# SEAMAP Reef Fish Survey of Offshore Banks: Yearly Indices of Abundance for mutton snapper (*Lutjanus analis*)

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## INTRODUCTION

The objective of the annual Southeast Area Monitoring and Assessment Program (SEAMAP) offshore reef fish survey is to provide an index of the relative abundances of fish species associated with topographic features (banks, ledges) located on the continental shelf of the Gulf of Mexico (Gulf) in the area from Brownsville, TX to the Dry Tortugas, FL (Figure 1). The total reef area surveyed is approximately 1771 km²; 1244 km² in the eastern and 527 km² in the western Gulf. The offshore reef fish survey was initiated in 1992, with sampling conducted during the months of May to August from 1992-1997, and in 2001-2006. No surveys were conduced from 1998 to 2000 and in 2003. The 2001 survey was abbreviated due to ship scheduling and did not sample the Dry Tortugas. Mutton snapper were observed only near the Dry Tortugas and only data from the area around Fort Jefferson, Tortugas Bank and the southern most part of Pulley Ridge are included for the abundance index.

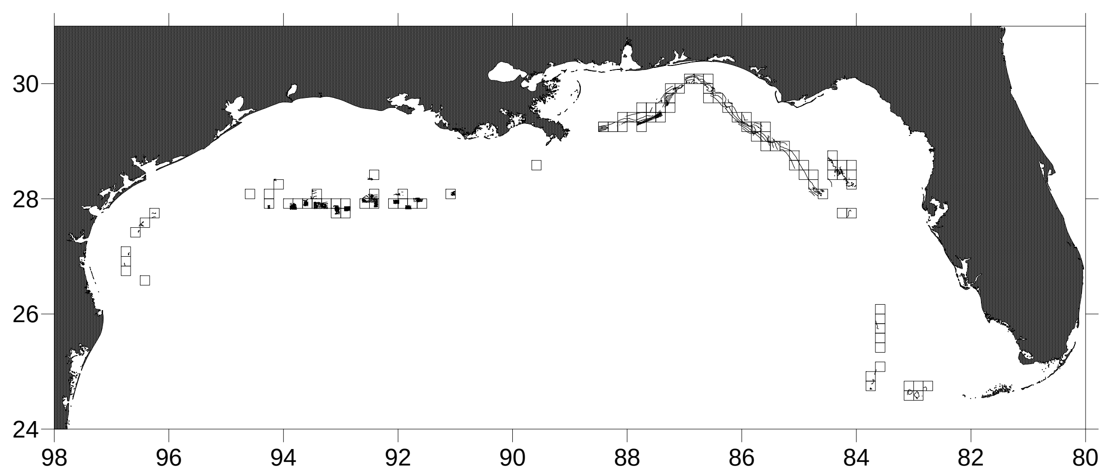


Figure 1. Gulf of Mexico shelf-edge banks sampled during SEAMAP offshore reef fish survey with sample blocks.

## SAMPLE DESIGN

The survey area is large. Therefore, a two-stage sampling design is used to minimize travel times between sample stations. The first-stage or primary sampling units (PSUs) are blocks 10 minutes of latitude by 10 minutes of longitude (Figures 2 and 3). The first-stage units are selected by stratified random sampling. The blocks were stratified, with strata defined by geographic region (4 regions: South Florida, Northeast Gulf, Louisiana-Texas Shelf, and SouthTexas), and by reef habitat area (Blocks ≤ 20 km² reef, Block > 20 km² reef). For the mutton snapper index, only the blocks near the Tortugas were used. The sample design was two-stage cluster sampling.

