**An Examination of the Mutton snapper, *Lutjanus analis, C*ommercial Catch per
Unit of Effort Data in Puerto Rico from 1983-2005 Available for Use in Developing
Estimates of Abundance**

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Report Version Dated 6/4/2007 3:27:25 PM

Introduction

Cummings and Matos-Caraballo (2007) and Matos-Caraballo (2004) provided descriptions of the commercial mutton snapper, *Lutjanus* analis, fishery in Puerto Rico. Those studies also provided summary information on observed (nominal) catch per unit of effort (CPUE) of mutton snapper in Puerto Rico's commercial fisheries. Recent studies have reported a growing concern regarding overfishing of many of the reeffish species in Puerto and in particular several species of snappers, groupers, and the hinds (Matos-Caraballo, 2004b). Matos-Caraballo (2004) reported increasing fishing pressure on mutton snapper and in particular, on spawning aggregations, between 1988-2001 and 2001-2001. Matos-Caraballo (2004b) further noted a general perception occurring that the mutton snapper population in Puerto Rico was declining.

The mutton snapper is considered to be a very wary fish, is known to exhibit solitary behavior and, rarely is found in groups or schools except during spawning aggregations (Domeier et al., 1996). Mutton snapper are known to form large transient schools during the period of spawning (Burton et al., 2005, Bortone and Williams, 1986, Figuerola and Torres, 2001, Rivera unpub.; Allen, 1985; Claro, 1981; Thompson and Munro, 1974). During the spawning period, it has been reported that the aggregations also exhibit site fidelity (Allen, 1985); this particular life history characteristic behavior makes the mutton snapper very vulnerable to fishing pressure. Matos-Caraballo (2004b) also reported that many fishers report that they only fish this species during the time of spawning. Percentage landings by month data provided by Cummings and Matos-Caraballo (2007, see Table 4, Figure 3a of that report) indicates that while the percentage of reported landings does show increases during the presumed time of spawning-spring and early summer, that mutton snapper have been historically exploited during all months of the year. Matos-Caraballo (2004) also reported that commercial fishers in Puerto have indicated that the mutton snapper spawning aggregations have been fished since the early 1980's. Mueller (1995) citing Brownell and Rainey, 1971) noted that overfishing of shelf-edge spawning aggregations had contributed to a major decline in landings and, in some locations off Florida and Cuba, to a total collapse of the fishery.

The objective of this report is to examine additional information on nominal CPUE of the mutton snapper commercial fisheries in Puerto Rico available since the Matos-Caraballo (2004) study and further to investigate the utility of the data for calculating stock abundance trends for mutton snapper population in Puerto Rico. The results are intended to supplement the existing information on mutton snapper CPUE trends in Puerto Rico. In addition, results from the analyses and steps leading to developing standardized mutton snapper CPUE trends may provide input into future research needs of the commercially fished reeffish stocks in Puerto Rico.

Data Used and Methods of Analysis

Fishery Data Collection Description and Data Used

The commercial fisheries data collection system in Puerto first began in July 1967 as a project entitled "Fishery Statistical Program" (2-56-R) under authority and financial assistance of the Commercial Fisheries Research and Development Act of 1964 (PL-88-309) (Juhl and Suarez-Caabro (1972). Detailed descriptions of the data collection

and field sampling procedures exist. Suarez-Caabro (1970), Collazo and Calderon (1988) and more recently Matos-Caraballo (2004) provided comprehensive accounts. Presently, the fishery data collection is carried out by the Fisheries Statistics Program (FSP) of the Puerto Rico, Department of Natural Environment and Resources (DNER), Fisheries Research Laboratory (FRL) located in Mayaguez (Puerto Rico). Attributes collected pertaining to the commercial fishery statistics data used in this study were described in detail by Cummings and Matos-Caraballo (2007, 2003). That report and Matos-Caraballo (2004b, 2004c) also provided information on concerns related to species identification problems and the possibility that aggregate data reporting occurred in the early years, for many species, including several snappers and groupers. There was concern that mutton snapper might have been reported as silk snapper or 'snapper' before 1987. In addition, discussion at the SEDAR14 Data Workshop occurred regarding the accuracy of data reporting during the early years of the statistics program. Therefore, analyses in this study only considered individual sales records since 1989.

All analyses of the CPUE data in this study were carried out on data records that were considered to be at the individual 'fishing trip' level of resolution. Cummings and Matos-Caraballo (2007, 2003), in their analyses of yellowtail snapper, documented that many of the individual reported yellowtail snapper sales records were not always at the individual (single) trip level (see Table 23 and Figure 14 that report). Similar calculations for mutton snapper and also for conch fishery (see Cummings and Matos, 2007; McCarthy, 2007; Valle-Esquivel, 2002) documented this reporting problem. Those latter studies independently recommended that for purposes of calculating CPUE that landings records having recorded values of '1' for the 'NTrips' data variable be used in analyses, and all other's excluded. Specifically for the mutton snapper CPUE records for 1983-2005, 68% of the observations indicated that 'NTrips' equaled '1' (see Table and Figure 5 of Cummings and Matos-Caraballo, 2007). The remaining data records reflected values for the 'NTrips' variable of '0' or values ranging from 1-99 or in many cases the 'NTrips' variable was 'missing'. Matos-Caraballo (2004b) in his analysis of the 1998-2001 landings data, that 82% of the landings records from those years indicated 'NTrips=1' and he conducted his analyses using only records where the 'NTrips' variable was '1'. It is possible that in the more recent years, that more of the fishers are reporting their landings at the individual trip level. Unfortunately, as noted in each of these studies, retaining only landings records with the 'NTrips' variable equal to '1' eliminates many of the individual records, however, there is no logical or objective basis on which to determine how to interpret the true value for 'NTrips' variable $>$'1' or equal to '0'.

Attributes Recorded and Measure of CPUE

For the majority of data records, the information recorded for each landings (sales) record included: date of sale (year, month, day), fishing center of sale, the gear employed (lines, nets, beach seine, pots, etc.), pounds sold, and the 'NTrips' variable. The data set available since 1983 in computerized form is to considered a sample of the trips as not all fishers report; landings became mandatory in 2004. Reporting rates have fluctuated over the time period, 1983-2005, from about 51% to 75% annually (Cummings and Matos-Caraballo, 2007; SEDAR14 Data Workshop Report Fishery Description Section, Table 4 that report). For the CPUE analyses, the measure of catch was 'landings

in weight' per individual trip and the measure of trip effort was a single or 'unique' trip. Units of landings weight (round weight) are believed to have been consistent over the period of the study, 1983-2005. Although some of the individual landings data records also included additional auxiliary information on effort including: hours fished, number of hooks, number of traps, number of hours soaked, and/or the number of divers however, these attributes were not recorded for the majority of landings records thus, the initial mutton snapper CPUE standardizations employed a trip as the basic unit of effort.

Reasoning for Data Inclusions

Prior to evaluating the data for CPUE trends, it was necessary to carry out several logistical or programmatic tasks on the individual landings data records. Since the analyses were carried out the individual trip resolution, it was first necessary to identify unique fishing trips in the dataset. Cummings and Matos-Caraballo (2003) noted that the Puerto Rico commercial landings sales records did not include a variable to identify unique fishing trips until 2003, at which time, a unique trip identifier was added to each sales record at the time of key punching. For the purpose of generating unique fishing trip identifiers for this study, a computer algorithm was used to generate a virtual trip identifier, containing all unique occurrences of several data attributes which were always recorded on the landings sales records: date + fisher identification code + municipality code + fishing center code + gear code+ 'NTrips' variable. A tabular listing and a general map of the municipality codes are provided in Table 1 and Figure 1. The resulting dataset of unique landings trip records were queried and individual trip data records having recorded values of '0' or >'1' for the 'NTrips' attribute were excluded from the mutton snapper CPUE analyses. In addition to generating unique landing trip records for the CPUE analyses, two additional programmatic tasks were carried out.

Selection of Zero Trip Landings Data Records

At the SEDAR 14 Data Workshop nominal indices for the positive or successful mutton snapper landings, as calculated by Cummings and Matos (2007) were presented and discussed. The SEDAR 14 panel recommended that in addition, to incorporating the positive or successful mutton snapper landings records into the CPUE trend, that also reeffish trips which could potentially have landed mutton snapper but did not indicate a positive catch of mutton snapper, be incorporated into the development of a standardized CPUE trend. These latter type observations are commonly referred to as 'zero trips'. This situation is frequently encountered by analysts when evaluating large fishery dependent data time series and attempting to identify or to partition out groups of the observations that are potentially relevant to the species under study. This analysis dilemma arises particularly in the case of examining commercial fisher logbook data, or datasets of recreational catches such as that from the Marine Recreational Fisheries Sampling Survey (MRFSS) (Osborn et al., 1996), and also from visual census surveys. In the situation where abundance trends are developed through a classical experimental survey, this situation does not normally occur. Stephens and MacCall (2004) noted the importance of objective reasoning in the approach used to identify the relevant zero trip data records.

