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

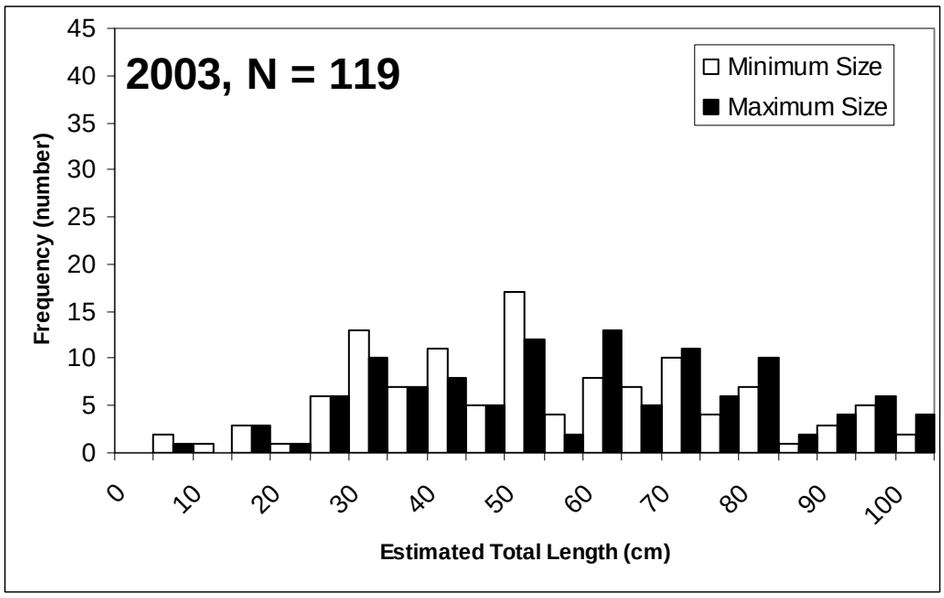

1998, N = 55
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

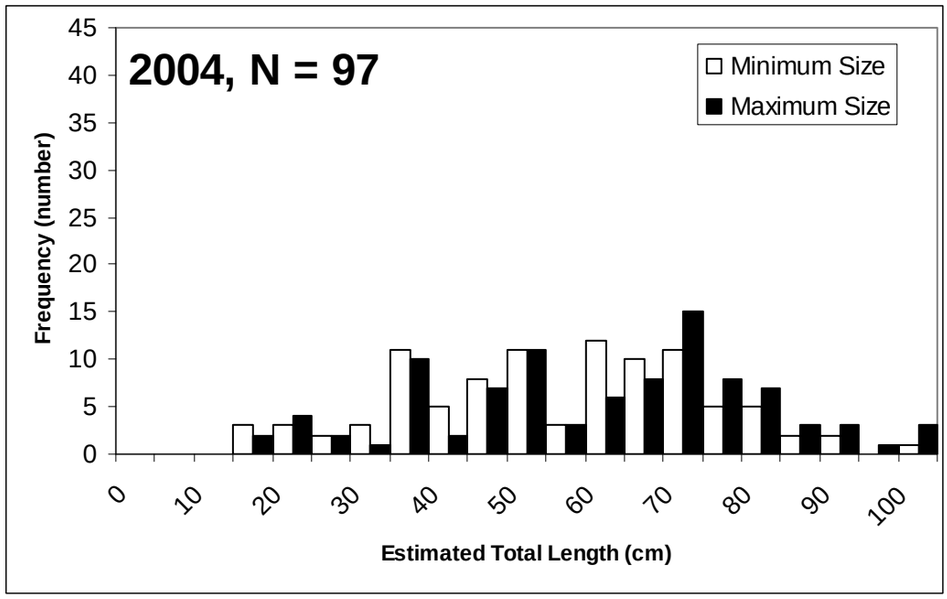

1999, N = 53
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

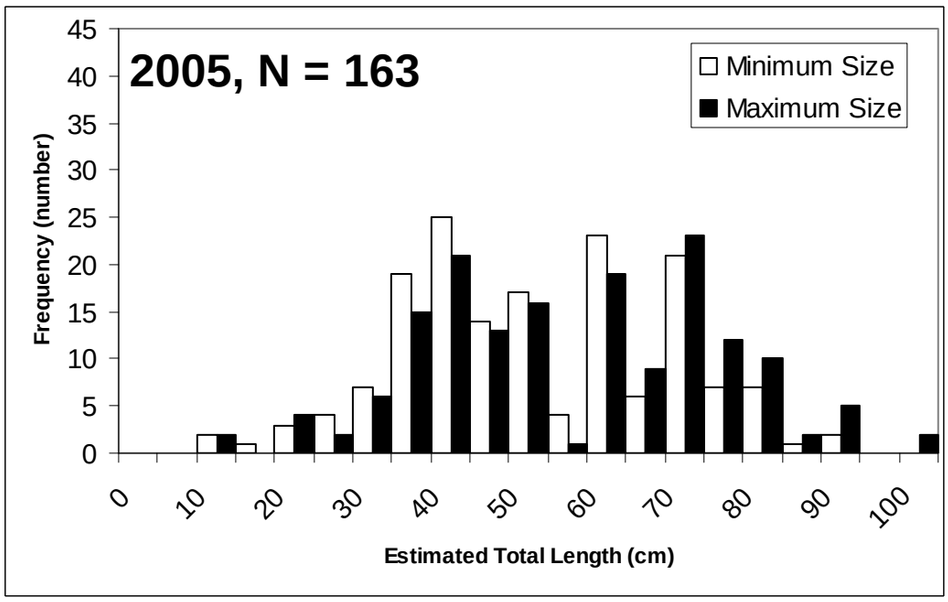

2000, N = 97
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

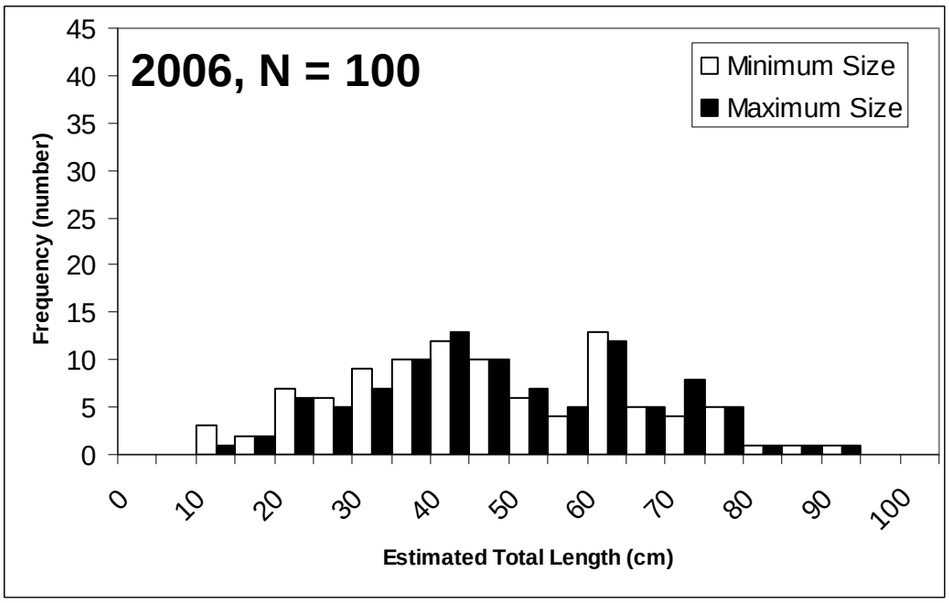

2001, N = 152
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

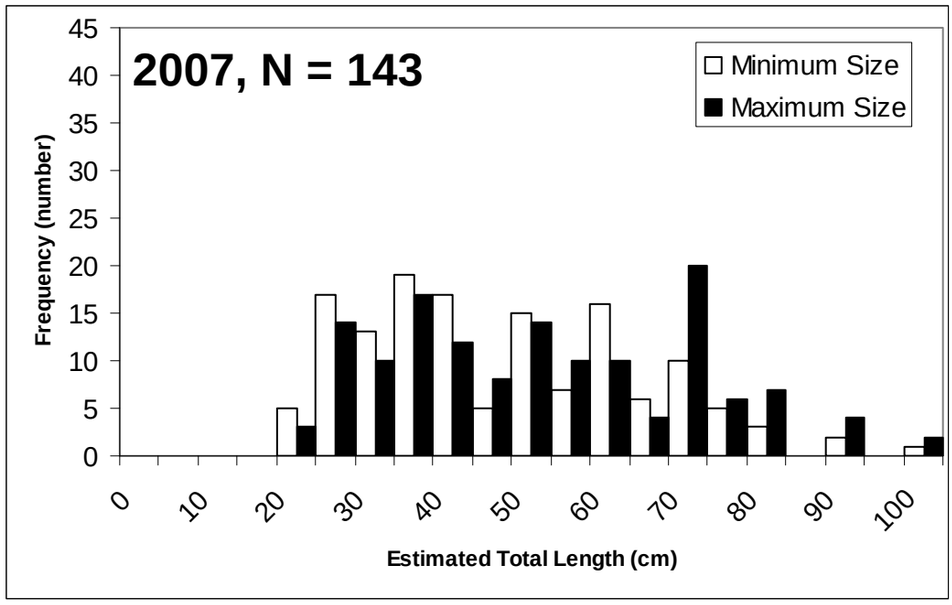

2002, N = 174
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)


2003, N = 119
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)


2004, N = 97
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

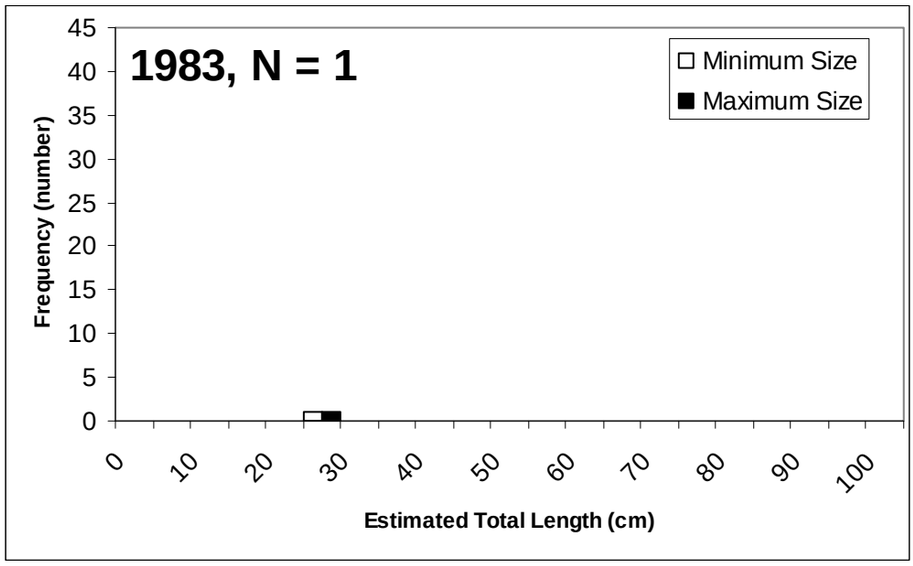

2005, N = 163
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

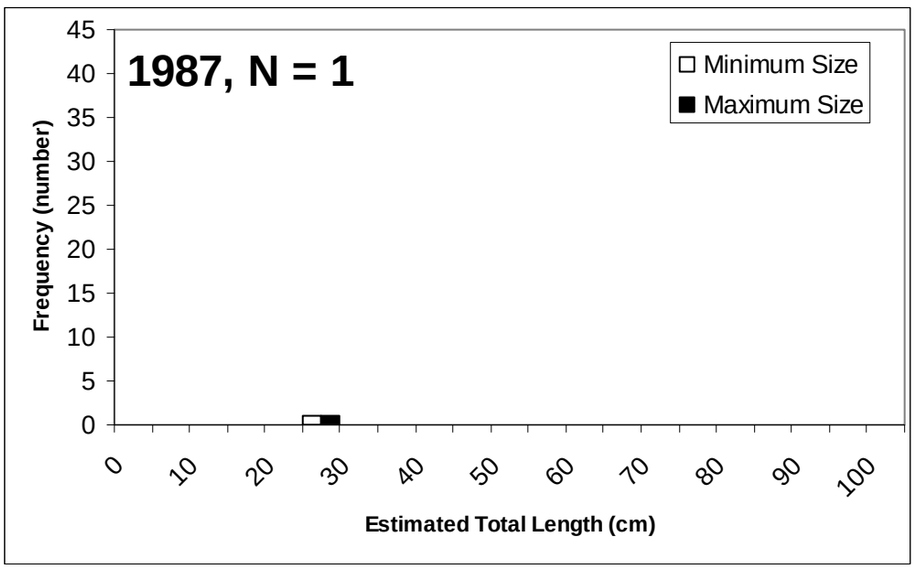

2006, N = 100
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

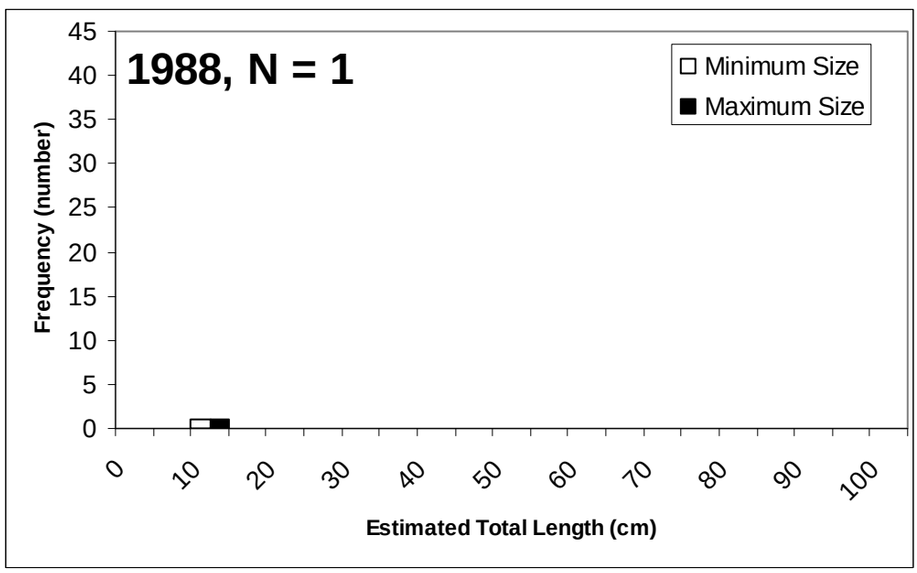

2007, N = 143
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100

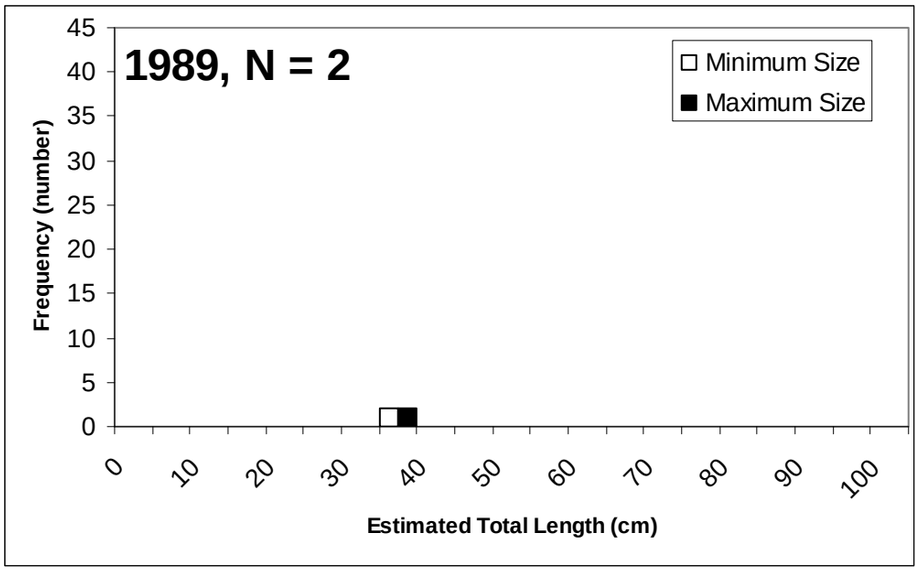
Appendix 3b:

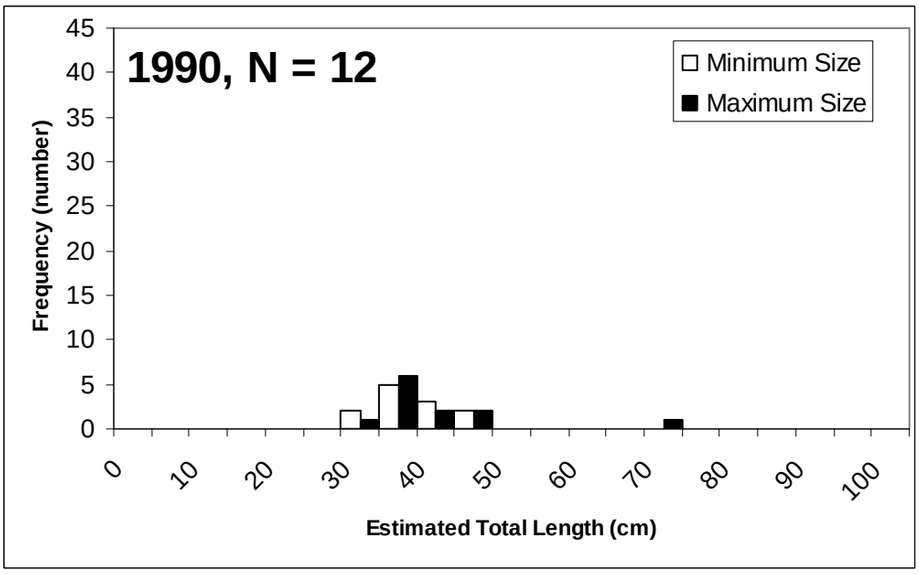
Length frequencies of red grouper observed in the Florida Keys during the RVC (1979 – 2007).