**GEAR**

The SEAMAP reef fish survey currently employs four Sony VX2000 DCR digital camcorders mounted in Gates PD150M underwater housings. The housings are rated to a maximum depth of 150 meters. The four Sony VX2000 camcorders are mounted orthogonally and a height of 30 cm above the bottom of the pod. A chevron (or arrow) fish trap with 1.5-inch vinyl-clad mesh is used to capture fish for biological samples. In its greatest dimensions, the trap is 1.76 m in length, 1.52 m in width and 0.61 m in depth. A 0.4 m by 0.29 m blow out panel is placed on one side and kept closed using 7-day magnesium releases. The magnesium releases are examined after each soak and replaced as needed. The trap is deployed at a randomly selected subset of video stations. Both the camera pod and fish trap are baited with squid.

**VIDEO TAPE VIEWING PROCEDURES**

One video tape from each station is selected out of the four for viewing. If all four video cameras face reef fish habitat and are in focus, the viewed tape is selected randomly. Tape viewers examine 20 minutes of the selected video tape, identify, and enumerate all species for the duration of the tape. Identifications are made to the lowest taxonomic level and the time when each fish enters and leaves the field of view is recorded. This is referred as a time in - time out procedure (TITO).

Tapes are viewed from the time when the view clears from any silt plume raised by the gear when it landed. Less than 20 minutes may be viewed if the duration when water is not clear enough to count fish is less than 20 minutes, or if the camera array is dragged. If a tape contains a large amount of fish, it is sub-sampled. There are four cases for sub-sampling: 1) when there is generally a large number of fish of a given species present throughout the tape so that following individual fish is difficult; 2) large number of fish occur in pulses periodically during the tape; 3) a single school of fish; and, 4) multiple schools of fish. The estimator of relative abundance we use from the video data is a minimum count (i.e., mincount: the greatest number of a taxon that appears on screen at one time).