Several procedures have commonly been used by fisheries researchers for the selection of what is often referred to as 'zero trips' or 'zero catch records'. These include for example: selecting trips based on some pre-set percentage contribution of a pre-selected group of species that are thought to co-exist with the study species. The approach for defining the 'species group' or the pre-set percentage contribution has been in many cases very subjective. Other researchers have employed an index similar to an ecological association value, or an index calculated for a species or group of species to exclude or include trips (e.g., the Heineman[1] Association Statistic –see Cass-Calay and Bahnick, 2002). Use of the Heineman approach requires selection of a cutoff value for the statistic for designating trip inclusions and does not have a statistical nor biological. Stephens and MacCall (2004) described an analytical approach based on the species composition of a trip, for determining objectively which observations might be included together in such analyses of CPUE observations. The results of the Stephens and MacCall approach are thought by some analysts to be more reproducible in theory, and thus possibly more effectively eliminate potential subjectivity normally introduced from less objective approaches. Their procedure utilizes a logistic regression of the presence-absence matrix of the multi-species catch composition. Clearly there is no definitive way of selecting the 'zero' catch trips.

The Stephens and MacCall (2004) method was used in this study, subsequent to the SEDAR14 Data Workshop, as an aid in designating or identifying the 'zero' catch trips that could have possibly occurred in habitat where mutton snapper could have been caught. The input data set was a presence absence matrix for each of the unique trip identified by the computer algorithm, in which the species included had occurred historically in at least 1% of the mutton snapper trips. The evaluation of the logistic regression was carried out using computer software code made available by staff of the NMFS, SEFSC Sustainable Fisheries Division which implements the logistic model using the Statistical Analysis System (SAS, Version 9.0) GenMod procedure (M. Ortiz, pers. com.).

In Puerto Rico, mutton snapper is landed as one of a large number of very common reeffish species, so not unexpectedly many species were frequently indicated as caught along with the study or target species. The final input analysis set included some 32 species having been landed in at least 1% of all the reeffish trips, the full preliminary input analysis set prior to ranking the island wide reeffish trips, included 273 unique species id's having been recorded as landed. Of these, some 69 species were represented in 75% of the total trips. There were a large number of species recorded who were very rarely landed, their representation in the overall reeffish data set was less than 0.1% each of all the trips. Normally, the landings contribution of these lesser species was less than 100 pounds total and the frequency of occurrence was low, <25 landing reports. Weiler and Suárez (1980) noted that about 130 species were represented in the small scale Puerto Rican fishery representing about twenty-one finfish families and five species of invertebrates. In this study, some 32 species occurred in at least 1% of all the trips reported from 1983-2005. Dammanm (1969) commenting on the diversity of the fish

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[1] Heinemann, Dennis. The Ocean Conservancy, 1725 DeSales Street, Suite 600, Washington, D.C. 20036

fauna in the Caribbean, noted that early researchers (e.g., Bullis and Carpenter, 1968 cited in Dammanm, 1968) had documented some 1,700 fish species existing in the greater Caribbean. He further noted that some 450 species had been documented in Puerto Rico and of those about 200 species were considered commercially important with the remaining referred to as 'latent' resources (Erdman, 1968; Dammanm, 1969). Dammanm noted that some 275-300 species had been documented for the Virgin Islands; his notes further suggest that some 60-80 species were being utilized commercial at that time (Dammanm, 1969; Randall, 1968). The full evaluation results for the Stephens and MacCall (2004) analysis for the Puerto Rico commercial landings data with mutton snapper are available upon request. Summary results are presented in Table 1 of this report and those indicate that nearly all of the 32 top ranking species, those that were recorded in at least 1% of the trips, were found to be significant with the target species, mutton snapper.

Geographic or Spatial Data Inclusions

In addition to selection of zeros trips based on species occurrence, consideration was given to identifying geographical areas that were areas of suitable habitat for mutton snapper. During the SEDAR14 Data Workshop, a subgroup of the panel consisting of the Puerto Rico DNER port agents (H. Lopez-Pelet, L. Rivera) and a commercial fisherman (A. Maldonado) examined maps of fishing centers and summary tables delineating the individual fishing centers where mutton snapper were landed (See Cummings and Matos-Caraballo, 2007, Table 5, Figure1). Additional discussion was made by telephone with Puerto Rico samplers unable to attend the Data Workshop. This information was used to identify distinct areas (i.e., municipalities) which could potentially be considered as mutton snapper habitat and all fishing centers where mutton snapper could be landed at. In addition, municipalities that contributed 1% of more across all years were included as probable areas where the study species could be caught and landed. These municipalities were identified by unique codes and are listed in table 2 and the locations are depicted in Figure1.

From the SEDAR14 Data Workshop discussions and the Stephens and MacCall output results, a 'Base Case' data set was formed which included all trips from these municipalities, having landed one of more of the species indicated through the Stephens-McCall (2004) method as being significantly related to mutton snapper catch. In addition, all the positive or successful trips landing mutton snapper were also included. These observations were then utilized to evaluate standardizations of CPUE trends for the mutton snapper in Puerto Rico commercial fisheries. Cummings and Matos-Caraballo (2007) and Matos-Caraballo (2004) identified the primary or dominant gears accounting for the majority of removals of mutton snapper. Historically throughout the 23 year time series, 1983-2005, removals from hook and line gear have accounted for some 46% of the removals across all years while pots or traps have accounted for about 28.5%. Mutton snapper landings (in pounds) were also taken in nets (12.5%) diving operations (6.8%), seines (3.3%), vertical lines (2.2) and some by cast nets (0.4 %. Subsequent analyses in this study of the CPUE data included only observations of mutton caught using hook and line gear and from the pot fisheries from 1989 forward, and these were examined separately to derive individual fishery specific CPUE trends. Although substantial

quantities of mutton snapper are taken by gillnets, seines on occasion and through dive operations the number of available observations was not sufficient temporally nor spatially to allow standardizations to the raw data. Cummings and Matos-Caraballo (2007) presented the distribution of observations by gear within a year; that information is also provided here to allow a brief review of sample sizes of unique trips available by fishery within year for use in CPUE standardizations as Table 5.

CPUE Standardization Procedures:

For each of the two major gears or fisheries harvesting mutton snapper in Puerto Rico, lines and pots, standardized yearly CPUE indices were developed. The analytical procedure is briefly described here. Because the input datasets contained a large number of zero observations of mutton snapper trips, the delta lognormal approach (Lo et al., 1992) was employed to accommodate the 'zeros' in the data. Although other index estimation approaches have been implemented, including the conventional 'adding of a constant' to the zero catch observations, application of the delta lognormal procedure was considered appropriate here for a several reasons . Porch and Scott (1992) provided results which support using a delta-lognormal analysis for parameter estimation. The choice of the constant to add can be problematic and lead to difficulties in carrying out hypothesis tests as the choice of the constant affects the residual distributions (see Porch and Scott, 1992). The relevance of this task lies in the ability to be able to precisely evaluate main effects and thus in final choice of model factors.

In application in this study, first a lognormal model was fitted to the set of positive trip catch records (referred to as "positives" or "successes"). Then, a separate analysis, a binomial fit, was made on the distribution of the proportion of positive landings records (trips) (referred to as "the proportion of positives") was carried out. The Lo approach combines the two analyses, the lognormal on the successes with the binomial on the proportion of positives, to yield estimates of the annual year effects, the main parameter of interest.

For each of the two models fitted, the lognormal and the binomial, the input model included main effect terms or factors that could potentially have an effect on resulting CPUE, as independent variables in the model fit. As mentioned above in the description of the input data, very few attributes were recorded for each landings record and included again: Year, month, day, fishing center, major municipality and gear. Variables that were evaluated in this study as effecting CPUE were: Year, Month, Major municipality. In some fits possible interaction effects between two variables were evaluated: Year*Month, Year*Area, and Area*Month. Interaction term effects were only evaluated after the selection of the final model factors was made. Interaction terms were always modeled as random effects in the model.

Model evaluation was done using a generalized linear modeling Glimmix and the Mixed procedure (Version 8.02 of the SAS System for Windows © 2000, SAS Institute Inc., Cary, NC, USA). For the proportion of successful trips per stratum (i.e., year-area, year-month, year-month, area) it was assumed that the density approximated a binomial distribution, where the estimated probability was a linearized function of the fixed main

effect factors. In addition, the second generalized linear model fitted to examine the effect of the fixed factors on log(CPUE) of successful trips was carried out assuming a normal error distribution. To evaluate model factor selection a forward stepwise procedure was used to quantify the relative importance of the factors (main effects) that influenced catch rates. First the null model was run containing only the year effect. These results reflect the distribution of the nominal data. Next a potential main effect factor was added to the null model one at a time, and the resulting reduction in deviance calculated. Deviance is a measure of the ability of the model factor(s) to explain the residuals (i.e., the error from the model fit) and can be used to evaluate the performance between models to fit the data. It was assumed that the deviance between two models follows a Chi-square distribution. The factor that produced the largest reduction in deviance was added to the base model if the factor was significant (p<0.05) based upon a Chi-Square test, and the reduction in deviance per degree of freedom was evaluated. This model then became the base model, and the process was repeated, adding factors and interactions individually until no factor or interaction met the criteria for incorporation into the final model. Deviance tables were prepared for review of the effects of the individual main effect factors for each component in the delta model: the binomial fitted to the proportion of successful trips and the lognormal model fitted to the positives. The final model factor selection was based on 1) review of the deviance tables, 2) significance of each main effect as determined by a chi-square distribution, and 3) the corrected Akaike information criteria (AICC) statistic. Year was always included in the model, regardless of its importance because it is required to calculate the standardized catch index for each year. In reality, for this study, model selection of main effects was fairly straightforward as there were only three main effects (Year, Area, and Month). Main effect terms were incorporated into the final model evaluation as fixed effects while interactions were included as random effects.