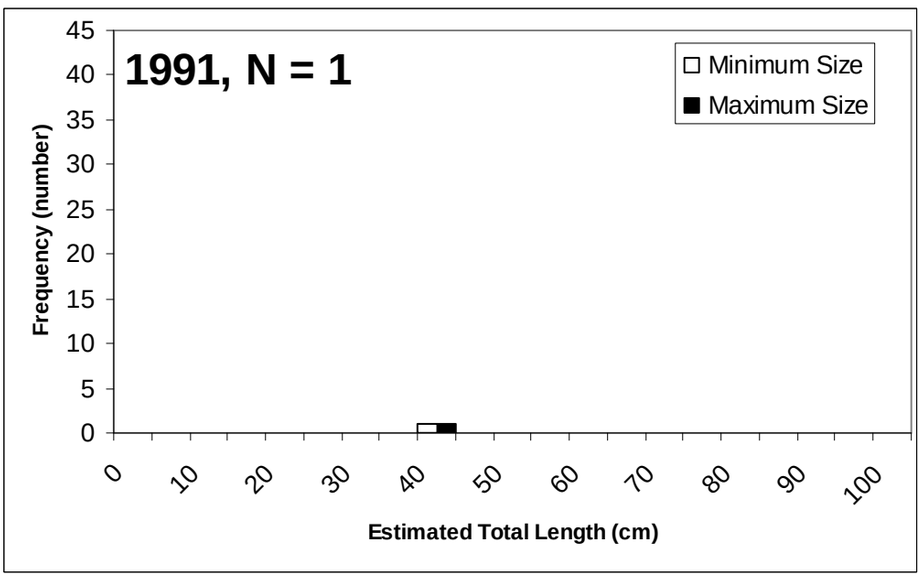


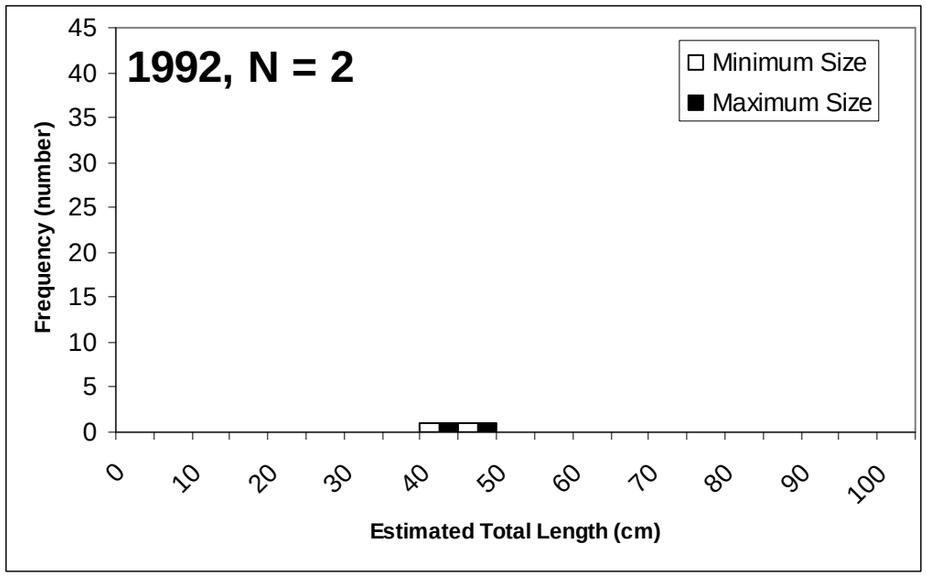


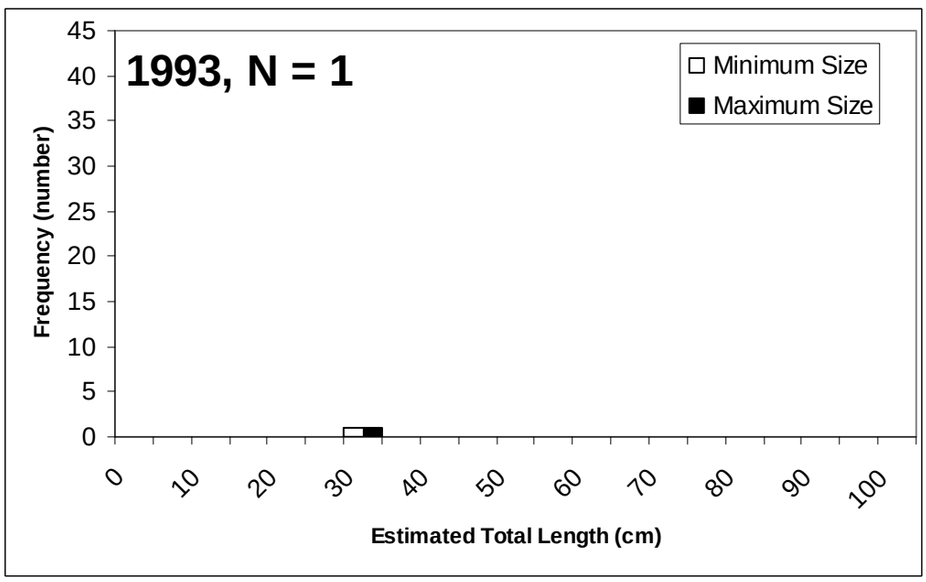


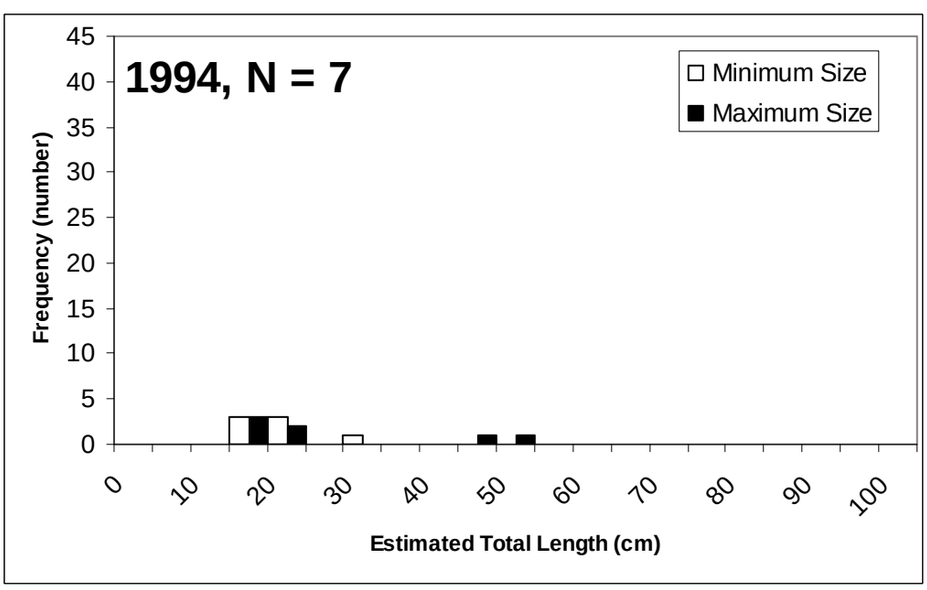

1989, N = 2
Minimum Size
Maximum Size
Frequency (number)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100
Estimated Total Length (cm)

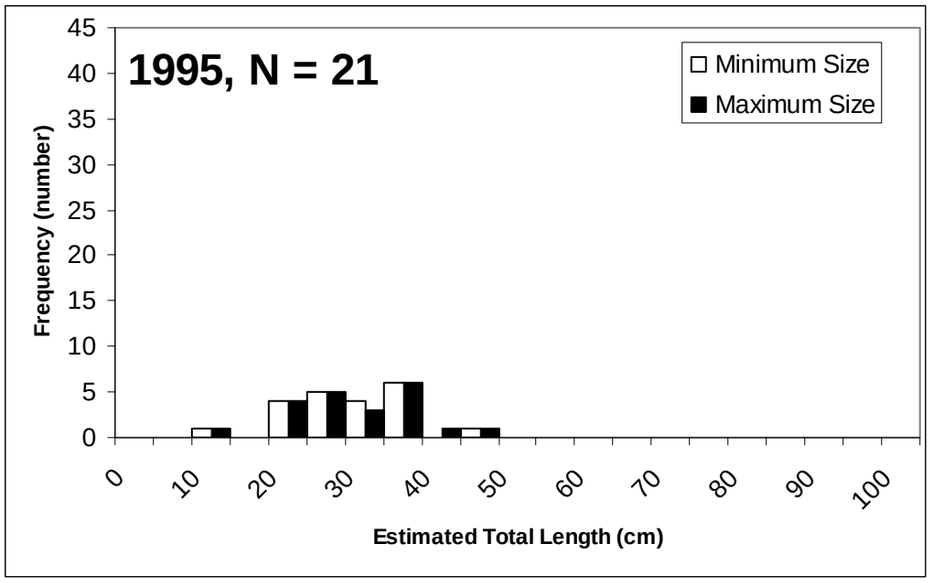

1990, N = 12
Minimum Size
Maximum Size
Frequency (number)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100
Estimated Total Length (cm)

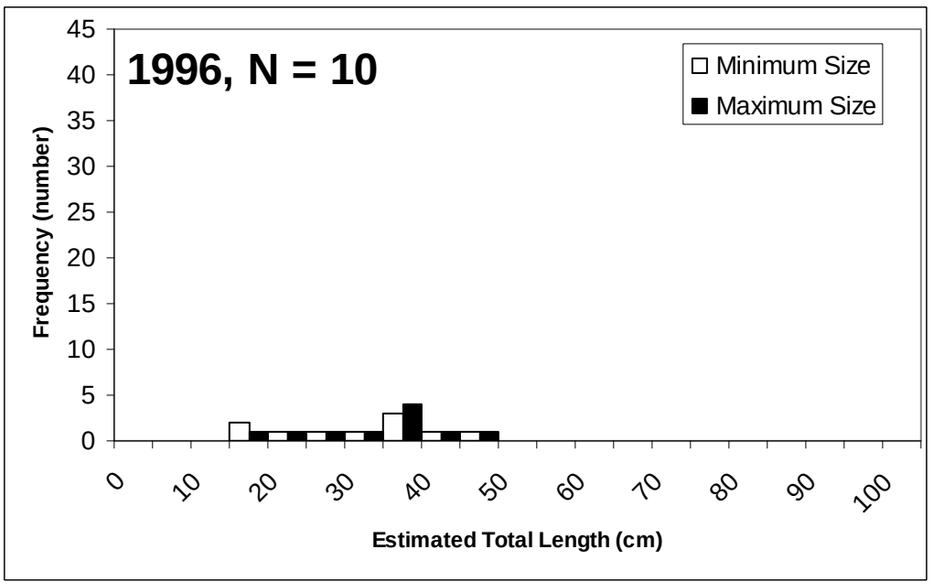

1991, N = 1
Minimum Size
Maximum Size
Frequency (number)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100
Estimated Total Length (cm)

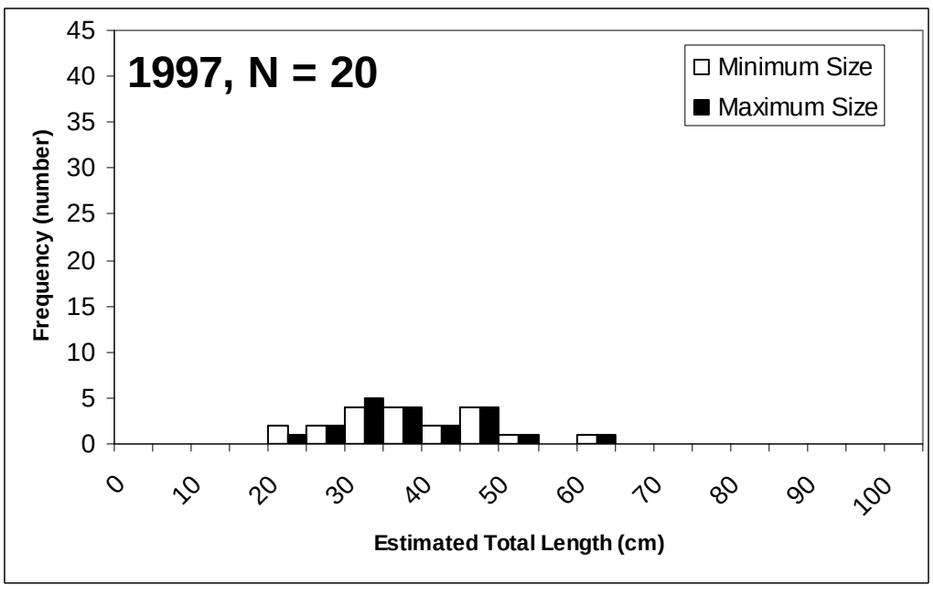

1992, N = 2
Minimum Size
Maximum Size
Frequency (number)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100
Estimated Total Length (cm)