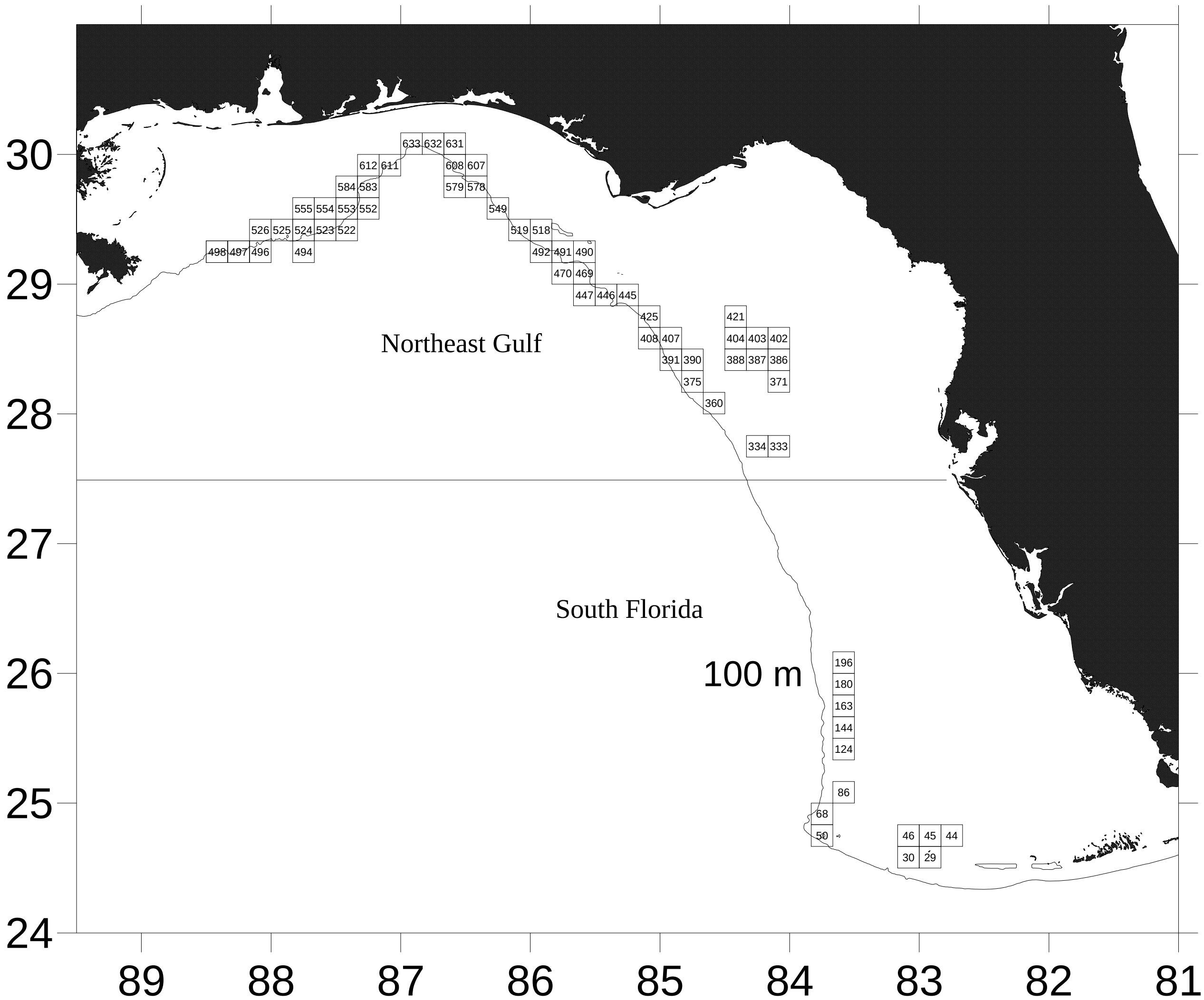


Figure 2. SEAMAP offshore reef fish survey sample blocks in the eastern Gulf of Mexico. The mutton snapper index was developed from sample blocks 29, 30, 44, 45, 46, and 50).

## STATISTICS

### Design-based Estimator

The design-based estimator of abundance employed is a ratio estimate for two-stage sampling with unequal cluster size (Cochran, 1977).

### 1. Cluster mean

$\overline{x} = \dfrac{\sum_{i=1}^{n} \sum_{j=1}^{m_i} x_{ij}}{\sum_{i}^{n} m_i}$, is a ratio estimate of the number of mutton snapper where $x_{ij}$ is the number of fish observed at the *j*-th site in the *i*-th block, and $m_i$ in the number of sites sampled in the *i*-th block.

**2. Variance of the ratio estimate of the cluster mean ($V(\bar{x})$), ignoring finite population correction**

$$V_{\bar{x}} = \frac{1}{\bar{m}^2}\left[s_x^2 + \bar{x}^2 s_m^2 + 2\bar{x}COV_{x,m}\right],$$

where $s^2_x$ and $s^2_m$ are the variances of the number of mutton snapper and number of units sampled in a cluster, $COV_{x,m}$ is the covariance between number of mutton snapper and number of units sampled in a cluster and $\bar{m}$ is the average number of sites sampled within a block.

**Model-based Index**

In addition to the calculations of cluster means, a delta-lognormal modeling approach (Lo *et al*., 1992) was employed in order to develop standardized indices of annual average mincount for mutton snapper in the region near the Tortugas. This index is a mathematical combination of yearly mincount estimates from two distinct generalized linear models: a binomial (logistic) model which describes proportion of positive mincounts (i.e., presence/absence) and lognormal model which describes variability in only the nonzero mincount data. The GLMMIX and MIXED procedures in SAS were employed to provide yearly index values for both the binomial and lognormal sub-models, respectively. The parameters tested for inclusion in each sub-model were region, year, block nested within year, and station depth (scaled to a mean of one). All variables were considered fixed except for block nested within station, which was considered random. Also, separate covariance structures were developed for each survey year. For the binomial sub-models, a logistic-type mixed model was employed. Model selection was based upon the AICc statistic (i.e. the Akaike's Information Criterion corrected for sample size). This statistic considers both the likelihood of the model and the number of parameters (Burnham and Anderson, 1992); the smaller the statistic – the more appropriate the model. Initially, several sub-model types were used to describe the nonzero mincount data. These included lognormal, Poisson and negative binomial. Based on analyses of residual scatter and QQ plots, the lognormal sub-model was more fitting than the others in describing the variability in the nonzero data.