Results

Puerto Rico Commercial Mutton Snapper Line Fishery

Over the 17 year time period for which mutton snapper standardized CPUE was evaluated, 1989-2005, some 10,283 individual trip records existed from the total set of virtual (i.e., computer generated) records, indicating positive or successful landings. These 10,283 trips represented the successful catches of mutton snapper by line gear from the fishing municipality locations having been identified by port agents and fishers during the SEDAR14 Data Workshop. The annual nominal unadjusted trends in CPUE (lbs/trip) are presented in Figure 2a.

The frequency distribution of the individual log(CPUE) observations is presented in Figure 2b and does not indicate any major deviance from normality. The unadjusted annual nominal CPUE trend (Figure 2a) suggests a decline in mutton snapper line fishery CPUE in 1991 that continued through 1993, followed by an increase in nominal log(CPUE) through about 2003, after that period mutton snapper line CPUE declined.

Final Standardized Index Model Structure :

1. Lognormal Fit on the positives (successful) log (CPUE):

The Puerto Rico commercial reeffish data included 10,283 positive trip records that indicated landing mutton snapper between 1989 and 2005. On an annual basis, the percentage of positive trips of all trips ranged from about 6.2% to 14.2% averaging 10% but in general the proportion of positives increased with time (Figure 3a). Clearly many factors could contribute to the ratio of positives to the total number of reeffish trips. These factors could include variability in fisher reporting rates by area, by fishery, and individual fisher variability. In addition, the selection process for inclusion of the zero trip observation is a very important factor. Lastly, changes in abundance or some operational change in the fishery could have affected the proportion of positive CPUE records. The increase in nominal log (CPUE) indicated in Figure 2a is also associated with an increase in the annual proportion of trips having positive or successful landings of the study species, mutton snapper (Figure 3a). Whether this observation is related to the rate of fisher reporting or to more accuracy in reporting landings cannot be determined.

The final lognormal model selected for the mutton snapper line fishery positive trips contained terms for these main effects: Year, Municipality and Month in addition to an interaction effect for year and municipality. Municipality can be considered a spatial effect reflecting to some degree spatial variability in population abundance. The results of the deviance analysis are presented in Table 6. The results show that for the lognormal model that municipality (area) had the largest effect in the fit, followed by month. In addition, the interaction effect for Year*Municipality was found to be significant in the final lognormal model. The final model structure fitted to the positive line fishery log(CPUE) observations was:

$$\text{log (CPUE)} = \text{Year} + \text{Municipality} + \text{Month} + \text{Year} * \text{Municipality}$$

Note, the Year and Area term were not highly correlated 0.0699 however the results suggest overdispersion. In the absence of correlated variables and assuming the model (the lognormal) was appropriate; it is possible that the model did not contain sufficient information (main factors) to explain the variability. As indicated in the description of the model standardization procedures, very few attributes were recorded for the individual landings trip data.

2. Binomial Fit to the Proportion of Positives of log (CPUE)

The final binomial model selected for the mutton snapper line fishery contained terms for Year, Municipality and Month in addition to an interaction effect for year and municipality. Municipality can be considered to characterize the spatial structure in the data, reflecting to some degree spatial variability in population abundance as reflected in the municipality effect. The resulting deviance table which summarizes the effects of each main effect input into the lognormal modes is presented in Table 7. The frequency distribution of the proportion of percent positives is shown in Figure 3b and shows that overall, the proportion of positives was low was fairly low. The average proportion of positives averaged about 10% across all years but was very low particularly between 1993 and 1997. The final binomial model structure fitted to the proportion of positives was:

Proportion Positives = Year + Municipality+ Month + Year*Municipality.

Note, the Year and Area term were not highly correlated (r=0.17), however the fitted results indicated overdispersion. In the absence of correlated variables and assuming the model (binomial) was appropriate it is possible, that the model did not contain sufficient information (main factors) to explain the variability. Very few attributes were recorded for the landings trip records.

3. Resulting Standardized Mutton Snapper Line Fishery Indices
  The resulting Year effects from the combination of the estimates from the fitted binomial to the proportion of positives and the lognormal fitted to the positive log(CPUE) are presented in Table 8. Estimated 95% confidence intervals are also given in Table 8. The plotted estimates of the nominal log (CPUE) annual values and the predicted index are presented in Figure 4a. The plotted estimates of the standardized log(CPUE) yearly indices, 95% confidence intervals and the nominal log (CPUE) yearly values are presented in Figure 4b. The observed nominal percentage of positives along with the predicted percentages of positives is illustrated in Figure 4c. From Figure 4c, it is apparent that the predicted fit of the positives tracks the observed trend much better in the later part of the time series. There is a tendency of the model to underestimate the observed log (CPUE) during the middle years, 1994-1997. The latter year, when the model fit is better, is the period of years in which the percentage of positives (trips) was increasing, possibly with the additional observations more information was added to the model. During the later years, 1999-2002, the percentage of positive trips increased from around 7% to 14%, but declined again during 1004 and 2005 (Table 8, obppos=annual proportion of positives). Matos-Caraballo (2004a) reported that the annual fisher reporting rate declined between 2002 and 2003 from 86% to 56% and also that there existed some possibility of both over and under reporting. Matos-Caraballo (2007, pers. Com.) also reported that the annual reporting rate from 2003-2004 increased from 56% to 61% and thereafter declined from 2004 to 2005 to 51% (see Table 1, Cummings and Matos-Caraballo, 2007).

Diagnostics regarding the lognormal fit to the positive log (CPUE) observations and the binomial fit to the proportion of positives are presented in Figures 5a-c. These plots do not indicate any significant biases from the model assumptions. Figure 5d does indicate some tendency during the early years for the predicted model to underestimate, again as suggested from Figure 4c for the lognormal fit to the positives. The reader is reminded that during these early years of the time series, that the percentage of positive trips was very low of the total base reeffish data set. In addition, the line log(CPUE) model by necessity only included a limited number of auxiliary variables in the structure.

Puerto Rico Commercial Mutton Snapper Pot Fishery
  Over the 17 year time period, 1989-2005, some 8,497 individual trip records, existed indicating positive or successful landings of the mutton snapper by pot gear from the fishing municipality locations having been identified by port agents and fishers during

the SEDAR14 Data Workshop.   Figure 6a illustrates the observed nominal annual log(CPUE) values for the mutton snapper pot fishery in Puerto Rico since 1990.   The nominal log(CPUE) trend in Figure 6a suggests a relatively flat or stable CPUE through the late 1989's followed by a larger increase after 1998 through 2000. This increase was followed by a decline in 2001 and a second increase between 2002 and 2003 (Figure 6a). The frequency distribution of the individual log(CPUE) observations is presented in Figure 6b and does not indicate any major deviance from normality in the mutton snapper pot fishery log(CPUE) observations.   Some examination of the pot landings trips for 1989 was done, however the models did not converge so the mutton snapper pot fishery analyses were limited to 1990 forward.

As with the mutton snapper line fishery the number of positive or successful mutton snapper virtual trips from pot gear of the total reeffish trips was not large in any particular year. On an annual basis, the percentage of positive (successful) trips of all reeffish trips ranged from about 3.8 % to 21.2 % averaging 10 .3%. Worthy of mention was that the proportion of positives was very low, below 5%, particularly early in the time series. Prior to 1998, the percentage of positives ranged from 3 % to 7%, while thereafter the proportion ranged from 12% to 21% (Figure 7a). As for the line fishery proportion of positives, there are many factors that could alter the observed ratio of positives to the total number of reeffish trips. These could include reporting rates by area, by fishery, by fisher as well as to total number of trips and also to changes in abundance or to some operational change in the fishery.   In addition, as mentioned earlier, realistically the selection process for designating zero trips must be considered also. The increase in the nominal mutton snapper pot log(CPUE) during the late 1990's through about 2003 shown in Figure 6a is also associated, with an increase in the annual proportion of trips having positive or successful landings of the study species, mutton snapper (Figure 7a). Whether this increase is related to the rate of fisher reporting or to more accuracy in reporting landings cannot be determined.

Final Standardized Index Model Structure:
1. Lognormal fit to the Positives Log (CPUE):
        After individual evaluation of the effects of several independent variables on the fit of the log (CPUE) data, a final model was selected on the basis of the overall deviance explained by the model. The final lognormal model selected for the mutton snapper pot fishery contained terms for Year, Municipality and Month in addition, to an interaction effect for Municipality*Month. Municipality can be considered a spatial effect reflecting to some degree spatial variability in population abundance.   The resulting table of deviance is found in Table 9. The final model structure fitted to the positives log(CPUE) observations was:

$$\text{Log(CPUE)} = \textbf{Year} + \textbf{Municipality} + \textbf{Month} + \textbf{Municipality*Month}$$

Figure 6b provides the frequency distribution of log(CPUE) observations and a fitted normal distribution to the data and indicates no gross biases or violations of the model assumptions of normality in the response variable.   Note, the Area and Month effects were not correlated (r=0.00713) however, there was some tendency of the data to be

overdispersed. In the absence of highly correlated variables and assuming the model was appropriate it is possible, that the model did not contain sufficient information to explain the variability.