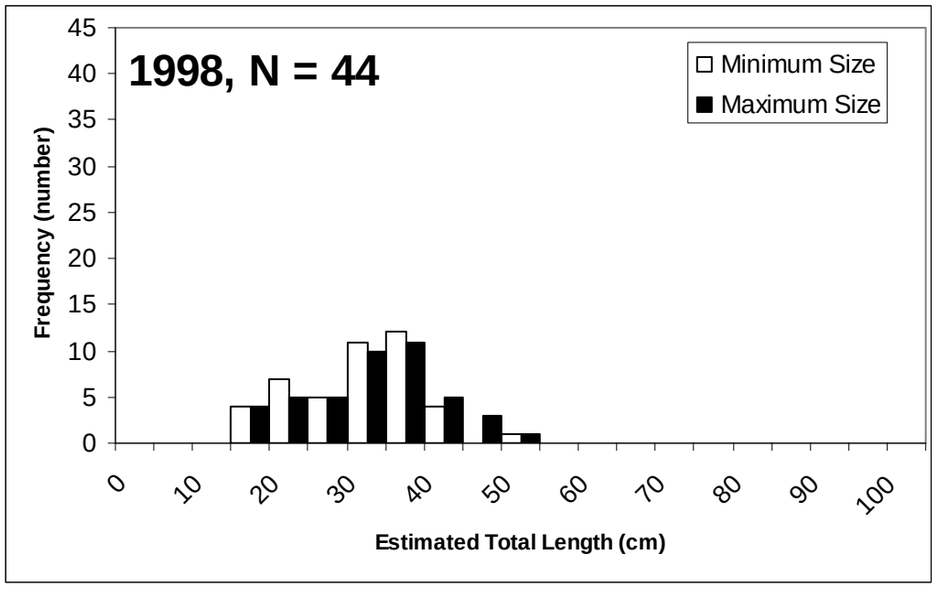

1993, N = 1
Minimum Size
Maximum Size
Frequency (number)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100
Estimated Total Length (cm)

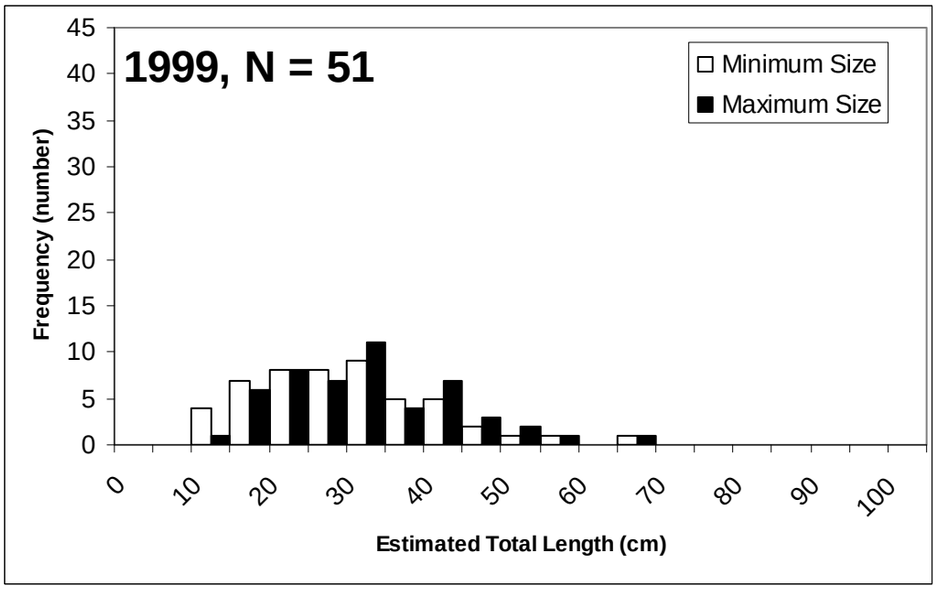

1994, N = 7
Minimum Size
Maximum Size
Frequency (number)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100
Estimated Total Length (cm)