**Fish Sizes**

The size of mutton observed during the SEAMAP survey comes from fish measured on video tape using laser reference points, which were first introduced in 1995.

## RESULTS

**Design-based Results and Conclusions**

Abundance data from all blocks sampled around the Dry Tortugas were included for analysis during all years. Few sites were sampled in 1992 – 1994. Sampling effort increased is subsequent surveys. The index of mutton snapper abundance has increased since 1992 (Table 1, Figure 1). No mutton snapper were hit by lasers until the 2005 survey. Two fish were measured in 2005 and three fish in 2006. Fork length ranged from 439 mm FL to 517 mm FL (Table 2).

**Model-based Results and Conclusions**

Due to issues of model convergence and index calculation, we dropped data during the 1994 survey year for both sub-models, due to zero catch at all site sites that year. Table 3 summarizes the parameters of the resulting binomial sub-model with the lowest AICc = 1405.2. The lognormal sub-model would neither converge while using separate covariance structures for each year, nor while including block nested within year as a random variable. Therefore, a similar covariance structure was used for all years, and block was included as a fixed variable in the sub-model. Table 4 summarizes the parameters of the resulting lognormal sub-model with the lowest AICc = 76.6. Table 5 and Figure 2 summarize the index values for mutton snapper from the Dry Tortugas area. There is an increasing trend early in the time series, with the trend reaching a plateau in 1997. This differs from the design-based index in that it peaks in 2002. Also, the design-based index has lower CV values. Point estimates between indices were very similar during the early years of the time series, and during later years, the greatest difference occurred in 2002. Usually, the advantages of a model-based approach, used to standardize annual abundance indices and based on the variables described herein, would result in a recommendation for its use over a design-based approach. However, due the small difference between point estimates of both approaches and due to the lower CV values, we recommend the use of the design-based indices (Table 5).

## LITERATURE CITED


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Table 1. Ratio estimate of the number of mutton snapper (CV=SE/Mean) observed near the Dry Tortugas.

| YEAR | Number of blocks | Number of sample units | Nominal Index | Scaled Index | V(Index) | SE(Index) | CV |
|---|---|---|---|---|---|---|---|
| 1992 | 2 | 11 | 0.182 | 0.623 | 0.107 | 0.231 | 1.273 |
| 1993 | 2 | 14 | 0.143 | 0.489 | 0.003 | 0.041 | 0.286 |
| 1994 | 2 | 14 | 0.000 | 0.000 | 0.000 | 0.000 | |
| 1995 | 3 | 44 | 0.023 | 0.078 | 0.002 | 0.025 | 1.080 |
| 1996 | 4 | 28 | 0.321 | 1.101 | 0.088 | 0.148 | 0.462 |
| 1997 | 4 | 33 | 0.364 | 1.246 | 0.069 | 0.131 | 0.361 |
| 2002 | 4 | 34 | 0.559 | 1.914 | 0.085 | 0.146 | 0.261 |
| 2004 | 4 | 26 | 0.462 | 1.581 | 0.119 | 0.172 | 0.373 |
| 2005 | 6 | 48 | 0.375 | 1.285 | 0.155 | 0.161 | 0.429 |
| 2006 | 6 | 57 | 0.491 | 1.683 | 0.131 | 0.148 | 0.300 |

Table 2. Mutton snapper fork length measured with lasers from video tapes. No fish were hit by lasers prior to 2005.

| Year | Station | Fork Length (mm) |
|---|---|---|
| 2005 | 457 | 500 |
| 2005 | 459 | 517 |
| 2006 | 42 | 475 |
| 2006 | 42 | 439 |
| 2006 | 42 | 463 |