2. Binomial on Proportion of Positives:

The final binomial model structure fit to the mutton snapper proportion of positives for the pot fishery contained terms for Year and Municipality in addition to an interaction effect for year and Municipality. Municipality can be considered a spatial effect reflecting to some degree spatial variability in population abundance. Month was also explored as a fixed effect in the binomial model but was found to be marginally important to the overall explanation of the deviance. Interaction terms for Year*Month were included along with main effects of Year + Municipality + Month, The resulting model predicted a non-significant Year effect when a YearxMonth term was included. Finally, interaction effects for Month*Municipality were evaluated along with main effect terms for Year + Municipality + Month and the resulting main effects for Year and Month were non-significant. The final model was:

Proportion Positives = Year + Municipality + Year*Municipality

As found for the mutton snapper line fishery log (CPUE) observations, municipality (area) had a very significant effect on the binomial model fit. The final binomial pot fishery model included main effects for Year + Municipality in addition to an interaction term for a Year * Municipality (Area), the latter term included as a random effect and the latter interaction term was found statistically significant. The resulting table of deviance is found in Table 10.. The final model structure fitted to the proportion of positives was:

The frequency distribution of the proportion of percent positives is shown in Figure 7b and shows as was found for the line fishery data that overall, the proportion of positives was low was fairly low, ranging from 4% to 21% and averaging about 10% across years. The range of the proportion of positives for the pot fishery was much larger than that of the line fishery proportion of positives which was 6% to 14% although the average across the time series was similar (mean=10%). In addition, both sets of log(CPUE) observations suggest two phases, one of very low to low proportion of positives, on the order of 3-7% and a second, from 10-14% during the later years. Clearly, many factors contributed to these percentages.

Note also in this model fit, that, the Year and Area main effects were highly correlated (r=0.592) and over dispersion was indicated in the data. It is possible that the over dispersion could be due to the correlated variables however, in addition, it is possible that the model did not contain sufficient information (i.e., auxiliary variables) to explain the variance.

3. Resulting Standardized Mutton Snapper Pot Fishery Indices

The resulting combination of the estimates from the fitted binomial to the proportion of positives and the lognormal fitted to the positive log(CPUE) are presented in Table 11. The plotted estimates of the nominal log (CPUE) annual values and the

predicted standardized index are presented in Figure 8a. Estimates of the standardized indices, 95% confidence intervals and the nominal log (CPUE) values are presented in Figure 8b. Figure 8b indicates that the calculated index (STDCPUE) falls below the observed nominal log(CPUE) value for some years in the time series, however the trends are not dissimilar. Only in 2002 and 2003, is the predicted index higher. The observed nominal percentage of positives along with the predicted percentages of positives is illustrated in Figure 8c. From Figure 8c, it is apparent that the predicted fit of the proportion of positives slightly underestimates the observed trend throughout the time series. Again, throughout the time series, 1990-2005, the proportion of positives of the log(CPUE) was variable ranging from 6% to 14% and averaging 10%. The proportion of positives was found to be more variable in the pot fishery CPUE data than observed for the mutton snapper line fishery.

Additional diagnostics pertaining to the lognormal fit to the positive log (CPUE) observations and the binomial fit to the proportion of positives are presented in Figures 9a-d. The residual distribution for the positive log(CPUE) data shown in Figure 9a, b do not indicate any significant biases from the model assumptions. Figure 9d however shows the tendency for the proportion positives binomial fit to underestimate the observed proportion of positives particularly in the early years.

Comparing the Puerto Rico Commercial Mutton Snapper Line and Pot Fishery Standardized CPUE Trends

The results presented above indicated that overall predicted trends in mutton snapper CPUE were similar to the nominal trends for both pot and line fisheries in Puerto Rico. Figure 10 provides a graphical depiction of the mutton snapper standardized indices of CPUE for the two fisheries, pot and line. The general trend in estimated Standardized CPUE (i.e., the indices) is reasonably similar between the two fisheries, lines and pots, over the entire time series. Mutton snapper CPUE declined between 1990 and 1993 in both fisheries, and showed an increasing trend subsequently. Estimated CPUE for the pot fishery increased through 1998, then declined again, and showed a steeper increase in CPUE beginning around 2001 in the pot fishery than the increasing trend predicted for the line fishery around that same time. This increase in mutton snapper CPUE was predicted for 2002 in the line fishery. Subsequent to 2003, mutton snapper CPUE declined in both the pot fishery and the line fishery in Puerto Rico.

An overall idea of the current level of mutton snapper CPUE can be obtained from these results. The 2005 line fishery CPUE value is 49% lower than the maximum predicted CPUE over the time series, predicted for 2003. The 2005 predicted line CPUE is also 5.1 % lower than the stable trend of CPUE predicted between 1993 and 1998. Similarly, the 2005 pot fishery CPUE is 31.8 % lower than the maximum predicted CPUE over the time series, predicted for 2003. The 2005 predicted pot standardized CPUE is 186% larger than the predicted CPUE index from the 1993-1997 stable period. Overall, the pot fishery CPUE data suggest a much larger net increase over the time series than predicted for the line fishery data.

Discussion and Recommendations

Comparisons of Trends in CPUE with other studies

Estimates of standardized CPUE for mutton snapper do not exist in the literature for comparison to the estimates developed in this study. However, Matos-Caraballo's (2004b) nominal CPUE values can be qualitatively compared to the results in this study. Matos-Caraballo (2004b) compared nominal CPUE (lbs/trip) between two time periods, 1988-1994 and 1994-2001, by pooling 100 randomly selected trips within each period and then computing the associated statistic of interest (average CPUE, average nominal effort, etc..) and comparing between the two time periods. Results of those calculations suggested an increase in nominal unadjusted CPUE for both the pot and line fishery between the two time periods. Matos-Caraballo (2004b) found increases in both lbs/trip for both the pot and line fishery had occurred between 1988 – 1994 and 1995-2001. That study also provided calculations for CPUE based on hook hours (line) and trap days (pots) and similar percentage increases were reported.

Matos's (2004b) results of nominal CPUE trends are very informative and suggest also that nominal CPUE of mutton snapper from the pot fishery increased and possibly that a decrease in the number traps (effort) used per trip declined by 11.8%. In addition Matos reported that the number of days that traps were left soaking increased by 34%. Although that study included only a small sample (n=100 trips) of the available data in the analysis, and the data evaluated were only successful mutton snapper trips, the results are nonetheless informative and provide a base for qualitative comparisons of the trends from two different approaches utilizing entirely different input datasets. Matos's input data could be considered to be a very small subset of the data set used in this analysis. The total data set utilized in this analysis considered some 197,000 individual fish trips while Mato's analyses included only 100 randomly selected trips. This study provided annual estimates of standardized CPUE and incorporated zero trips into the CPUE calculations however, the results here also indicate net increases in mutton snapper CPUE in both the line and pot fisheries between the late 1980's and 2003, as reported by Matos. The results presented here also indicated CPUE declined after 2003 in both fisheries. Whether Matos's random sample of 100 observations is reflective on a spatial and temporal scale with the entire reeffish pot fishery Puerto Rico is not known. In addition, whether the dataset utilized in this study containing zero trips in addition, to the positive successful trips landing mutton snapper, is reflective of trips targeting or that could be targeting the study species is not known. However, similar results emerge between both Matos's (2004b) nominal trends as well as the results presented in this analysis for both the line and pot fisheries.

Analysis Considerations

The CPUE model standardizations were limited to a set of years in which some confidence in the underlying data observations existed. Discussions by port agents and individuals familiar with the early data collection procedures at the SEDAR14 Data Workshop, suggest that before about 1998 or 1989 the fisheries catch information being reported could be less reliable than for later years. In addition, there was some concern regarding aggregate species reporting until the late 1980's.

The commercial fisheries statistics collection program in Puerto Rico began around 1967 however computerized information is not available until 1983. By necessity restricting the analyses to only the later years for which the data are computerized and for which the information is considered of better quality (more reliable in terms of accuracy) provides a rather short time series, about 17 years from which to evaluate changes. It is recommended that efforts be taken to attempt to assemble the available information for prior to 1983 if available. Clearly commercial fisheries have been ongoing since at least the early 1960's and having the early year's data available could be informative in developing models of CPUE. In addition, this information could be extremely informative in evaluating other changes in the commercial Puerto Rican reeffish fishers, including changes in effort and species compositional changes, as well as geographical (spatial) changes over the past 40 years in the Puerto Rican shallow water reeffish fisherie.

The diagnostic results of these initial CPUE standardizations for the lognormal model fits to the log(CPUE) observations did not indicate major violations of applying the models. However, there was some indication that the binomial fits did not explain much of the variation in the data. Briefly, from both the pot and line proportion of positive fits, overdispersion was suggested. There could a number of factors contributing to this including non-informative main factors included in the model, highly correlated variables (factors), or inappropriate model form. By necessity the models explored contained very few attributes or main effects as very few attributes were collected for each single landing trip. With overdispersed data, there is some potential that model selection can be inaccurate thus this problem is a concern. In addition, the measure of effort used was that of a 'fishing trip'. It is recommended that additional work be done to investigate the source of the overdispersion in the model fits. It is also recommended that the data collection personnel in the Puerto Rico DNER continue to work with analysts to evaluate what additional attributes of fishing success could be reliably measured and recorded by the fishers. This latter research effort could help to improve the model development.