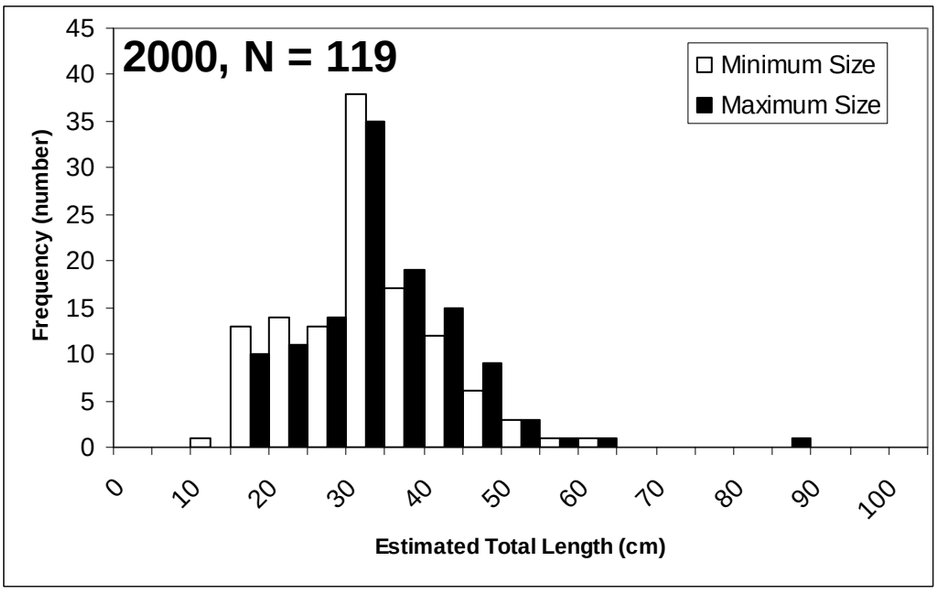

1995, N = 21
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

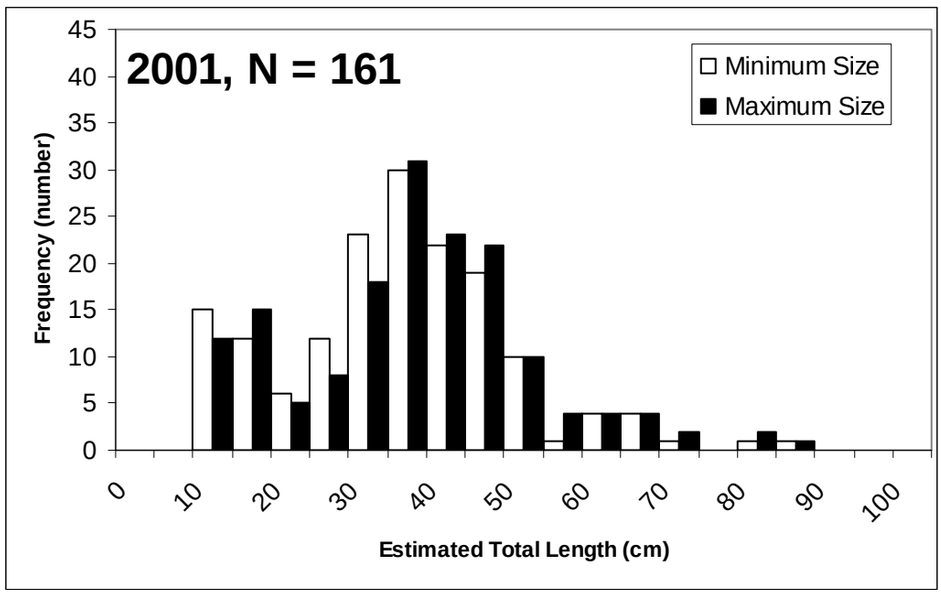

1996, N = 10
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

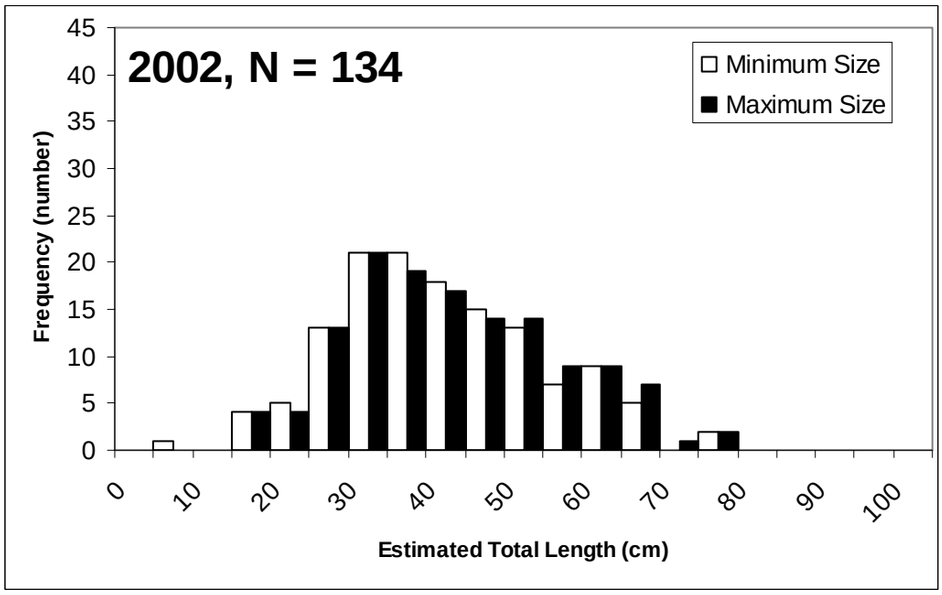

1997, N = 20
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

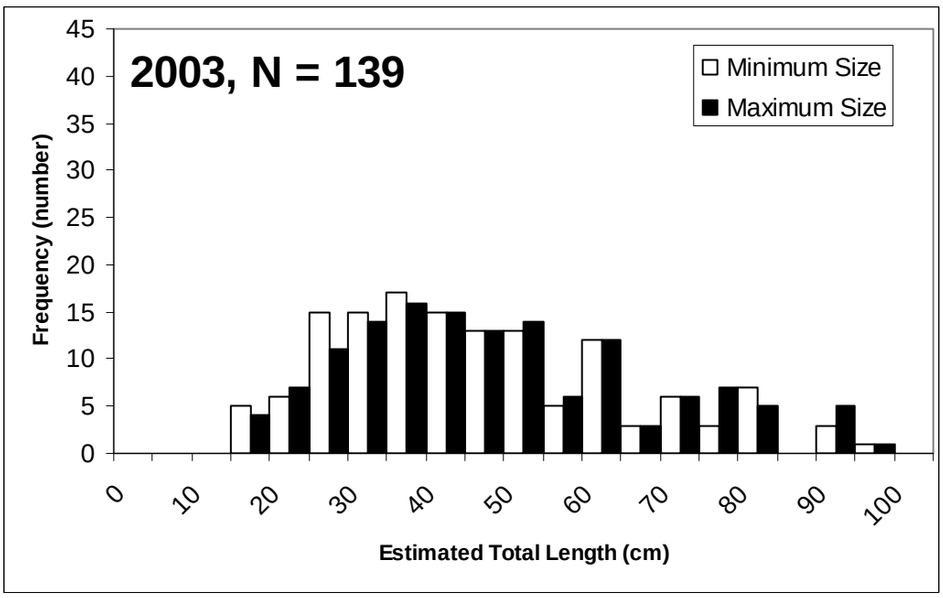

1998, N = 44
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

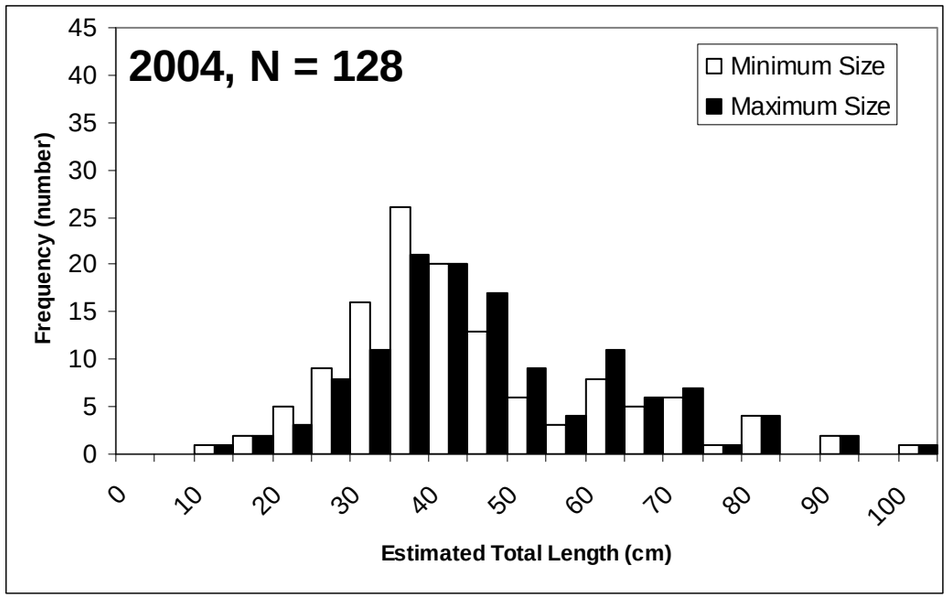

1999, N = 51
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

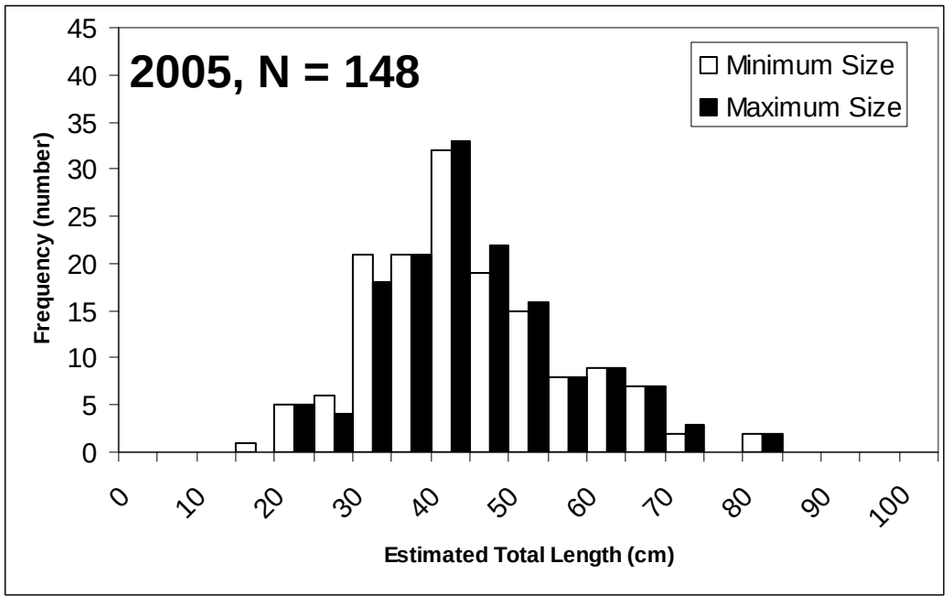

2000, N = 119
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

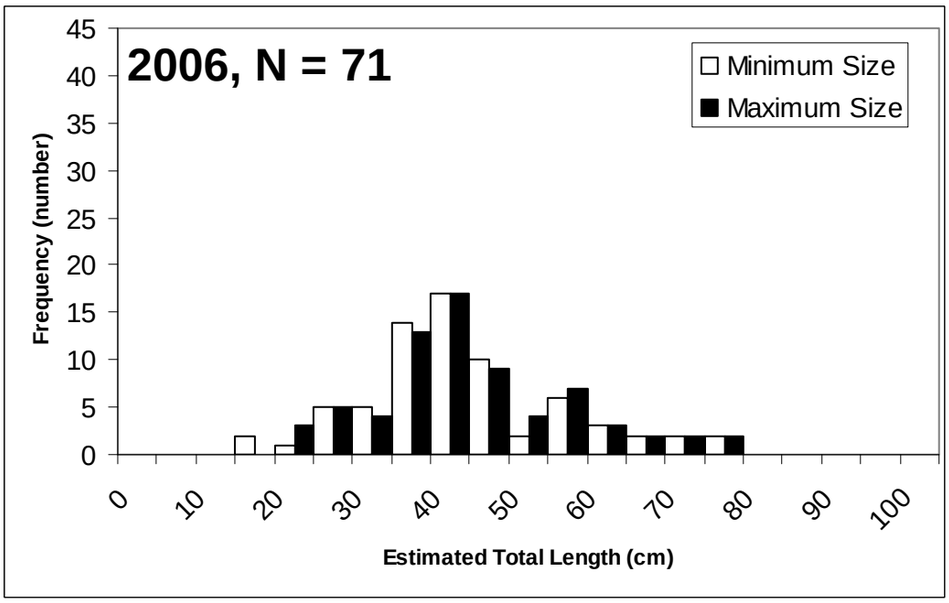

2001, N = 161
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

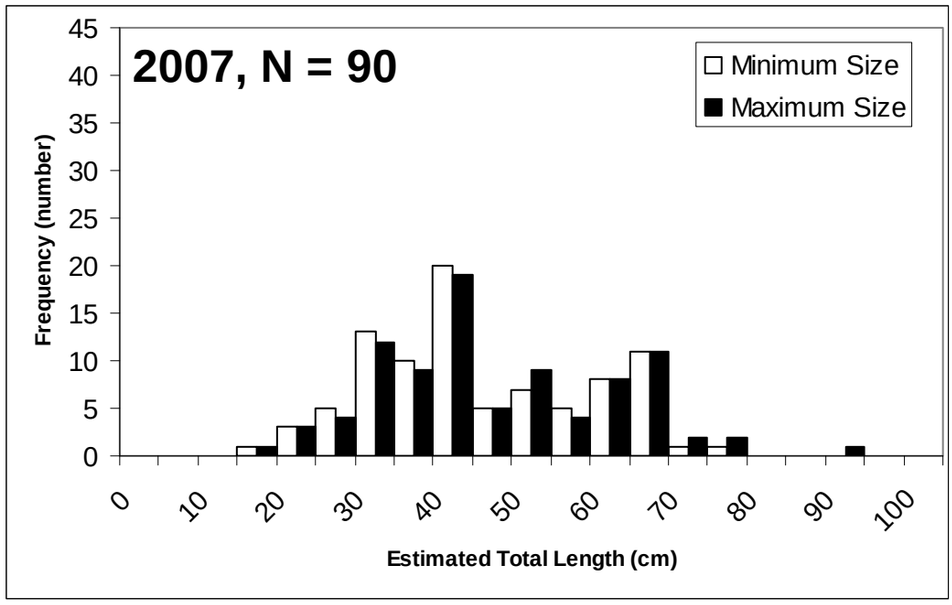

2002, N = 134
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)


2003, N = 139
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)


2004, N = 128
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

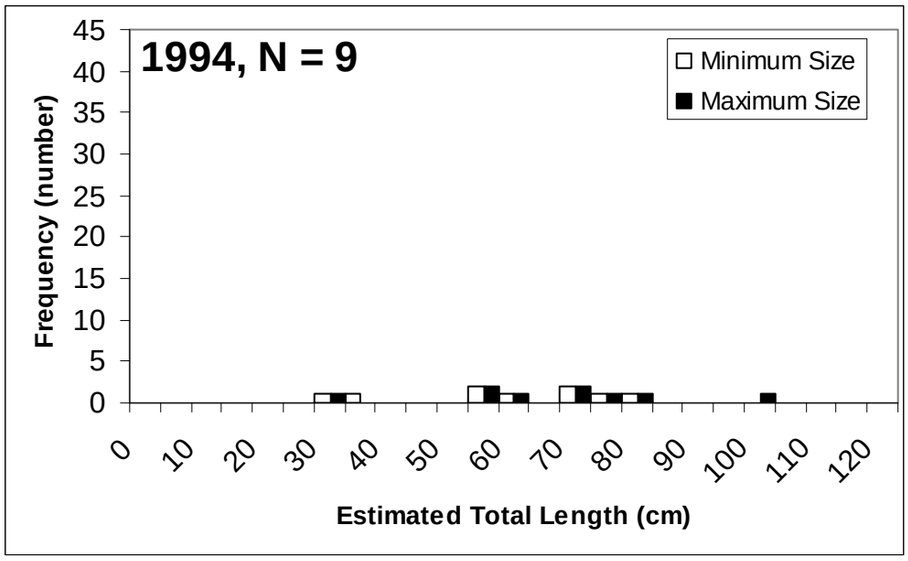

2005, N = 148
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

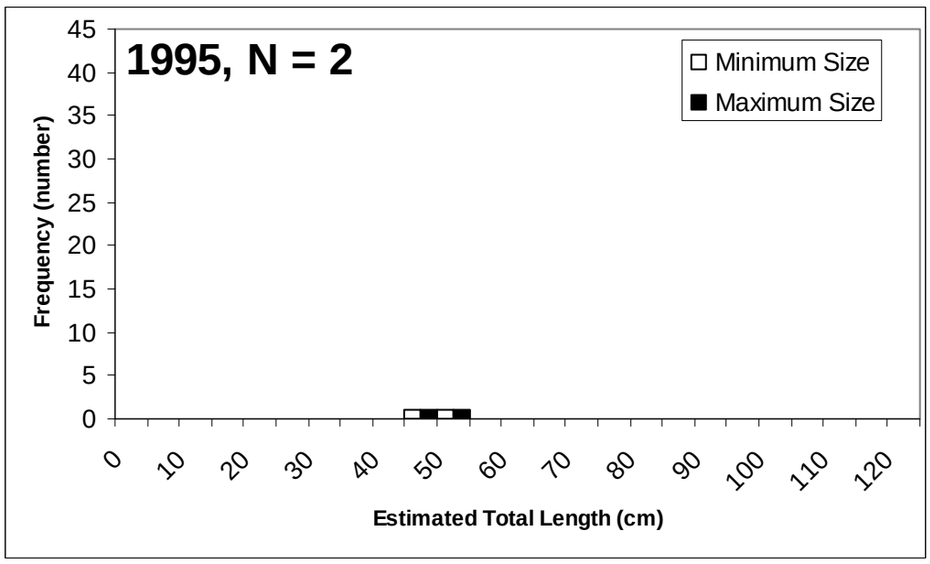

2006, N = 71
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

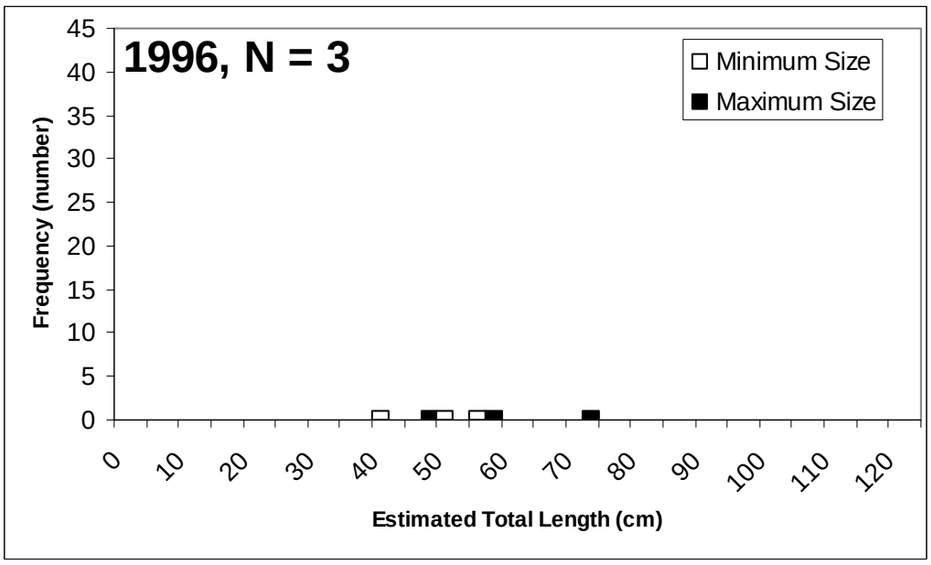

2007, N = 90
Minimum Size
Maximum Size
Frequency (number)
45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Estimated Total Length (cm)

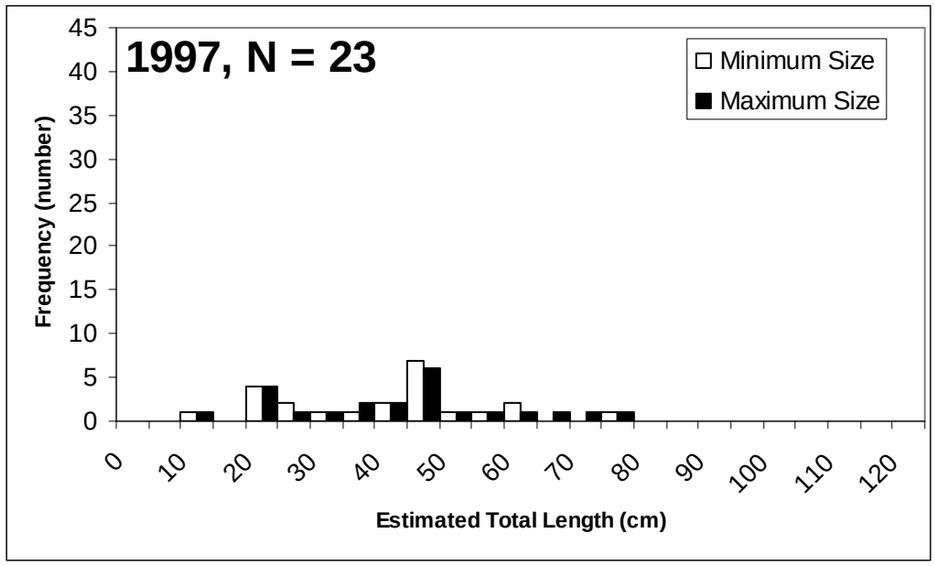
Appendix 3c:

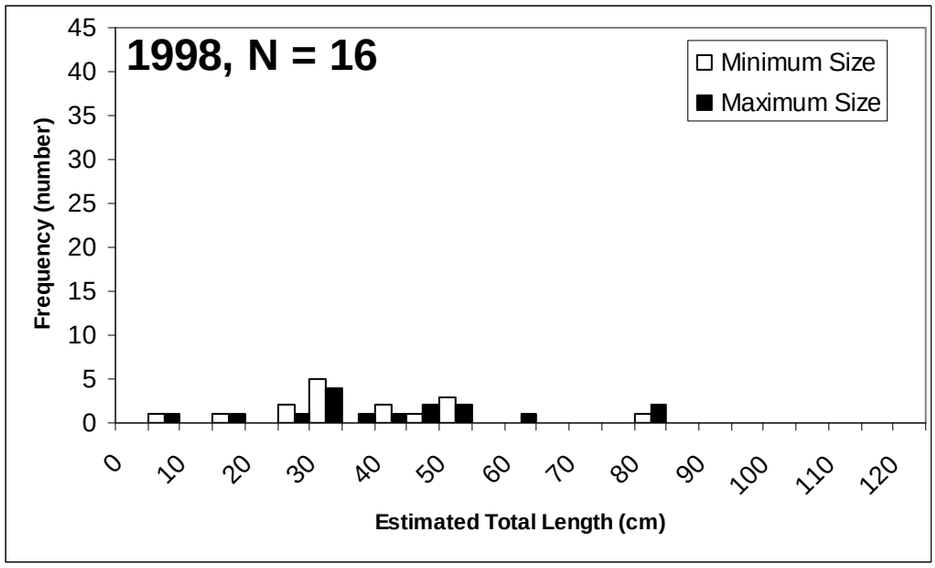
Length frequencies of black grouper observed in the Dry Tortugas during the RVC (1994 – 2008).