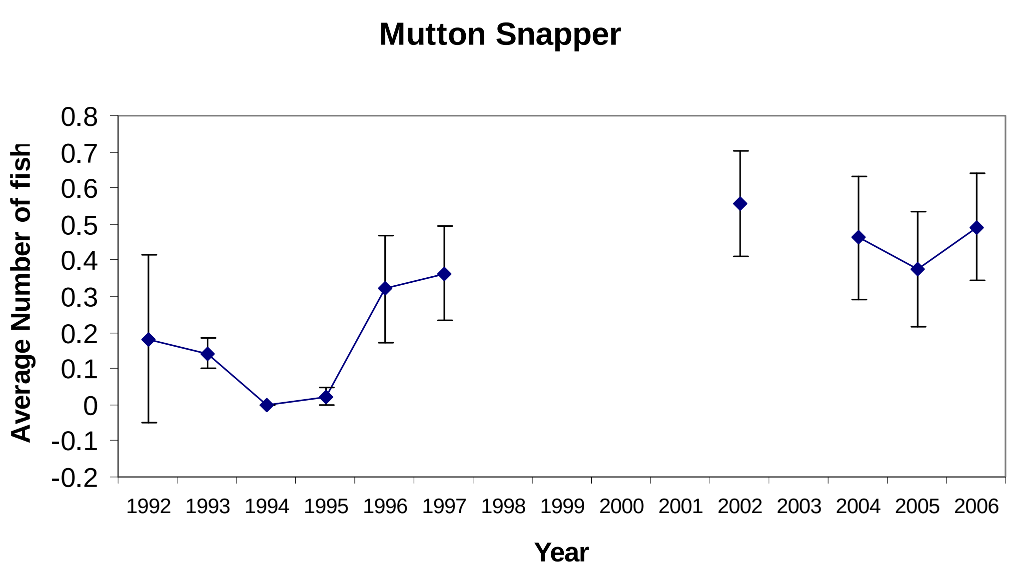


Figure 1. Design-based nominal index of abundance ± SE from SEAMAP video survey blocks located near the Dry Tortugas.

Table 3. The parameters of the resulting binomial sub-model.

3a. *Solution for Fixed Effects*

| *Effect* | *season* | *YEAR* | *Estimate* | *Standard Error* | *DF* | *t Value* | *Pr > \|t\|* |
|---|---|---|---|---|---|---|---|
| *Intercept* | | | -0.6700 | 0.4615 | 17.7 | -1.45 | 0.1640 |
| *YEAR* | | 1992 | -0.8953 | 1.0077 | 16.3 | -0.89 | 0.3872 |
| *YEAR* | | 1993 | -1.1038 | 1.0056 | 18.5 | -1.10 | 0.2864 |
| *YEAR* | | 1995 | -3.1173 | 1.1026 | 45.9 | -2.83 | 0.0069 |
| *YEAR* | | 1996 | -0.2651 | 0.6782 | 21.2 | -0.39 | 0.6998 |
| *YEAR* | | 1997 | -0.3385 | 0.6631 | 19.5 | -0.51 | 0.6155 |
| *YEAR* | | 2002 | -0.05993 | 0.7539 | 19.2 | -0.08 | 0.9375 |
| *YEAR* | | 2004 | 0.2375 | 0.7705 | 21.4 | 0.31 | 0.7609 |
| *YEAR* | | 2005 | -0.5558 | 0.6205 | 20.7 | -0.90 | 0.3807 |
| *YEAR* | | 2006 | 0 | . | . | . | . |
| *season* | spring | | 0.1326 | 0.7457 | 22.8 | 0.18 | 0.8604 |
| *season* | summer | | 0 | . | . | . | . |