The basic information used to calculate CPUE was pounds landed per trip. Matos's (2004b) CPUE analyses also utilized a trip as a measure of effort. He found that on average, most successful mutton trips were of about ahalf day duration. If this is consistent tendency for the shallow water reeffish trips possibly utilizing 'the fishing trip' may not introduce severe biases in the calculation of CPUE. It is recommended however to query the recent years of landings data as to the sufficiency of observations. Preliminary information indicated that analyses utilizing hours fished or trap days, etc. as an effort measure would be restricted to more recent years thus limiting the length of the series available for describing temporal trends.

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Table 1. Summary information regarding the Stephens and MaCall (2004) analysis of the Puerto Rico commercial reeffish observations with mutton snapper as the target species.

Input set: Number of individual trip s= 197,105 computer generated virtual trips from
           1983-2005
Input set: Ranking of individual species occurring with the mutton snapper in the
           commercial trips.

Cross matching list of input sp_code and matching species name:

Sp_code	Name	Fishery/Habitat
1	spiny lob	Reef
2	lane	Reef
3	ytail	Reef
4	wh grunt	Reef
5	conch	Reef
6	boxfishes	Reef
7	silk snapper	Reef
8	queen triggerfish	Reef
9	hogfish	Reef
10	cubera	Reef
11	parrotfishes	Reef
12	King M	Reef
13	red hind	Reef
14	sea basses	Reef
15	porgies	Reef
16	octopus	Reef
17	bar jack	Reef
18	jacks	Reef
19	wh mullet	Estuarine
20	cero	Pelagic
21	squirrelfishes	Reef
22	spotted goatfish	Reef
23	requiem shark	Pelagic
24	snooks	Estuarine
25	coney	Reef
26	qu snapper	Reef
27	vermillion snapper	Reef
28	mojarras	Reef
29	nassau grouper	Reef
30	unknown	Unknown
31	barracudas	Reef
32	macks	Pelagic

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Output statistics

The GENMOD Procedure

Model Information

```
Data Set              LANDMUT.SPMATINP
Distribution                  Binomial
Link Function                    Logit
Dependent Variable              target
```

```
Number of Observations Read      197105
Number of Observations Used      197105
Number of Events                  19868
Number of Trials                 197105
```

Class Level Information

Class	Levels	Values
sp1	2	0 1
sp2	2	0 1
sp3	2	0 1
sp4	2	0 1
sp5	2	0 1
sp6	2	0 1
sp7	2	0 1
sp8	2	0 1
sp9	2	0 1
sp10	2	0 1
sp11	2	0 1
sp12	2	0 1
sp13	2	0 1
sp14	2	0 1
sp15	2	0 1
sp16	2	0 1
sp17	2	0 1
sp18	2	0 1
sp19	2	0 1
sp20	2	0 1
sp21	2	0 1
sp22	2	0 1
sp23	2	0 1
sp24	2	0 1
sp25	2	0 1
sp26	2	0 1
sp27	1	0
sp28	2	0 1
sp29	2	0 1
sp30	2	0 1
sp31	2	0 1
sp32	2	0 1

Response Profile

Ordered Value	target	Total Frequency
1	1	19868
2	0	177237

PROC GENMOD is modeling the probability that target='1'.

The GENMOD Procedure

Criteria For Assessing Goodness Of Fit

Criterion	DF	Value	Value/DF
Deviance	2E5	113192.4849	0.5744
Scaled Deviance	2E5	113192.4849	0.5744
Pearson Chi-Square	2E5	188386.9749	0.9559
Scaled Pearson X2	2E5	188386.9749	0.9559
Log Likelihood		-56596.2424	

Algorithm converged.

Analysis Of Parameter Estimates

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
Intercept		1	1.3044	0.2717	0.7718	1.8370	23.04	<.0001
sp1	0	1	0.4477	0.0220	0.4045	0.4908	412.77	<.0001
sp1	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp2	0	1	-0.5371	0.0176	-0.5716	-0.5026	932.88	<.0001
sp2	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp3	0	1	-0.3665	0.0178	-0.4013	-0.3316	423.87	<.0001
sp3	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp4	0	1	-0.3453	0.0210	-0.3865	-0.3041	269.99	<.0001
sp4	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp5	0	1	0.0681	0.1167	-0.1607	0.2969	0.34	0.5596
sp5	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp6	0	1	-0.1608	0.0258	-0.2114	-0.1102	38.86	<.0001
sp6	1	0	0.0000	0.0000	0.0000	0.0000	.	.

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Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr > ChiSq
sp7	0	1	0.9584	0.0364	0.8871	1.0298	693.98	<.0001
sp7	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp8	0	1	-0.4797	0.0261	-0.5308	-0.4285	338.25	<.0001
sp8	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp9	0	1	-0.7026	0.0337	-0.7686	-0.6366	435.42	<.0001
sp9	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp10	0	1	-0.8653	0.0256	-0.9154	-0.8151	1143.12	<.0001
sp10	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp11	0	1	-0.3030	0.0334	-0.3684	-0.2376	82.49	<.0001
sp11	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp12	0	1	0.0588	0.0325	-0.0049	0.1225	3.27	0.0707
sp12	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp13	0	1	-0.2055	0.0291	-0.2625	-0.1485	49.90	<.0001
sp13	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp14	0	1	-0.1506	0.0302	-0.2099	-0.0914	24.86	<.0001
sp14	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp15	0	1	-0.9270	0.0278	-0.9814	-0.8726	1115.97	<.0001
sp15	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp16	0	1	-0.5863	0.0750	-0.7332	-0.4394	61.17	<.0001
sp16	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp17	0	1	-0.1229	0.0398	-0.2008	-0.0449	9.55	0.0020
sp17	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp18	0	1	-0.2959	0.0408	-0.3759	-0.2159	52.54	<.0001
sp18	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp19	0	1	-0.1680	0.0861	-0.3368	0.0008	3.80	0.0511
sp19	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp20	0	1	0.0675	0.0460	-0.0227	0.1578	2.15	0.1426
sp20	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp21	0	1	0.0776	0.0372	0.0047	0.1505	4.35	0.0371
sp21	1	0	0.0000	0.0000	0.0000	0.0000	.	.

Histogram of fitted values Target Mutton US PR   15:35 Tuesday, May 8, 2007 11
PR commercial Landings Mutton US PR trips (actual & predicted)

The GENMOD Procedure

Analysis Of Parameter Estimates

| | | | Standard | | Wald 95% Confidence | | Chi- | |
Parameter		DF	Estimate	Error	Limits		Square	Pr > ChiSq
sp22	0	1	0.0987	0.0416	0.0172	0.1803	5.64	0.0176
sp22	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp23	0	1	-0.1744	0.0585	-0.2891	-0.0597	8.88	0.0029
sp23	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp24	0	1	-0.4055	0.0889	-0.5798	-0.2313	20.80	<.0001
sp24	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp25	0	1	-0.1312	0.0447	-0.2188	-0.0436	8.63	0.0033
sp25	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp26	0	1	1.1523	0.1032	0.9501	1.3545	124.78	<.0001
sp26	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp27	0	0	0.0000	0.0000	0.0000	0.0000	.	.
sp28	0	1	0.0299	0.0991	-0.1644	0.2242	0.09	0.7627
sp28	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp29	0	1	-0.3313	0.0569	-0.4428	-0.2198	33.92	<.0001
sp29	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp30	0	1	0.2591	0.0736	0.1148	0.4034	12.38	0.0004
sp30	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp31	0	1	-0.3682	0.0644	-0.4944	-0.2420	32.70	<.0001
sp31	1	0	0.0000	0.0000	0.0000	0.0000	.	.
sp32	0	1	0.4124	0.0831	0.2496	0.5753	24.63	<.0001
sp32	1	0	0.0000	0.0000	0.0000	0.0000	.	.
Scale		0	1.0000	0.0000	1.0000	1.0000		

NOTE: The scale parameter was held fixed.

Histogram of fitted values Target Mutton US PR   15:35 Tuesday, May 8, 2007 12
PR commercial Landings Mutton US PR trips (actual & predicted)

The SUMMARY Procedure

Analysis Variable : target

```
Sum
ƒƒƒƒƒƒƒƒƒƒƒ
19868.00
ƒƒƒƒƒƒƒƒƒƒƒ
```

Histogram of fitted values Target Mutton US PR   15:35 Tuesday, May 8, 2007 13
PR commercial Landings Mutton US PR trips (actual & predicted)

The SUMMARY Procedure

```
Variable          Sum          N
ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
target         19868.00     197105
corrpred      169974.00     197105
falseneg       13196.00     197105
falsepos       13935.00     197105
ƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒƒ
```

Histogram of fitted values Target Mutton US PR   15:35 Tuesday, May 8, 2007 14
PR commercial Landings Mutton US PR trips (actual & predicted)

Per Obs	Per trips	Per tripspos	corrpred	falseneg	falsepos	Correct	Falseneg	Falsepos
1	197105	19868	169974	13196	13935	86.2353	6.69491	7.06984

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Table 2. Tabled listing identifying the major municipalities in Puerto Rico used to delineate commercial fishing landing areas (see Figure 1 for location map) by Puerto Rico, DNER, FRL, FSP in the commercial fishery data collection system. Areas 12-41 were indicated as a probable area where mutton snapper could be landed.