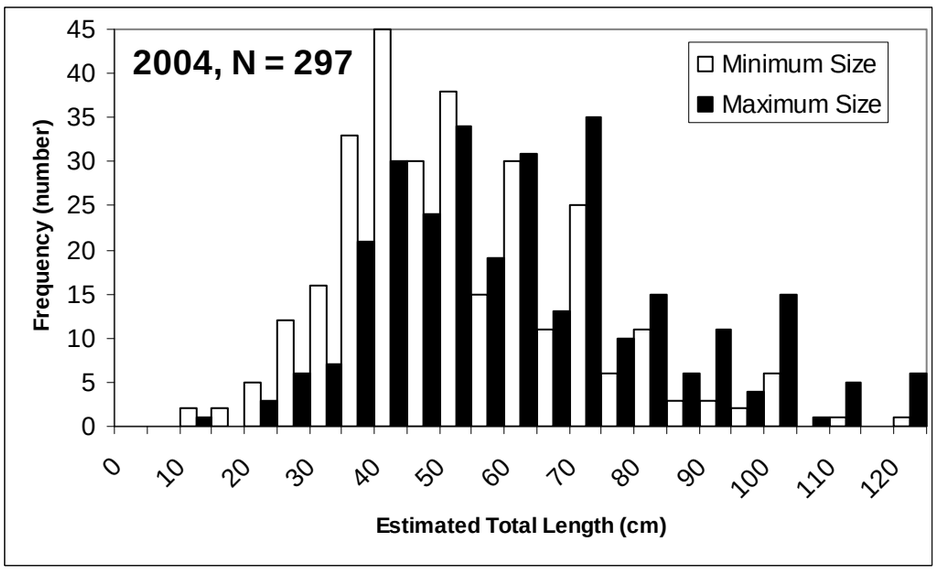


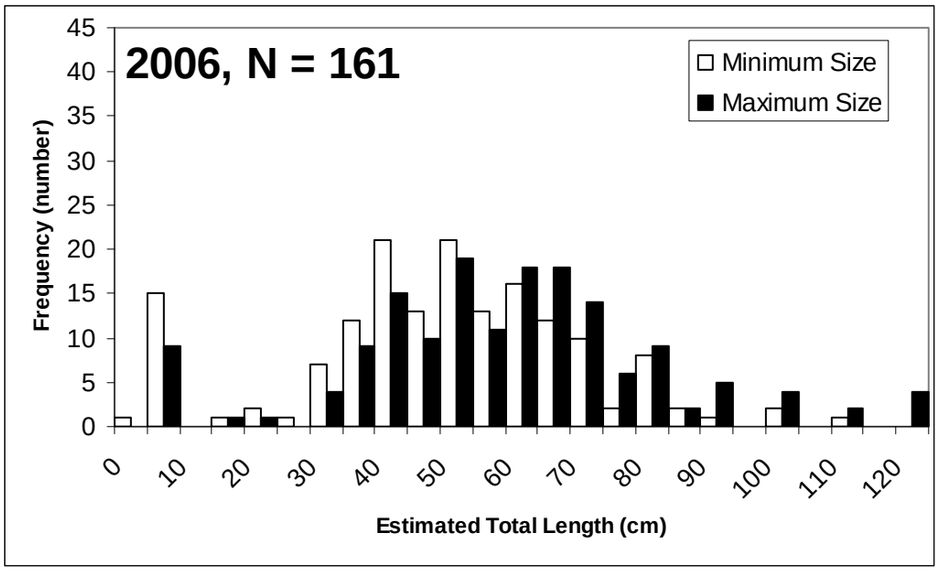


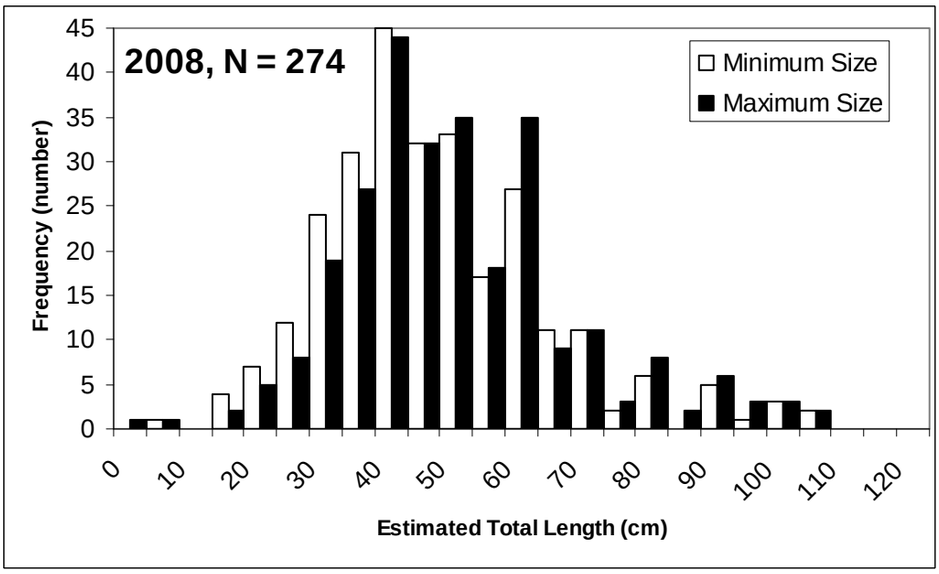



1997, N = 23
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

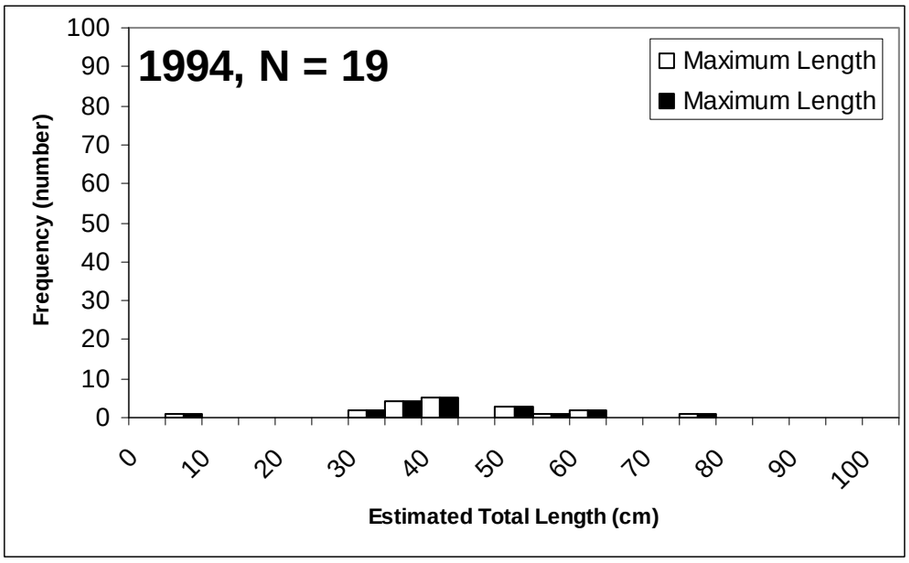

1998, N = 16
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

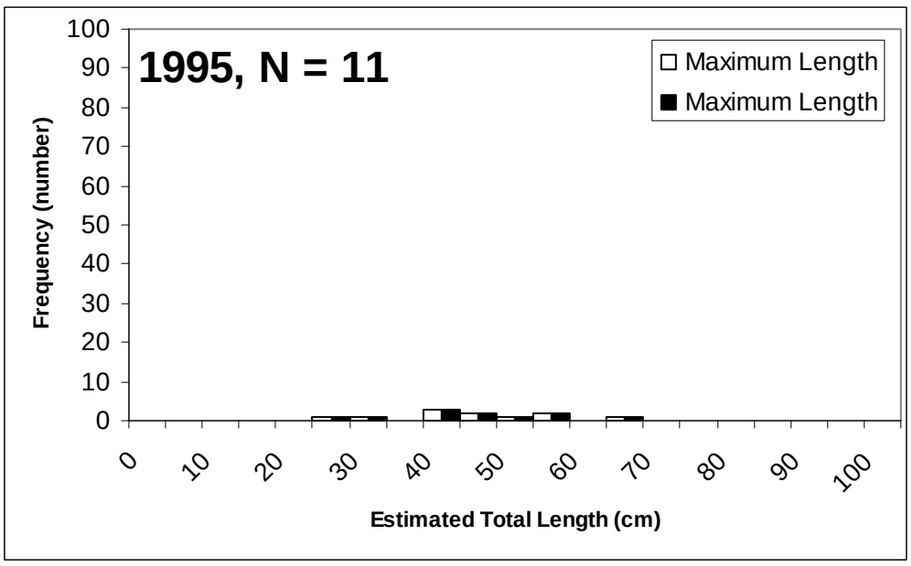

2004, N = 297
Minimum Size
Maximum Size
Frequency (number)
Estimated Total Length (cm)

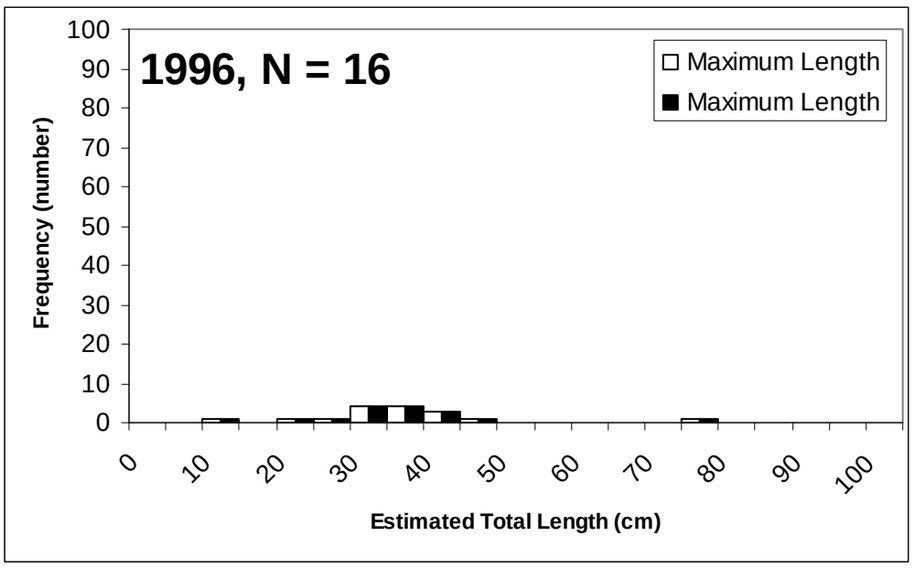

2006, N = 161
Minimum Size
Maximum Size
Frequency (number)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100
110
120
Estimated Total Length (cm)

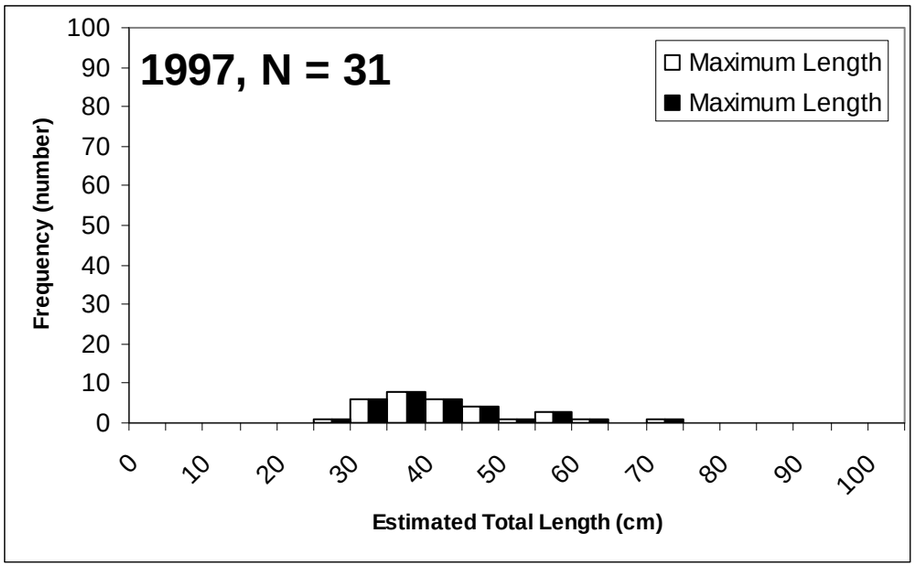

2008, N = 274
Minimum Size
Maximum Size
Frequency (number)
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90
100
110
120
Estimated Total Length (cm)

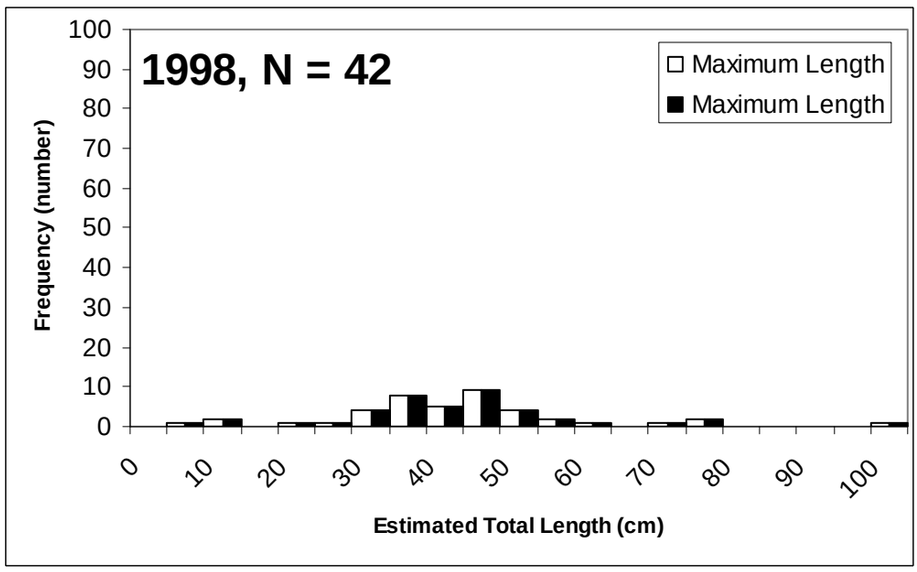
Appendix 3d:
Length frequencies of red grouper observed in the Dry Tortugas during the RVC (1994 – 2008).

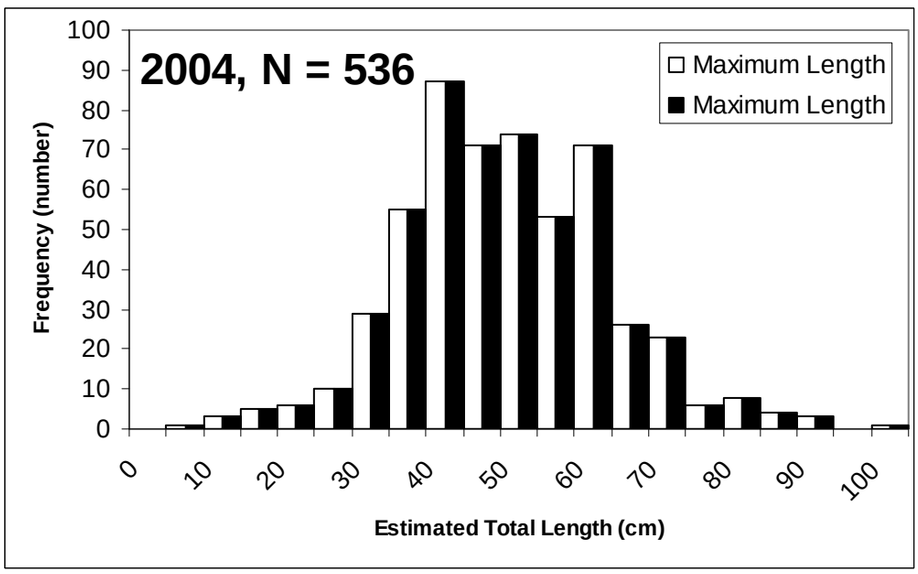


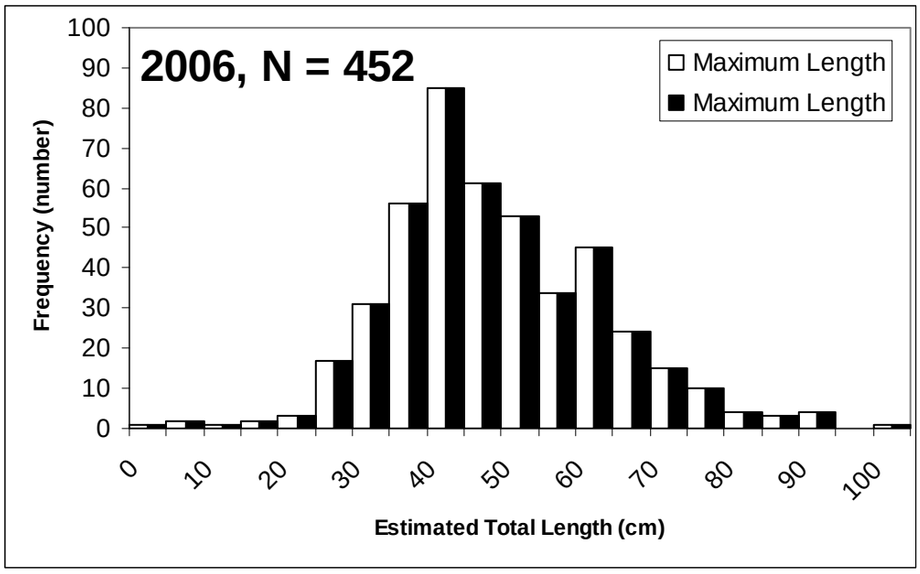


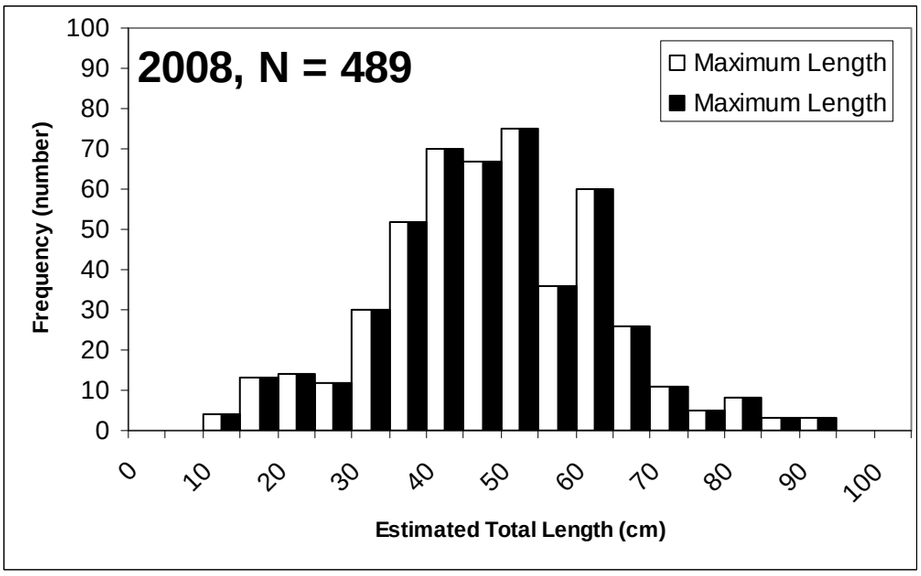



1997, N = 31
Maximum Length
Maximum Length
Frequency (number)
Estimated Total Length (cm)


1998, N = 42
Maximum Length
Maximum Length
Frequency (number)
Estimated Total Length (cm)


2004, N = 536
Maximum Length
Maximum Length
Frequency (number)
Estimated Total Length (cm)


2006, N = 452
Maximum Length
Maximum Length
Frequency (number)
Estimated Total Length (cm)
0
10
20
30
40
50
60
70
80
90
100


2008, N = 489
Maximum Length
Maximum Length
Frequency (number)
Estimated Total Length (cm)
0
10
20
30
40
50
60
70
80
90
100

Appendix 4:

Model building results of black and red grouper observed during the RVC for both the Florida Keys (1979 – 2007) and Dry Tortugas (1994 – 2008).