3b. *Solution for Random Effects*

| *Effect* | *YEAR* | *blockno* | *Estimate* | *Std Err Pred* | *DF* | *t Value* | *Pr > \|t\|* |
|---|---|---|---|---|---|---|---|
| *blockno(YEAR)* | 1992 | 30 | 0.1870 | 0.5743 | 3.02 | 0.33 | 0.7659 |
| *blockno(YEAR)* | 1992 | 50 | -0.1870 | 0.5743 | 3.02 | -0.33 | 0.7659 |
| *blockno(YEAR)* | 1993 | 29 | -0.06835 | 0.5703 | 3.03 | -0.12 | 0.9121 |
| *blockno(YEAR)* | 1993 | 30 | 0.06835 | 0.5703 | 3.03 | 0.12 | 0.9121 |
| *blockno(YEAR)* | 1995 | 29 | -0.09621 | 0.5711 | 2.88 | -0.17 | 0.8774 |
| *blockno(YEAR)* | 1995 | 30 | 0.1991 | 0.5713 | 2.97 | 0.35 | 0.7506 |
| *blockno(YEAR)* | 1995 | 45 | -0.1029 | 0.5712 | 2.89 | -0.18 | 0.8689 |
| *blockno(YEAR)* | 1996 | 29 | -0.4740 | 0.5620 | 4.01 | -0.84 | 0.4463 |
| *blockno(YEAR)* | 1996 | 30 | 0.07465 | 0.5583 | 4.13 | 0.13 | 0.8999 |
| *blockno(YEAR)* | 1996 | 44 | 0.4561 | 0.5500 | 4.38 | 0.83 | 0.4498 |
| *blockno(YEAR)* | 1996 | 50 | -0.05671 | 0.5514 | 4.34 | -0.10 | 0.9227 |
| *blockno(YEAR)* | 1997 | 29 | 0.1256 | 0.5410 | 4.52 | 0.23 | 0.8266 |
| *blockno(YEAR)* | 1997 | 44 | -0.03089 | 0.5477 | 4.35 | -0.06 | 0.9575 |
| *blockno(YEAR)* | 1997 | 45 | 0.4027 | 0.5417 | 4.5 | 0.74 | 0.4942 |
| *blockno(YEAR)* | 1997 | 46 | -0.4974 | 0.5567 | 4.1 | -0.89 | 0.4209 |
| *blockno(YEAR)* | 2002 | 29 | 0.2289 | 0.5371 | 4.44 | 0.43 | 0.6899 |
| *blockno(YEAR)* | 2002 | 30 | 0.2289 | 0.5371 | 4.44 | 0.43 | 0.6899 |
| *blockno(YEAR)* | 2002 | 45 | -0.2888 | 0.5345 | 4.5 | -0.54 | 0.6147 |
| *blockno(YEAR)* | 2002 | 46 | -0.1690 | 0.5415 | 4.34 | -0.31 | 0.7693 |
| *blockno(YEAR)* | 2004 | 29 | -0.03014 | 0.5599 | 4.07 | -0.05 | 0.9596 |

3b. *Solution for Random Effects*

| *Effect* | *YEAR* | *blockno* | *Estimate* | *Std Err Pred* | *DF* | *t Value* | *Pr > \|t\|* |
|---|---|---|---|---|---|---|---|
| *blockno(YEAR)* | 2004 | 30 | 0.4243 | 0.5485 | 4.41 | 0.77 | 0.4785 |
| *blockno(YEAR)* | 2004 | 45 | 0.09926 | 0.5537 | 4.26 | 0.18 | 0.8659 |
| *blockno(YEAR)* | 2004 | 46 | -0.4934 | 0.5490 | 4.39 | -0.90 | 0.4153 |
| *blockno(YEAR)* | 2005 | 29 | -0.1871 | 0.5530 | 4.3 | -0.34 | 0.7510 |
| *blockno(YEAR)* | 2005 | 30 | -0.1399 | 0.5566 | 4.16 | -0.25 | 0.8135 |
| *blockno(YEAR)* | 2005 | 44 | 0.3237 | 0.5480 | 4.48 | 0.59 | 0.5832 |
| *blockno(YEAR)* | 2005 | 45 | -0.03455 | 0.5643 | 3.84 | -0.06 | 0.9542 |
| *blockno(YEAR)* | 2005 | 46 | -0.3123 | 0.5435 | 4.63 | -0.57 | 0.5924 |
| *blockno(YEAR)* | 2005 | 50 | 0.3501 | 0.5320 | 5.01 | 0.66 | 0.5395 |
| *blockno(YEAR)* | 2006 | 29 | -0.2055 | 0.5391 | 4.51 | -0.38 | 0.7203 |
| *blockno(YEAR)* | 2006 | 30 | 0.1827 | 0.5342 | 4.63 | 0.34 | 0.7473 |
| *blockno(YEAR)* | 2006 | 44 | -0.2055 | 0.5391 | 4.51 | -0.38 | 0.7203 |
| *blockno(YEAR)* | 2006 | 45 | 0.5448 | 0.5252 | 5.2 | 1.04 | 0.3454 |
| *blockno(YEAR)* | 2006 | 46 | -0.06107 | 0.5472 | 3.87 | -0.11 | 0.9167 |
| *blockno(YEAR)* | 2006 | 50 | -0.2554 | 0.5477 | 3.85 | -0.47 | 0.6661 |