MUNICIPALITY_CODE	MUNICIPALITY NAME
01	Isabela
02	Quebradillas
03	Camuy
04	Hatillo
05	Arecibo
06	Barceloneta
07	Manati
08	Vega Baja
09	Vega Alta
10	Dorado
11	Toa Baja
12	Catano
13	San Juan
14	Carolina
15	Loiza
16	Rio Grande
17	Luquillo
18	Fajardo
19	Ceiba
20	Naguabo
21	Humacao
22	Yabucoa
23	Maunabo
24	Culebra
25	Vieques
26	Patillas
27	Arroyo
28	Guayama
29	Salinas
30	Santa Isabel
31	Juana Diaz
32	PONCE
33	Penuelas
34	Guayamilla
35	Guanica
36	Lajas
37	Cabo Rojo
38	Mayaguez
39	Anasco
40	Rincon
41	Aguada
42	Aguadilla
00	UnKnown

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Table 2. (Continued).

43	Adjuntas
44	Aguas Buenas
45	Aibonito
46	Barranquitas
47	Bayamon
48	Caguas
49	Canovanas
50	Cayey
51	Ciales
52	Cidra
53	Coamo
54	Comerio
55	Corozal
56	Florida
57	Guaynabo
58	Gurabo
59	Hormigueros
60	Jayuya
61	Juncos
62	Lares
63	Las Marias
64	Las Piedras
65	Maricao
66	Moca
67	Morovis
68	Naranjito
69	Orocovis
70	Sabana Grande
71	San German
72	San Lorenzo
73	San Sebastian
74	Toa Alta
75	Trujillo Alto
76	Utuado
77	Villalba
78	Yauco

Table 3. Annual percentage of commercial sales(landings) of mutton snapper, *Lutjanus analis,* by gear category in Puerto from 1983 through 2003. 2005 Preliminary data. Data available beginning in 1983. [Information from Cummings and Matos-Caraballo, 2007, Table 3b). Percentages are based on landings in weight.

					agear				
	Cast Net	Dive, Spear, Scuba	Net	Other	Pot	Rod and Reel	Seine	Vertical Line	All
	pounds	pounds	pounds	pounds	pounds	pounds	pounds	pounds	pounds
	RowPctSum	RowPctSum	RowPctSum	RowPctSum	RowPctSum	RowPctSum	RowPctSum	RowPctSum	RowPctSum
cyear									
1983	0.1	4.6	5.2	.	57.7	24.9	6.1	1.4	100.0
1984	0.1	1.1	6.3	.	50.5	30.1	9.6	2.4	100.0
1985	.	2.5	13.7	.	43.7	33.4	2.7	4.0	100.0
1986	0.3	9.5	21.2	.	36.8	26.7	3.6	2.0	100.0
1987	1.0	5.7	16.6	.	31.0	34.8	7.4	3.4	100.0
1988	0.1	10.4	14.7	0.1	24.3	42.7	3.6	4.3	100.0
1989	1.0	13.2	8.6	0.0	28.5	41.5	5.5	1.7	100.0
1990	0.1	13.9	10.6	.	27.8	43.3	3.2	1.2	100.0
1991	1.0	8.8	12.1	.	28.1	45.7	3.1	1.1	100.0
1992	0.0	6.2	7.1	.	28.2	51.2	4.8	2.4	100.0
1993	0.4	10.9	8.8	.	29.7	43.0	6.7	0.5	100.0
1994	2.8	5.6	12.1	.	23.7	46.6	5.9	3.2	100.0
1995	1.0	4.4	10.7	.	20.0	59.6	2.2	2.1	100.0
1996	0.4	4.6	16.1	.	20.7	53.2	1.9	3.0	100.0
1997	1.3	4.5	16.2	.	23.6	50.2	2.2	2.0	100.0
1998	0.2	6.6	13.1	.	24.3	52.1	1.7	2.0	100.0
1999	0.1	5.5	12.8	.	24.3	53.8	1.3	2.2	100.0
2000	0.2	7.4	17.8	.	24.9	47.1	0.5	2.1	100.0
2001	0.2	6.8	15.2	.	22.9	50.4	3.1	1.4	100.0
2002	0.1	9.0	13.7	.	24.1	47.7	3.4	2.0	100.0
2003	.	5.2	9.8	.	24.6	55.3	3.1	2.0	100.0
2004	.	13.0	11.1	.	29.5	40.7	2.8	2.9	100.0
2005	.	15.2	7.2	.	26.2	47.8	0.7	2.9	100.0
All	0.4	6.8	12.5	0.0	28.5	46.4	3.3	2.2	100.0

[1]Prior to 1987 mutton snapper was classified in the Puerto Rico commercial landings as "first class fish" (Matos-Caraballo, 2004b).
. = No Reported Sales this cell.

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Table 4. Percentage annual commercial landings of mutton snapper, *Lutjanus analis,* in Puerto Rico, summary by fishing center and by year. 2005 preliminary.   Values represent cell percentages of pounds. [Taken from Cummings and Matos-Caraballo, 2007, Table 5b].