Appendix 4a: Model building results of black grouper observed during the RVC the Florida Keys (1979 – 2007).

Step 1 for Binomial: *Type 3 Tests of Fixed Effects, AIC* = 2034.9

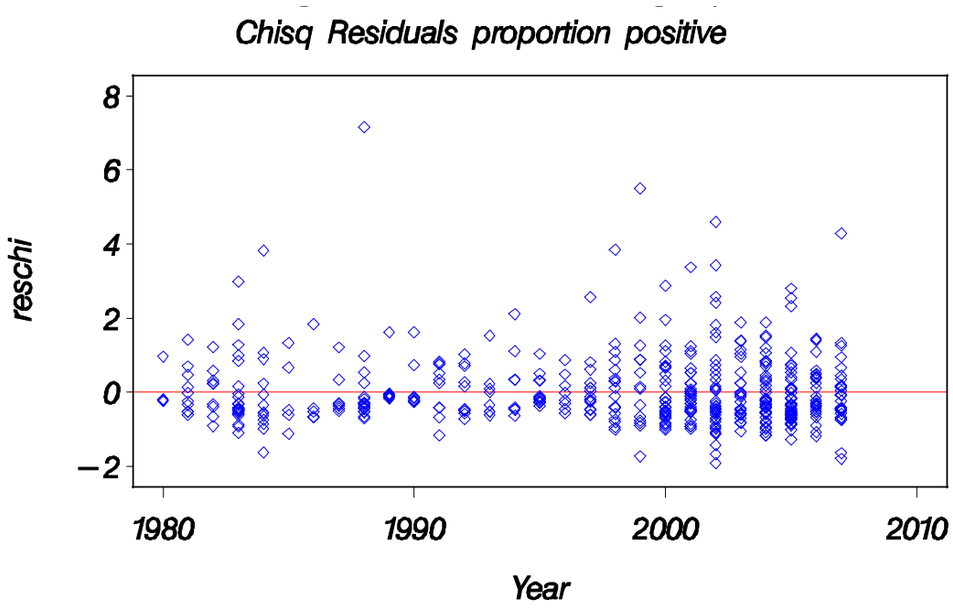
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	27	473	85.75	3.18	<.0001	<.0001
Month	11	473	21.97	2.00	0.0246	0.0270
Habitat	7	473	98.62	14.09	<.0001	<.0001

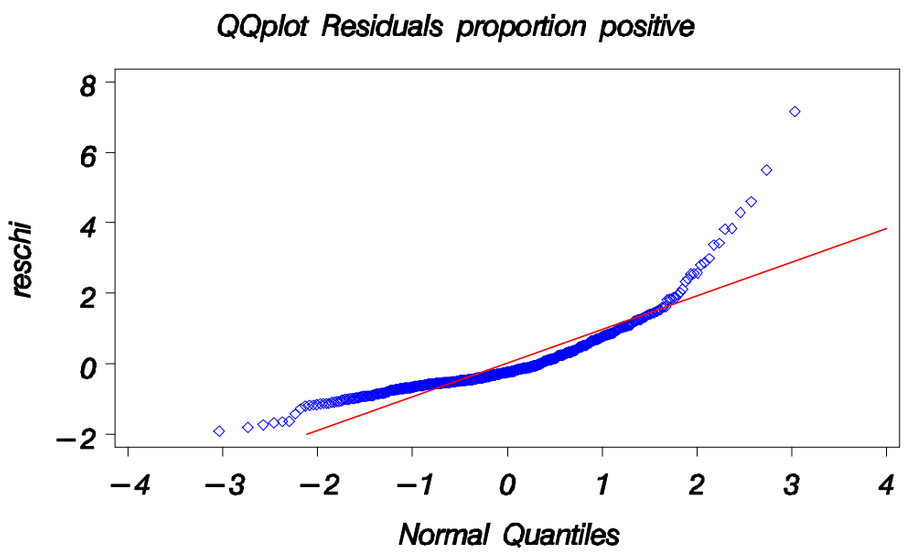
Step 1 for Poisson: *Type 3 Tests of Fixed Effects, AIC* = 2325.4

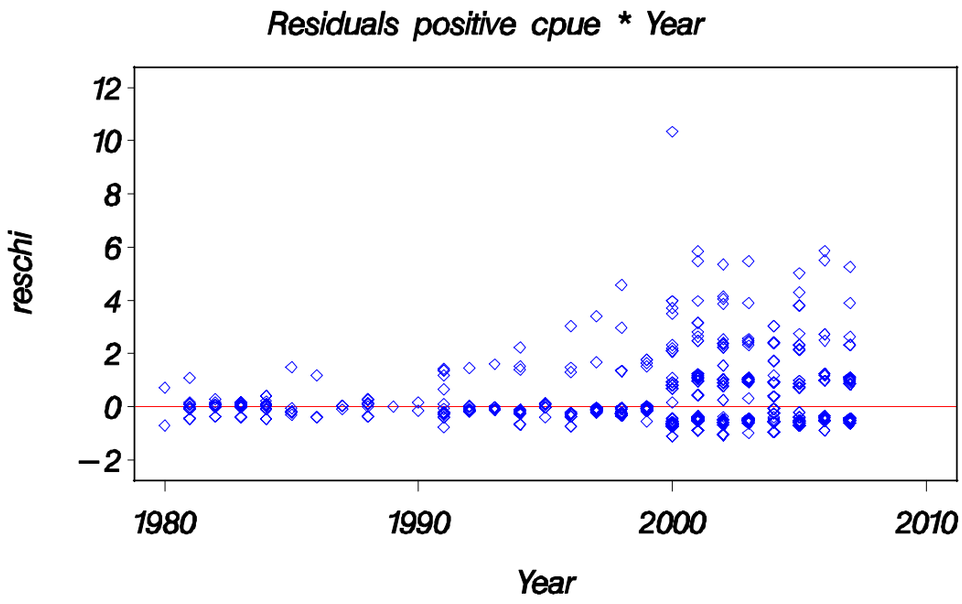
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	27	1483	65.24	2.42	<.0001	<.0001
Month	11	1483	39.79	3.62	<.0001	<.0001
Habitat	7	1483	9.54	1.36	0.2162	0.2172

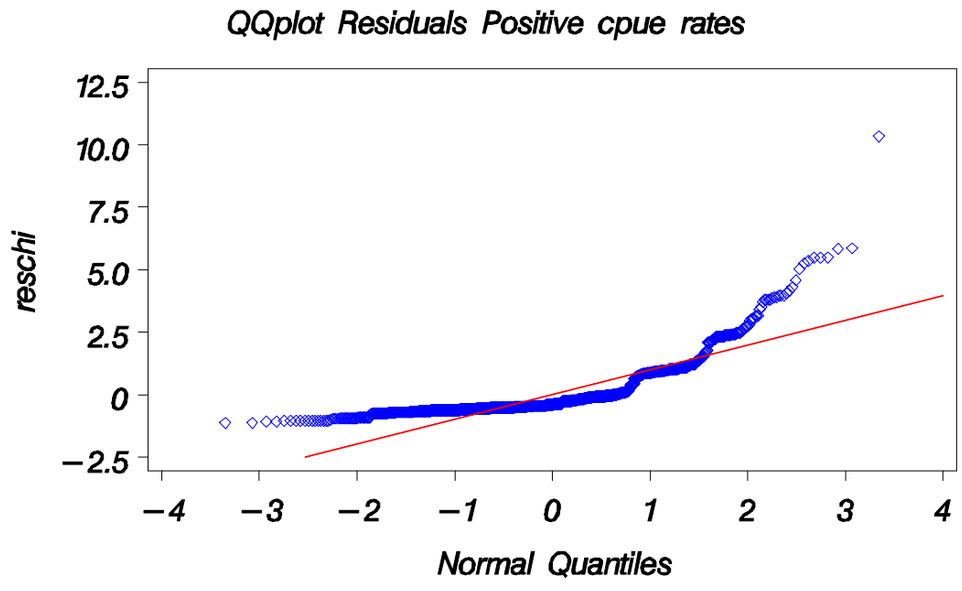
Step 2 for Poisson: *Type 3 Tests of Fixed Effects, AIC* = 2319.0

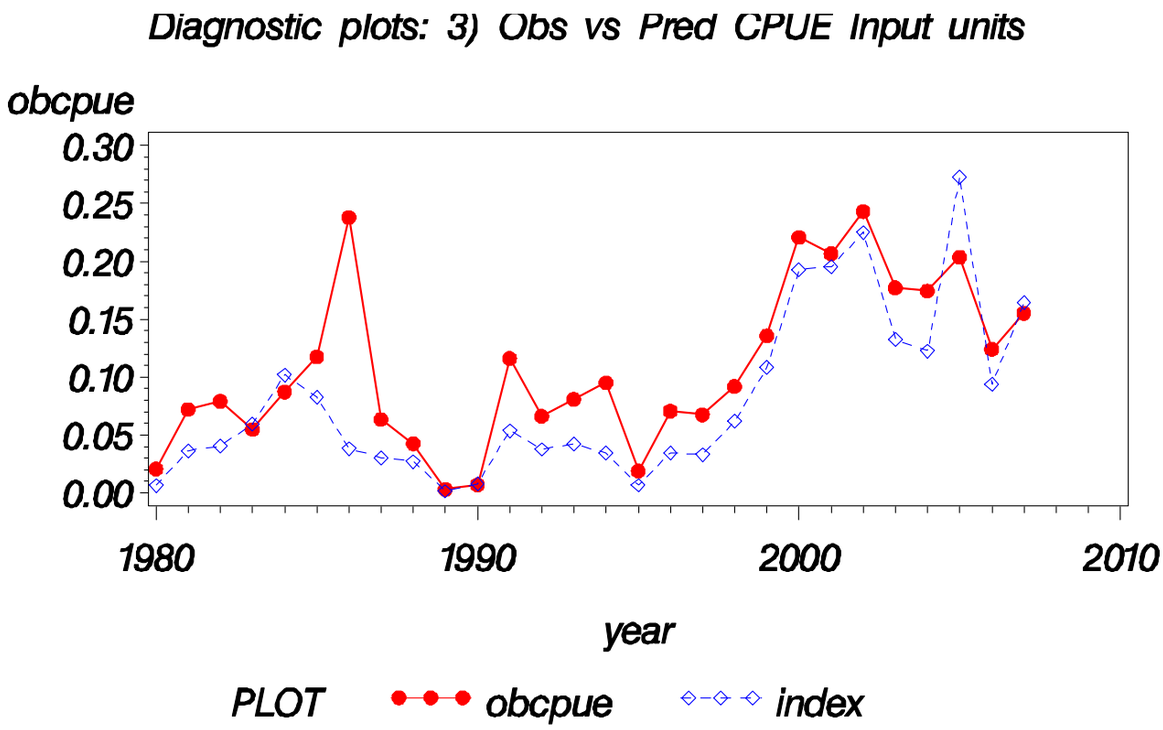
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	27	1490	71.65	2.65	<.0001	<.0001
Month	11	1490	39.31	3.57	<.0001	<.0001




QQplot Residuals proportion positive
reschi
8
6
4
2
0
−2
−4
−3
−2
−1
0
1
2
3
4
Normal Quantiles


Residuals positive cpue * Year
reschi
12
10
8
6
4
2
0
−2
1980
1990
2000
2010
Year


QQplot Residuals Positive cpue rates
reschi
12.5
10.0
7.5
5.0
2.5
0
−2.5
−4
−3
−2
−1
0
1
2
3
4
Normal Quantiles


Diagnostic plots: 3) Obs vs Pred CPUE Input units
obcpue
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1980
1990
2000
2010
year
PLOT
obcpue
index

Appendix 4b: Model building results of red grouper observed during the RVC the Florida Keys (1979 – 2007).

Step 1 for Binomial: *Type 3 Tests of Fixed Effects, AIC* = 1876.3

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	20	409	38.57	1.93	0.0075	0.0097
Month	11	409	9.33	0.85	0.5914	0.5917
Habitat	7	409	51.06	7.29	<.0001	<.0001

Step 1 for Poisson: *Type 3 Tests of Fixed Effects, AIC* = 1683.0

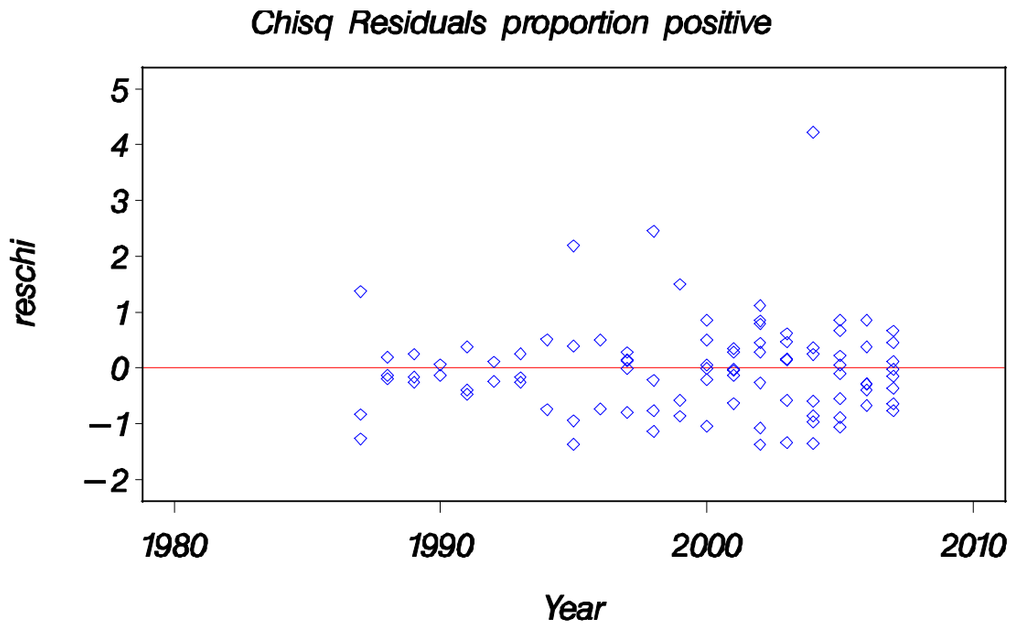
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	20	1228	81.93	4.10	<.0001	<.0001
Month	11	1228	13.94	1.27	0.2365	0.2380
Habitat	7	1228	41.35	5.91	<.0001	<.0001

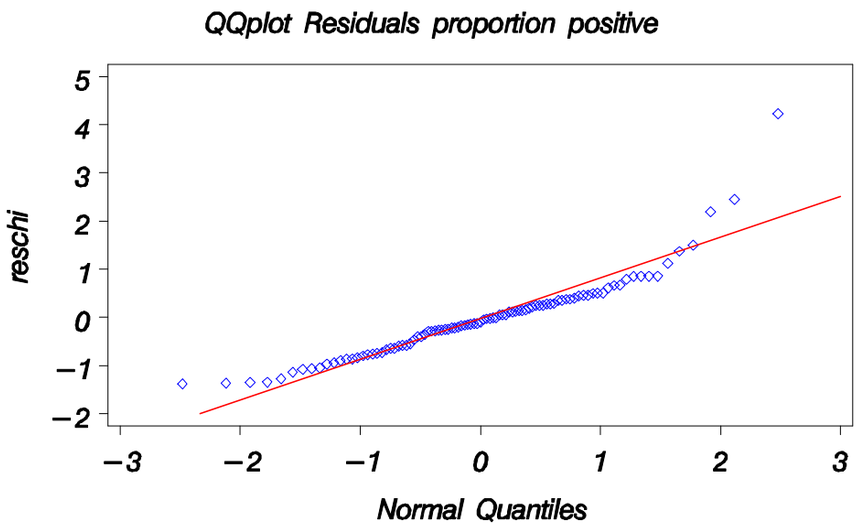
Step 2 for Binomial: *Type 3 Tests of Fixed Effects, AIC* = 237.0