Table 4. The parameters of the resulting lognormal sub-model.

*Solution for Fixed Effects*

| *Effect* | *season* | *YEAR* | *blockno* | *Estimate* | *Standard Error* | *DF* | *t Value* | *Pr > \|t\|* | *Alpha* | *Lower* | *Upper* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Intercept* | | | | 0.04712 | 0.2317 | 60 | 0.20 | 0.8395 | 0.05 | -0.4163 | 0.5106 |
| *YEAR* | 1992 | | | 0.1091 | 0.3432 | 60 | 0.32 | 0.7517 | 0.05 | -0.5774 | 0.7956 |
| *YEAR* | 1993 | | | 0.1034 | 0.3375 | 60 | 0.31 | 0.7604 | 0.05 | -0.5717 | 0.7785 |
| *YEAR* | 1995 | | | 0.1091 | 0.4601 | 60 | 0.24 | 0.8134 | 0.05 | -0.8114 | 1.0295 |
| *YEAR* | 1996 | | | -0.05541 | 0.2176 | 60 | -0.25 | 0.7999 | 0.05 | -0.4907 | 0.3799 |
| *YEAR* | 1997 | | | 0.1615 | 0.1964 | 60 | 0.82 | 0.4144 | 0.05 | -0.2315 | 0.5544 |
| *YEAR* | 2002 | | | -0.05680 | 0.2292 | 60 | -0.25 | 0.8051 | 0.05 | -0.5152 | 0.4016 |
| *YEAR* | 2004 | | | -0.2716 | 0.2353 | 60 | -1.15 | 0.2529 | 0.05 | -0.7422 | 0.1990 |
| *YEAR* | 2005 | | | 0.2365 | 0.2015 | 60 | 1.17 | 0.2451 | 0.05 | -0.1665 | 0.6394 |
| *YEAR* | 2006 | | | 0 | . | . | . | . | . | . | . |
| *blockno* | | 29 | | -0.1448 | 0.2335 | 60 | -0.62 | 0.5375 | 0.05 | -0.6118 | 0.3222 |
| *blockno* | | 30 | | -0.1562 | 0.2214 | 60 | -0.71 | 0.4832 | 0.05 | -0.5990 | 0.2866 |
| *blockno* | | 44 | | 0.2680 | 0.2148 | 60 | 1.25 | 0.2170 | 0.05 | -0.1617 | 0.6976 |
| *blockno* | | 45 | | -0.04676 | 0.2199 | 60 | -0.21 | 0.8324 | 0.05 | -0.4867 | 0.3932 |
| *blockno* | | 46 | | -0.3976 | 0.2438 | 60 | -1.63 | 0.1081 | 0.05 | -0.8852 | 0.08998 |
| *blockno* | | 50 | | 0 | . | . | . | . | . | . | . |