fishcent	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	All
Isabela	0.4	0.7	5.6	1.0	.	.	0.3	1.0	1.4	1.8	1.1	0.2	1.0	1.0	0.8	0.2	0.1	0.1	0.3	0.6	0.1	.	.	0.7
Camuy	0.4	0.2	0.9	0.0	0.7	1.0	0.2	0.2	0.1	0.5	0.1	.	0.2	0.1	0.3	0.8	0.4	0.6	0.1	0.2	0.8	0.2	0.5	0.4
Hatillo	0.7	0.6	1.7	0.6	2.3	1.3	1.4	0.8	.	1.0	0.0	0.1	0.5	0.5	0.6	0.0	0.4	.	0.1	0.1	0.1	0.1	.	0.4
Arecibo	.	.	.	.	0.0	.	0.1	.	0.3	.	0.0	0.4	0.1	0.3	0.2	0.4	0.2	0.3	1.4	0.2	1.2	1.7	2.7	0.4
Barceloneta	0.3	0.0	0.1	0.0	0.4	0.2	0.1	0.0	0.0	.	0.0	0.5	0.2	0.4	0.4	0.6	0.2	0.2	3.1	0.2	0.1	0.1	0.1	0.4
Manati	.	.	.	0.0	.	.	0.0	0.1	0.0	0.2	0.3	0.2	0.4	0.3	0.4	0.3	0.1	0.0	0.4	0.1	0.0	.	0.7	0.2
Vega Baja	0.1	0.0	0.1	0.4	0.2	.	0.0	.	0.2	0.4	.	0.1	0.2	0.1	0.3	1.2	0.5	1.0	1.2	0.6	0.4	.	.	0.4
Vega Alta	0.2	0.1	0.3	0.3	0.1	0.2	0.1	1.1	0.2	0.1	0.3	0.2	0.3	0.2	0.1	0.1	0.1	0.0	0.4	0.2	0.3	0.4	0.1	0.2
Dorado	0.1	.	0.0	0.6	.	0.0	0.1	0.0	0.5	0.0	.	0.3	0.1	0.7	0.3	0.1	0.1	0.0	1.6	0.2	0.1	0.1	0.1	0.3
Toa Baja	0.1	.	.	.	0.1	.	.	.	0.1	.	.	.	.	.	.	0.0	0.0	0.4	.	.	.	.	.	0.0
Catano	0.3	0.1	0.1	0.7	0.6	0.3	0.4	2.0	3.8	3.5	4.4	4.1	3.5	1.2	1.4	1.2	0.7	0.5	0.5	0.7	0.5	0.4	0.5	1.2
San Juan	2.1	3.2	3.9	3.5	4.3	2.9	4.9	5.4	5.6	4.6	7.3	7.3	4.1	2.6	4.0	4.7	4.3	5.2	5.0	2.6	1.4	1.3	3.7	3.9
Carolina	0.0	0.1	0.1	0.0	0.2	1.4	1.2	0.3	0.5	0.8	0.4	1.1	0.5	0.4	0.2	0.5	0.6	0.5	1.6	0.4	.	.	.	0.5
Loiza	0.9	0.1	0.0	1.1	0.9	0.5	0.0	0.5	2.6	2.5	1.4	3.3	1.7	0.4	0.9	0.9	0.3	0.1	0.7	0.8	1.3	0.9	0.4	0.9
Rio Grande	0.8	1.1	0.4	0.9	0.6	0.2	0.3	0.2	0.1	0.6	0.6	0.0	0.4	0.8	1.2	0.7	0.8	0.7	0.8	1.0	0.6	0.6	0.8	0.7
Luquillo	1.2	1.1	1.5	4.0	4.0	0.8	0.3	.	4.7	3.6	1.1	0.4	0.9	0.6	0.8	0.5	0.7	0.3	0.2	0.4	0.1	0.2	0.0	0.9
Fajardo	4.2	3.2	4.7	7.2	10.6	3.3	4.5	0.2	0.3	0.7	0.9	1.3	2.7	5.0	3.8	2.9	2.8	2.3	4.4	3.2	3.1	4.4	2.0	3.3
Ceiba	1.1	1.0	1.0	0.4	5.7	2.3	2.3	2.0	2.7	2.1	4.1	1.5	1.6	1.8	1.7	2.8	1.7	2.6	3.2	3.2	2.2	4.4	1.4	2.2
Naguabo	1.9	1.8	1.9	3.7	4.2	0.3	2.6	1.5	0.5	0.8	0.7	2.9	1.5	0.9	1.6	2.7	1.6	3.7	3.2	2.1	4.0	3.0	2.6	2.2
Humacao	1.3	0.9	1.0	1.8	1.7	1.4	1.0	0.4	0.4	1.3	3.6	2.5	1.6	1.2	1.4	1.4	2.7	2.3	1.9	1.0	4.5	3.4	1.6	1.8
Yabucoa	0.0	0.5	0.3	0.9	0.2	1.3	0.9	0.4	4.0	3.0	5.1	1.4	1.9	1.0	0.5	0.4	0.8	1.8	1.8	1.0	2.2	0.6	1.2	1.3
Maunabo	0.3	0.6	0.4	0.8	0.2	0.8	0.2	0.0	0.0	0.1	0.1	0.3	0.2	0.7	1.5	1.4	1.9	2.2	0.2	0.2	0.2	0.3	0.2	0.7
Culebra	0.7	0.9	0.8	0.6	0.4	0.6	0.0	0.4	0.5	1.1	1.1	0.5	0.3	0.1	0.3	.	0.4	0.3	0.2	0.3	0.2	0.5	0.1	0.4
Vieques	2.6	0.8	2.1	7.0	4.4	3.1	5.0	3.1	0.7	2.1	3.3	0.5	0.9	3.4	2.6	4.1	1.8	1.0	4.8	7.2	6.6	8.3	1.2	3.4
Patillas	2.0	3.1	1.1	0.3	1.0	0.6	0.3	1.0	0.8	1.0	1.5	0.4	1.7	0.9	1.5	1.2	1.3	1.1	1.1	0.5	0.8	1.5	1.5	1.2
Arroyo	2.6	3.5	1.9	0.0	0.9	0.4	0.3	0.9	1.2	0.1	0.5	0.2	0.1	0.2	0.8	0.5	0.4	0.5	0.4	0.4	1.6	0.7	0.9	0.8
Guayama	7.2	3.8	2.6	4.8	2.7	0.9	1.0	2.2	3.8	4.6	4.8	5.4	4.3	5.6	5.9	5.6	4.8	3.2	3.4	3.3	3.8	6.2	5.6	4.4
Salinas	5.1	7.0	4.3	7.6	5.5	7.0	2.0	5.4	4.5	6.7	10.1	12.2	14.7	11.8	11.2	8.4	7.2	6.4	6.8	5.9	7.4	7.2	8.2	7.8
Santa Isabel	0.4	0.3	.	.	.	0.3	7.5	0.8	0.7	.	.	0.4	1.4	2.6	1.8	1.9	2.0	2.9	2.1	1.9	1.4	1.6	2.0	1.6
Juana Diaz	8.2	8.5	2.1	2.7	3.3	2.7	1.9	1.8	3.3	2.9	1.6	1.2	1.1	1.5	2.6	1.1	3.3	5.9	2.7	2.6	2.3	4.5	6.2	3.3
Ponce	1.4	1.5	0.6	.	.	.	.	.	.	.	0.5	2.1	1.5	2.2	0.8	1.6	1.5	4.2	1.5	1.6	2.3	2.0	2.5	1.5
Penuelas	0.2	0.0	0.2	0.2	0.3	0.1	0.2	0.3	0.3	0.3	0.7	0.2	0.4	0.4	0.3	0.6	0.2	0.7	0.4	0.3	1.1	1.4	1.8	0.5
Guayamilla	8.0	7.2	3.7	5.6	7.1	6.2	3.5	2.0	3.0	2.3	0.2	0.1	2.4	3.3	3.0	3.1	6.0	8.7	7.3	6.1	4.5	3.3	2.5	4.7
Guanica	2.9	3.4	3.2	2.6	4.7	5.5	2.0	2.3	3.2	10.1	4.4	6.7	8.9	4.5	2.4	6.5	7.5	4.8	2.8	7.5	3.5	1.3	0.7	4.7
Lajas	5.9	.	2.6	4.6	5.5	7.4	5.3	14.1	12.4	10.8	8.1	4.1	9.2	11.0	17.8	16.9	15.6	16.3	13.6	21.9	15.6	5.4	4.0	11.6
Cabo Rojo	26.8	34.2	41.1	23.2	11.2	22.0	27.8	28.6	20.5	12.6	10.2	15.6	6.9	12.7	10.7	9.3	7.8	8.2	7.5	6.5	6.9	17.3	18.3	14.6
Mayaguez	7.8	9.3	7.0	8.4	8.8	12.0	10.3	12.2	9.2	12.3	10.8	15.0	17.2	13.7	8.9	9.0	12.6	8.7	9.5	9.9	13.0	7.1	15.4	10.8
Anasco	0.0	.	0.2	0.0	0.2	0.6	0.2	0.1	0.6	0.4	0.1	0.3	1.0	0.7	0.3	0.1	1.0	0.3	0.3	0.4	0.1	0.1	0.1	0.4
Rincon	0.4	0.1	0.5	1.5	0.9	2.0	0.4	0.6	0.9	0.2	0.7	0.4	1.4	0.7	0.7	0.5	0.4	0.3	0.2	1.7	2.2	0.4	0.1	0.7
Aguada	0.3	0.1	0.1	0.7	1.2	1.2	1.0	2.6	0.8	0.9	5.8	4.5	0.3	1.7	2.1	1.6	1.4	1.0	1.1	1.3	1.3	2.3	1.9	1.4
Aguadilla	1.0	0.9	1.8	2.2	4.9	8.9	10.3	5.4	5.7	4.1	4.0	1.8	2.6	2.8	3.9	4.1	3.9	1.0	1.8	1.8	2.2	7.1	8.2	3.3
All	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[1]Prior to 1987 mutton snapper was classified in the Puerto Rico commercial landings as "first class fish" (Matos-Caraballo, 2004).

. = No Reported Sales this cell.

Shading depicts municipalities with combined annual landings of mutton snapper contributing 1 % or greater (by weight)   .

Table 5. Annual distribution of commercial landings (n=number of sales tickets) of mutton snapper, *Lutjanus analis,* in Puerto Rico by major gear category from 1983-2005. 2005 Preliminary data. Data available beginning in 1983.

																Gear Category			
				Dive, Spear,													Vertical			
	Cast Net		Scuba		Net		Other		Pot		Rod and Reel		Seine		Line		All Gears	
	RowPc-		RowPc-		RowPc-		RowPc-		RowPc-		RowPc-		RowPc-		RowPc-		RowPc-	
	N	tN	N	tN	N	tN	N	tN	N	tN	N	tN	N	tN	N	tN	N	tN
cyear																		
1983	3	0	84	4	109	6	.	.	1086	56	534	27	108	6	28	1	1952	100
1984	2	0	29	2	92	7	.	.	760	54	395	28	106	8	14	1	1398	100
1985	.	.	42	3	197	15	.	.	606	45	446	33	44	3	19	1	1354	100
1986	4	0	124	10	268	21	.	.	449	35	359	28	61	5	11	1	1276	100
1987	9	1	72	6	186	16	.	.	374	32	402	34	98	8	26	2	1167	100
1988	2	0	118	10	163	14	2	0	333	29	466	40	30	3	41	4	1155	100
1989	6	0	166	12	183	13	2	0	425	30	587	41	42	3	27	2	1438	100
1990	1	0	202	15	145	11	.	.	418	31	535	40	13	1	18	1	1332	100
1991	9	0	233	11	280	13	.	.	641	30	907	42	33	2	36	2	2139	100
1992	1	0	120	8	163	11	.	.	480	32	643	43	50	3	38	3	1495	100
1993	10	1	201	12	152	9	.	.	466	29	732	45	54	3	19	1	1634	100
1994	21	1	130	8	200	12	.	.	502	30	699	42	34	2	66	4	1652	100
1995	32	1	176	6	285	10	.	.	879	30	1379	47	89	3	92	3	2932	100
1996	14	0	235	6	631	17	.	.	1119	30	1438	39	84	2	173	5	3694	100
1997	44	1	251	7	710	18	.	.	1270	33	1366	36	66	2	134	3	3841	100
1998	12	0	310	9	509	14	.	.	1121	31	1453	41	28	1	144	4	3577	100
1999	6	0	301	8	631	16	.	.	1278	32	1567	40	22	1	138	3	3943	100
2000	9	0	327	8	683	17	.	.	1320	32	1609	39	18	0	135	3	4101	100
2001	10	0	343	8	711	17	.	.	1294	30	1739	41	44	1	120	3	4261	100
2002	4	0	397	9	753	17	.	.	1376	31	1757	39	60	1	154	3	4501	100
2003	.	.	386	9	673	15	.	.	1657	37	1516	34	61	1	129	3	4422	100
2004	.	.	689	20	410	12	.	.	1217	35	991	29	40	1	84	2	3431	100
2005	.	.	536	21	234	9	.	.	801	31	906	35	12	0	73	3	2562	100
All	199	0	5472	9	8368	14	4	0	19872	34	22426	38	1197	2	1719	3	59257	100

[1]Prior to 1987 mutton snapper was classified in the Puerto Rico commercial landings as "first class fish" (Matos-Caraballo, 2004).

. = No Reported Sales this cell

Table 6. Deviance analysis results from the lognormal model fit to log (CPUE) observations for the Mutton Snapper Commercial line fishery data in Puerto Rico. Area in the model referred to major municipality indicated as the landing site.