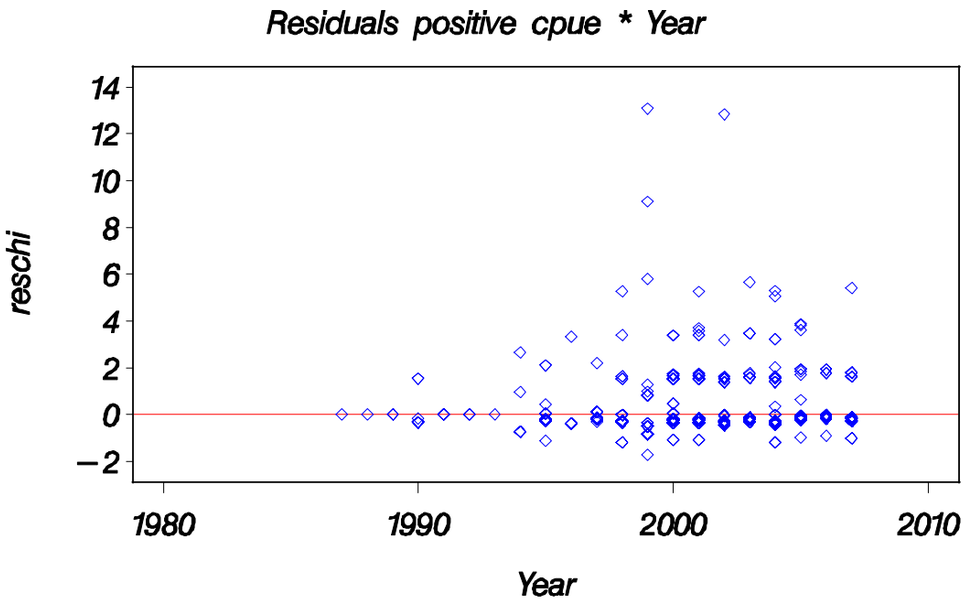
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	20	67	52.78	2.64	<.0001	0.0016
Habitat	7	67	46.25	6.61	<.0001	<.0001

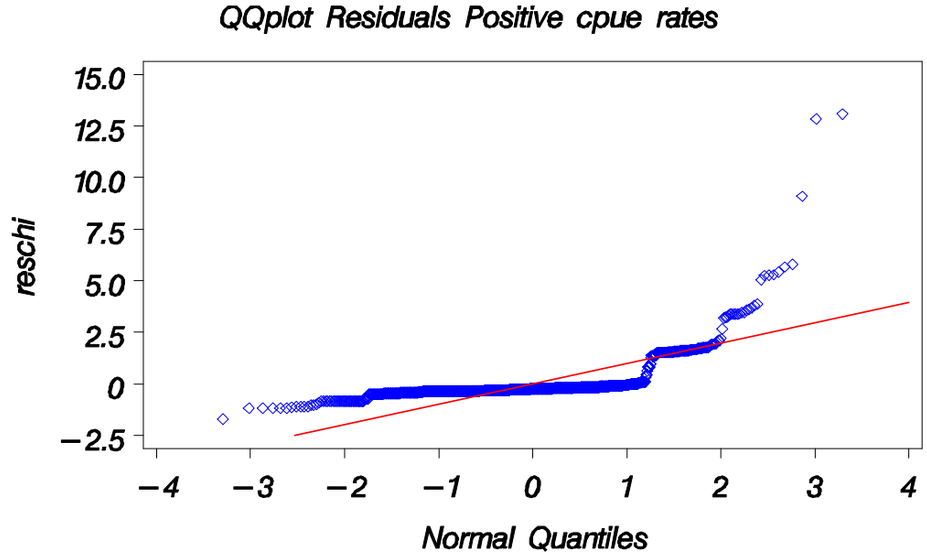
Step 2 for Poisson: *Type 3 Tests of Fixed Effects, AIC* = 1680.8

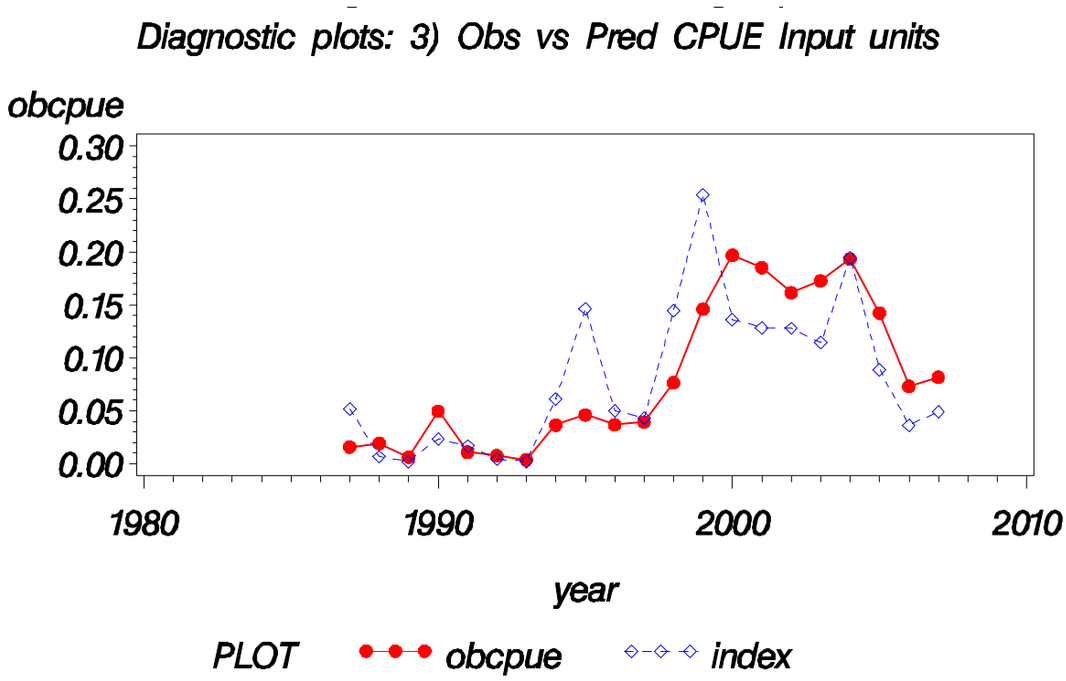
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	20	1239	78.39	3.92	<.0001	<.0001
Habitat	7	1239	41.28	5.90	<.0001	<.0001




QQplot Residuals proportion positive
reschi
5
4
3
2
1
0
−1
−2
−3
−2
−1
0
1
2
3
Normal Quantiles


Residuals positive cpue * Year
reschi
14
12
10
8
6
4
2
0
−2
1980
1990
2000
2010
Year


QQplot Residuals Positive cpue rates
reschi
15.0
12.5
10.0
7.5
5.0
2.5
0
−2.5
−4
−3
−2
−1
0
1
2
3
4
Normal Quantiles


Diagnostic plots: 3) Obs vs Pred CPUE Input units
obcpue
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1980
1990
2000
2010
year
PLOT
obcpue
index

Appendix 4c: Model building results of black grouper observed during the RVC the Dry Tortugas (1994 – 2008).

Step 1 for Binomial: *Type 3 Tests of Fixed Effects, AIC* = 166.7

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	43	16.55	2.36	0.0205	0.0389
Month	5	43	10.76	2.15	0.0564	0.0773
Habitat	13	43	17.92	1.38	0.1607	0.2091

Step 1 for Poisson: *Type 3 Tests of Fixed Effects, AIC* = 1843.9

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	721	6.96	0.99	0.4327	0.4337
Month	5	721	1.76	0.35	0.8810	0.8808
Habitat	13	721	8.42	0.65	0.8151	0.8141

Step 2 for Binomial: *Type 3 Tests of Fixed Effects, AIC* = 11.9

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	2	3.01	0.43	0.8843	0.8321
Month	5	2	1.38	0.28	0.9268	0.8938

Step 2 for Poisson: *Type 3 Tests of Fixed Effects, AIC* = 1846.6

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	726	15.34	2.19	0.0319	0.0331
Habitat	13	726	8.04	0.62	0.8412	0.8402

Step 3 for Binomial: *Type 3 Tests of Fixed Effects, AIC* = -18E307

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	0	.	.	.	.

Step 3 for Poisson: *Type 3 Tests of Fixed Effects, AIC* = 1856.7

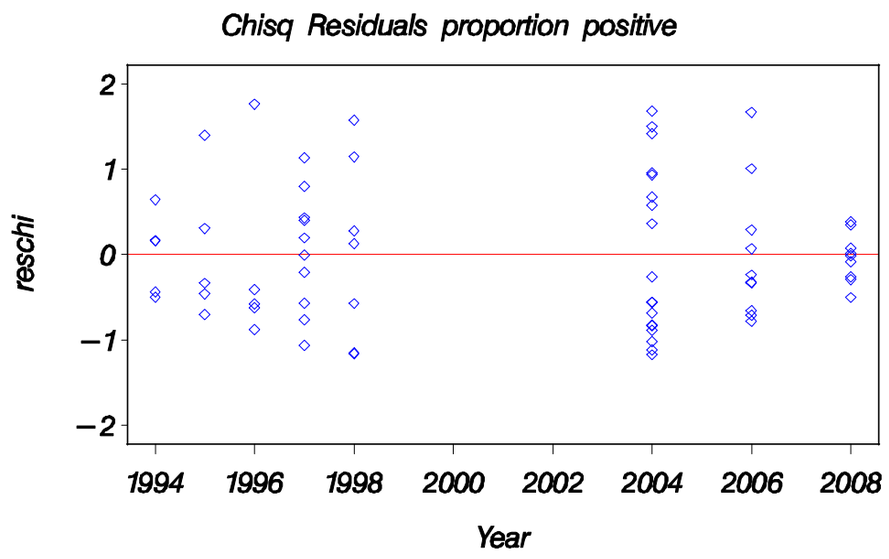
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	739	23.96	3.42	0.0012	0.0013

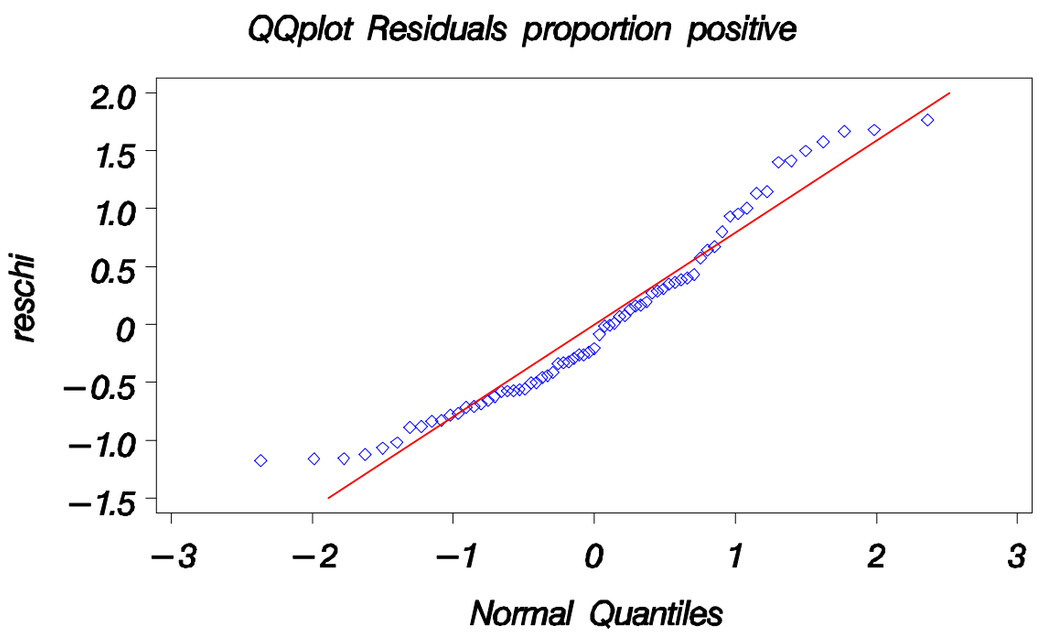
Step 4 for Binomial: *Type 3 Tests of Fixed Effects, AIC* = 166.7

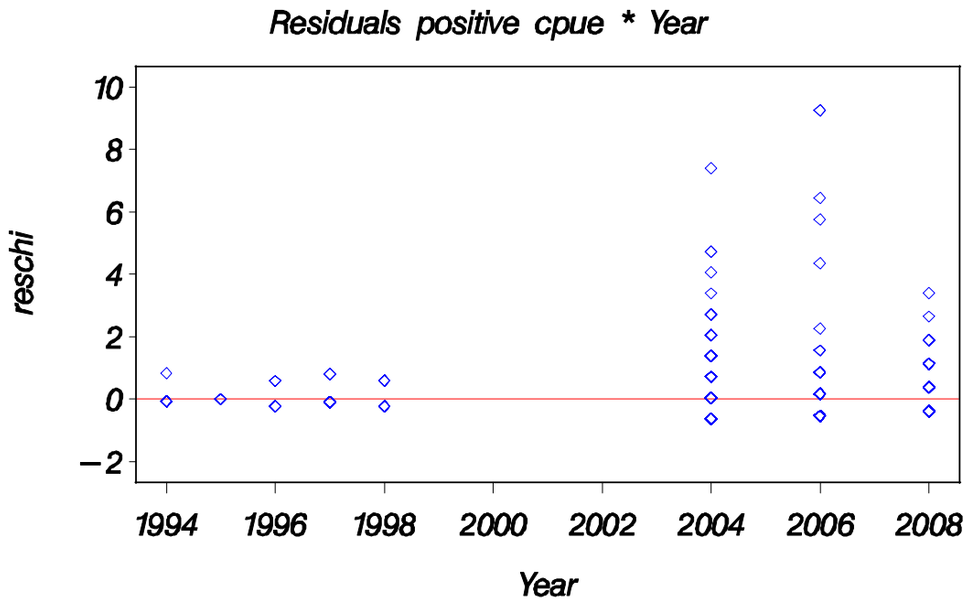
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	43	16.55	2.36	0.0205	0.0389
Month	5	43	10.76	2.15	0.0564	0.0773
Habitat	13	43	17.92	1.38	0.1607	0.2091