Table 4. The parameters of the resulting lognormal sub-model.

| *Solution for Fixed Effects* | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Effect* | *season* | *YEAR* | *blockno* | *Estimate* | *Standard Error* | *DF* | *t Value* | *Pr > \|t\|* | *Alpha* | *Lower* | *Upper* |
| *season* | | | spring | 0.4337 | 0.2351 | 60 | 1.84 | 0.0700 | 0.05 | -0.03660 | 0.9040 |
| *season* | | | summer | 0 | . | . | . | . | . | . | . |

Table 5. Index values for mutton snapper from the Dry Tortugas area.

| *Survey Year* | *Nominal Frequency* | *N* | *Index (in mincount units)* | *Scaled Index (to a mean of one)* | *CV* | *LCL (for Scaled Index)* | *UCL (for Scaled Index)* |
|---|---|---|---|---|---|---|---|
| 1992 | 0.18182 | 11 | 0.24522 | 0.77260 | 1.14304 | 0.12414 | 4.80850 |
| 1993 | 0.14286 | 14 | 0.20542 | 0.64718 | 1.21104 | 0.09676 | 4.32858 |
| 1994 | 0 | 14 | | | | | |
| 1995 | 0.02273 | 44 | 0.03029 | 0.09544 | 3.07720 | 0.00445 | 2.04563 |
| 1996 | 0.28571 | 28 | 0.34866 | 1.09848 | 0.60358 | 0.36031 | 3.34897 |
| 1997 | 0.27273 | 33 | 0.41260 | 1.29994 | 0.56709 | 0.45213 | 3.73751 |
| 2002 | 0.35294 | 34 | 0.40055 | 1.26200 | 0.54335 | 0.45633 | 3.49006 |
| 2004 | 0.42308 | 26 | 0.38867 | 1.22454 | 0.52440 | 0.45693 | 3.28168 |
| 2005 | 0.22917 | 48 | 0.37819 | 1.19152 | 0.57011 | 0.41240 | 3.44262 |
| 2006 | 0.36842 | 57 | 0.44699 | 1.40829 | 0.32102 | 0.75278 | 2.63460 |

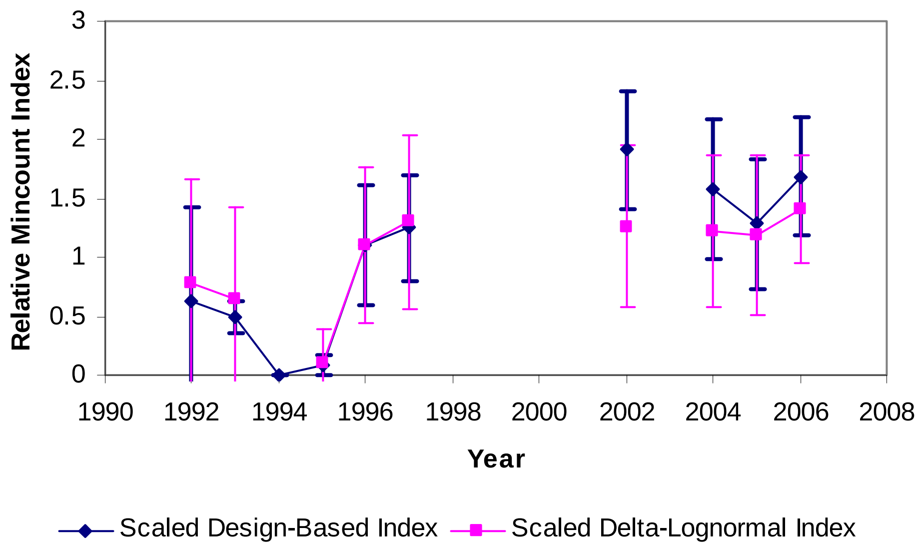


Figure 2. Scaled design-based and scaled delta-lognormal indices of abundance ± SE from SEAMAP video survey blocks located near the Dry Tortugas.