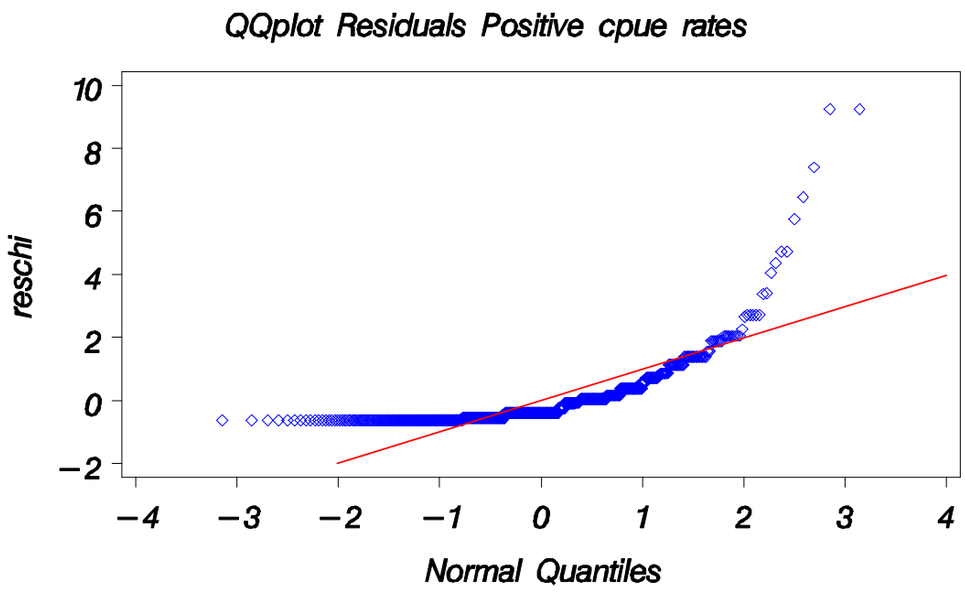
Step 4 for Poisson: *Type 3 Tests of Fixed Effects, AIC* = 1856.7

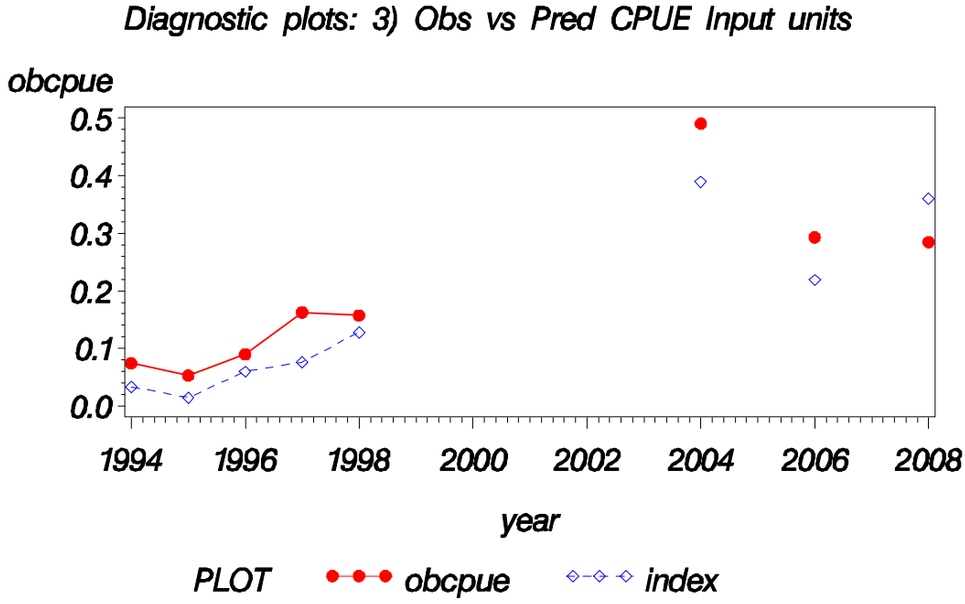
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	739	23.96	3.42	0.0012	0.0013


Chisq Residuals proportion positive
reschi
2
1
0
−1
−2
1994
1996
1998
2000
2002
2004
2006
2008
Year


QQplot Residuals proportion positive
reschi
2.0
1.5
1.0
0.5
0
−0.5
−1.0
−1.5
−3
−2
−1
0
1
2
3
Normal Quantiles


Residuals positive cpue * Year
reschi
10
8
6
4
2
0
−2
1994
1996
1998
2000
2002
2004
2006
2008
Year


QQplot Residuals Positive cpue rates
reschi
10
8
6
4
2
0
−2
−4
−3
−2
−1
0
1
2
3
4
Normal Quantiles


Diagnostic plots: 3) Obs vs Pred CPUE Input units
obcpue
0.5
0.4
0.3
0.2
0.1
0.0
1994
1996
1998
2000
2002
2004
2006
2008
year
PLOT
obcpue
index

Appendix 4d: Model building results of red grouper observed during the RVC the Dry Tortugas (1994 – 2008).

Step 1 for Binomial: *Type 3 Tests of Fixed Effects, AIC* = 173.9

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	46	16.25	2.32	0.0229	0.0408
Month	5	46	16.47	3.29	0.0056	0.0126
Habitat	14	46	20.17	1.44	0.1248	0.1733

Step 1 for Poisson: *Type 3 Tests of Fixed Effects, AIC* = 2148.4

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	1542	12.44	1.78	0.0870	0.0878
Month	5	1542	4.90	0.98	0.4276	0.4280
Habitat	14	1542	25.50	1.82	0.0300	0.0309

Step 2 for Binomial: *Type 3 Tests of Fixed Effects, AIC* = 10.9

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	2	5.06	0.72	0.6531	0.6886
Month	5	2	3.41	0.68	0.6369	0.6845

Step 2 for Poisson: *Type 3 Tests of Fixed Effects, AIC* = 2148.8

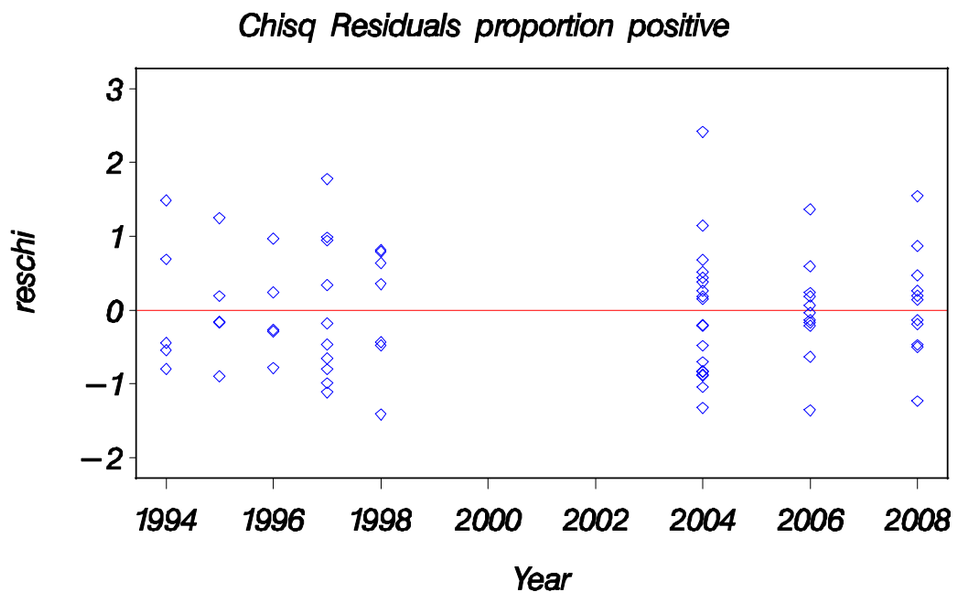
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	1547	23.79	3.40	0.0012	0.0013
Habitat	14	1547	27.76	1.98	0.0153	0.0160

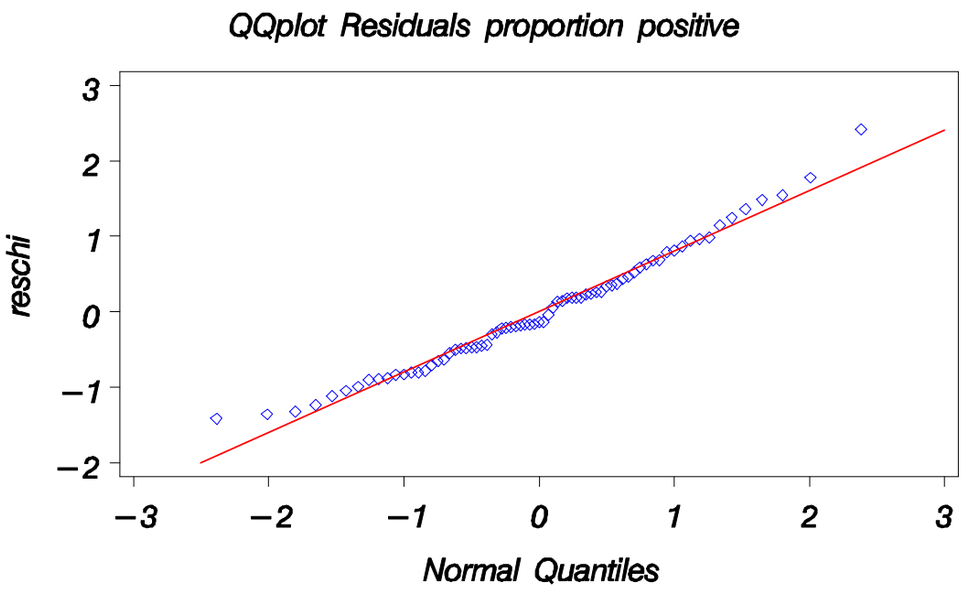
Step 3 for Binomial: *Type 3 Tests of Fixed Effects, AIC* = 173.9

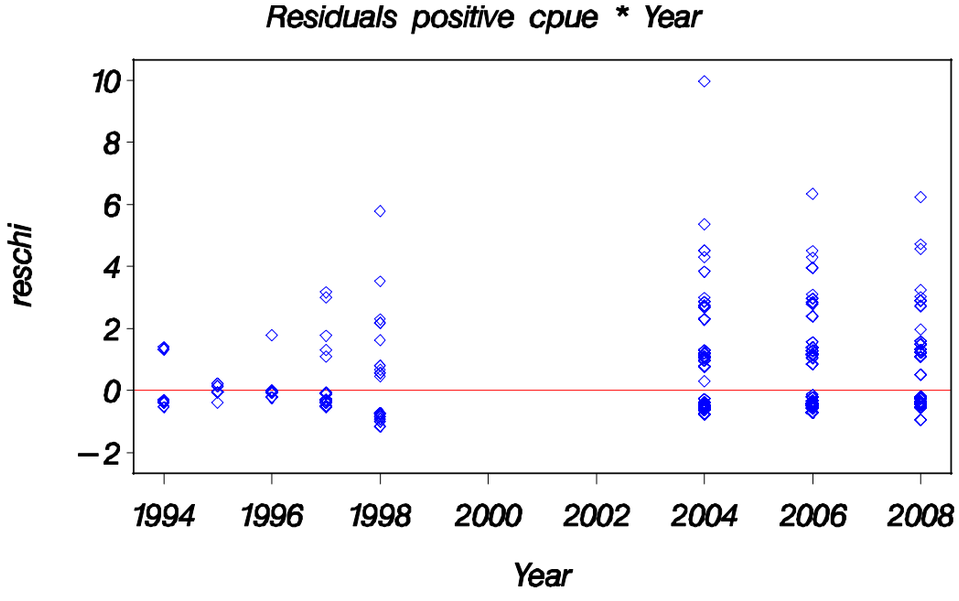
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	46	16.25	2.32	0.0229	0.0408
Month	5	46	16.47	3.29	0.0056	0.0126
Habitat	14	46	20.17	1.44	0.1248	0.1733

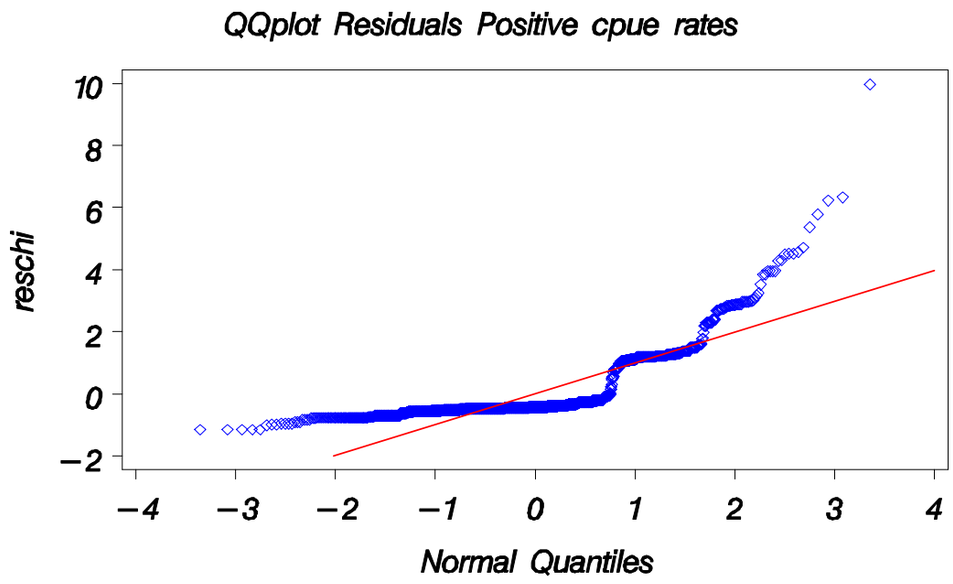
Step 3 for Poisson: *Type 3 Tests of Fixed Effects, AIC* = 2148.8

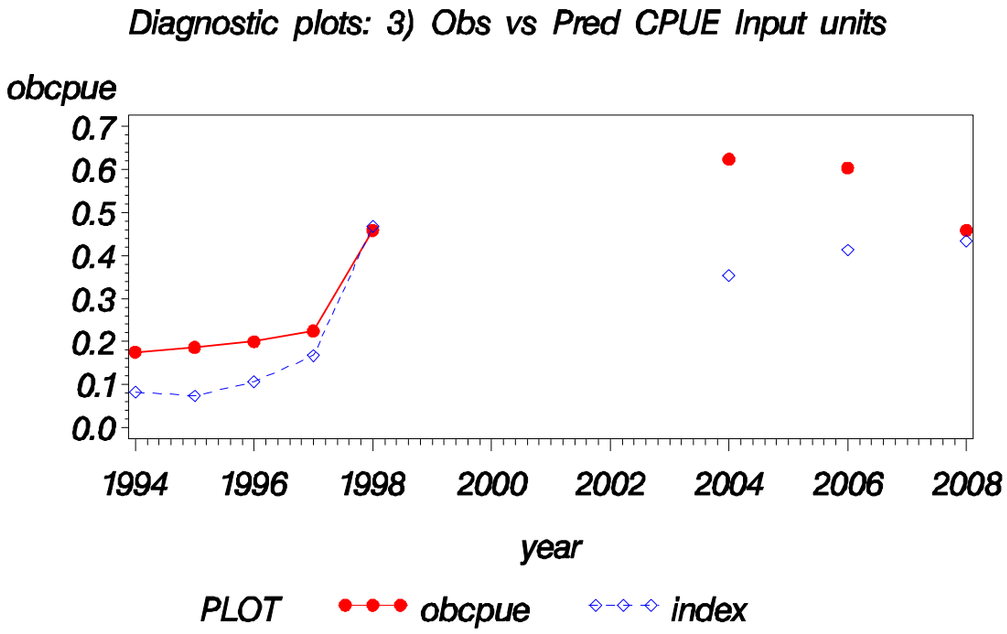
Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
Year	7	1547	23.79	3.40	0.0012	0.0013
Habitat	14	1547	27.76	1.98	0.0153	0.0160


Chisq Residuals proportion positive
reschi
3
2
1
0
−1
−2
1994
1996
1998
2000
2002
2004
2006
2008
Year


QQplot Residuals proportion positive
reschi
3
2
1
0
−1
−2
−3
−2
−1
0
1
2
3
Normal Quantiles


Residuals positive cpue * Year
reschi
10
8
6
4
2
0
−2
1994
1996
1998
2000
2002
2004
2006
2008
Year


QQplot Residuals Positive cpue rates
reschi
10
8
6
4
2
0
−2
−4
−3
−2
−1
0
1
2
3
4
Normal Quantiles


Diagnostic plots: 3) Obs vs Pred CPUE Input units
obcpue
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1994
1996
1998
2000
2002
2004
2006
2008
year
PLOT
obcpue
index