Model factors	Degrees of freedom	Residual Deviance	Change in Deviance	% Change in deviance	Chi-Square	Pr (Chiquare)	AICC Statistic	-2 REML
1. Year	16	9,419			176.7	<0.0001	28,356.4	28,356.4
2. Year Area	35	8,558.4	860.0	9.1	1,030.8	<0.0001	26,447.8	27,445.8
3. Year Month	27	9,020.5	398.5	4.2	453.4	<0.0001	27,966.9	27,964.9
4. Year Area Month	46	8,249.0	1,170.0	12.4	956.1	<0.0001	27,125.0	27,123.2
5. Year Area Month Year*Month	**298**	**7,640.0**	**1,779**	**18.9**			**26,780.**	**26,776.4**

Table 7. Deviance analysis results from binomial model fit to proportion of positives for the mutton snapper Commercial line fishery data in Puerto Rico. Area in the model referred to major municipality indicated as the landing site.

Model factors	Degrees of freedom	Residual Deviance	Change in Deviance	% Change in deviance	Chi-Square	Pr (Chiquare)	AICC Statistic	-2 REML
1. Year	16	9,376.1			176.7	<0.0001	13,180.3	13,178.3
2. Year Area	35	7,261.5	2,114.6	22.6	836.8	<0.0001	12,315	12,313.5
3. Year Month	27	9,129.3	246.0	2.6	79.7	<0.0001	13,154.4	13,154.4
4. Year Area Month	46	6,976.7	2,399.4	25.6	885.9	<0.0001	12,282.9	12,280.9
5. Year Area Month Year*Month	**267**	**5,721.8**	**3,654.3**	**39.0**			**11,897.3**	**11,893.3**

Table 8. Standardized CPUE indices for the Puerto Rico Mutton Snapper Commercial Line fishery, 1989-2005. Year = Calendar Year, STDCPUE=Index, LCI and UCI are 0.95 Upper and Lower Confidence Intervals. Obcpue=Nominal log(CPUE), obppos=proportion of positives log(CPUE), Cv_i=CV(Index).

YEAR	StdErr	obcpue	obppos	nobs	cv_i	MEANINDEX	STDCPUE	LCI	UCI	estcpue	obscpue
1989	0.292628	1.714655	0.077873	3968	0.188838	1.773522	0.873755	0.600899	1.270509	1.549624	0.73912
1990	0.377138	1.767548	0.115385	2080	0.215449	1.773522	0.987007	0.644619	1.511256	1.75048	0.76192
1991	0.282804	1.831079	0.106236	3031	0.207242	1.773522	0.769434	0.510567	1.159552	1.364609	0.789305
1992	0.330374	1.553954	0.078642	2238	0.217456	1.773522	0.856639	0.557308	1.316742	1.519269	0.669848
1993	0.220312	1.017553	0.06167	3616	0.205163	1.773522	0.605483	0.403397	0.908805	1.073837	0.438627
1994	0.262045	2.38644	0.075202	4202	0.190618	1.773522	0.775134	0.531231	1.13102	1.374717	1.028699
1995	0.268009	2.468328	0.080045	7146	0.157635	1.773522	0.958651	0.700777	1.311418	1.700189	1.063998
1996	0.255867	2.41838	0.085992	7617	0.154661	1.773522	0.932816	0.685886	1.268645	1.65437	1.042468
1997	0.229098	2.402755	0.079456	7652	0.158894	1.773522	0.812976	0.59282	1.114889	1.44183	1.035732
1998	0.315793	2.59266	0.108292	5282	0.156429	1.773522	1.138282	0.834061	1.553466	2.018768	1.117593
1999	0.382245	3.197473	0.121942	5232	0.150392	1.773522	1.433115	1.062631	1.932769	2.541662	1.378304
2000	0.290912	2.287454	0.113383	7188	0.145433	1.773522	1.127877	0.844502	1.506341	2.000315	0.986031
2001	0.284187	2.791383	0.117675	8379	0.143431	1.773522	1.11718	0.839796	1.486183	1.981343	1.203255
2002	0.2903	2.576073	0.138847	7303	0.139527	1.773522	1.173149	0.888681	1.548677	2.080606	1.110443
2003	0.365874	4.277426	0.141862	8896	0.135173	1.773522	1.526175	1.166072	1.997484	2.706705	1.843829
2004	0.296472	2.343065	0.114152	7490	0.146974	1.773522	1.137381	0.849039	1.523648	2.017171	1.010003
2005	0.21456	1.811411	0.099516	7235	0.156114	1.773522	0.774944	0.568181	1.056949	1.37438	0.780827

Table 9. Deviance analysis results from lognormal model fit to proportion of positives for the mutton snapper commercial pot fishery data. Area in the model referred to major municipality indicated as the landing site.

Model factors	Degrees of freedom	Residual Deviance	Change in Deviance	% Change in deviance	Chi-Square	Pr (Chi-quare)	AICC Statistic	2 REML
1. Year	15	5,188.0			70.5	<0.0001	19,997.5	19,995.5
2. Year Area	34	4,321.4	866.6	**16.7**	1,697.0	<0.0001	18,521.6	18,519.6
3. Year Month	26	5,171.7	16.0	0.3	226.7	0.005-NS	20,025.6	20,023.6
4. Year Area Month Year*Area	**274**	**3,696.1**	**1,491.9**	**28.8**			**17,759.5**	**17,755.5**
5. Year Area Month Area*Month	191	4,236	952	18.4			18,540.1	18,536.1
6. Year Area Year*Area	216	3,701.5	1,486.5	28.5			17,715.4	17,716.4

Table10. Deviance analysis results from binomial model fit to proportion of positives for Mutton Snapper Commercial pot fishery data. Area in the model referred to major municipality indicated as the landing site.

Model factors	Degrees of freedom	Residual Deviance	Change in Deviance	% Change in deviance	Chi-Square	Pr (Chi-Square)	AICC Statistic	2 REML
1. **Year**	15	10,968.3			484.5	<0.0001	12,442.4	12,440.4
2. Year **Area**	34	7,023.7	3,944.6	36.0	1169.7	<0.0001	11,738.1	11,736.0
3. Year **Month**	26	10,921.8	46.5	0.42	10.9	0.449	12,466.9	12,464.9
4. Year Area Year*Area	**274**	**4,569.2**	**6,399.1**	**58.3**			**10,926.4**	**10,922.4**

Table 11. Standardized lCPUE indices for the Puerto Rico Mutton Snapper Commercial Pot fishery, 1990-2005.
Year =Calendar Year, STDCPUE=Index, LCI and UCI are 0.95 Upper and Lower Confidence Intervals. Obcpue=Nominal
log(CPUE), obppos=proportion of positives log(CPUE), Cv_i=CV(Index)

YEAR	StdErr	obcpue	obppos	nobs	cv_i	MEANINDEX	STDCPUE	LCI	UCI	estcpue	obscpue
1990	0.125186	0.650032	0.038313	3106	0.322323	1.031664	0.376467	0.200748	0.705999	0.388388	0.49338
1991	0.162922	0.964225	0.056442	3508	0.270954	1.031664	0.582835	0.342258	0.992517	0.60129	0.731855
1992	0.202722	0.8682	0.070602	1728	0.290394	1.031664	0.676667	0.383027	1.19542	0.698093	0.658972
1993	0.132162	0.617265	0.044142	2424	0.304648	1.031664	0.420502	0.231741	0.763016	0.433817	0.468509
1994	0.170779	0.788712	0.055948	3539	0.255858	1.031664	0.646989	0.390998	1.070579	0.667475	0.598639
1995	0.135566	0.903051	0.076181	5802	0.23001	1.031664	0.571303	0.362787	0.899666	0.589393	0.685423
1996	0.141726	0.895432	0.072647	5451	0.233232	1.031664	0.58901	0.37172	0.933315	0.60766	0.679641
1997	0.106332	0.660293	0.055086	5319	0.251449	1.031664	0.409898	0.249809	0.672578	0.422877	0.501168
1998	0.161944	0.93067	0.080611	4255	0.234569	1.031664	0.669198	0.421243	1.063106	0.690388	0.706387
1999	0.304025	1.695057	0.124463	5351	0.213734	1.031664	1.378786	0.903481	2.10414	1.422444	1.286563
2000	0.303261	2.208763	0.141431	4907	0.205922	1.031664	1.427498	0.949659	2.14577	1.472699	1.67647
2001	0.235089	1.499756	0.118145	6145	0.198333	1.031664	1.148944	0.775689	1.701806	1.185325	1.138328
2002	0.303509	1.677623	0.134262	6100	0.187594	1.031664	1.568241	1.081128	2.274827	1.617898	1.273331
2003	0.387158	2.619283	0.211946	6931	0.169789	1.031664	2.210244	1.577648	3.096496	2.28023	1.988059
2004	0.351781	2.278151	0.200209	5744	0.187866	1.031664	1.815037	1.250605	2.634213	1.872509	1.729137
2005	0.306549	1.823613	0.162856	4636	0.196993	1.031664	1.508381	1.021013	2.228389	1.556143	1.384138

Table 12. Summary information on nominal commercial CPUE for mutton snapper in Puerto Rico as calculated by Matos-Caraballo (2004b).

Fishery	Statistic	Time Period	
		1988-1994	1995-2001
Line	**Nominal CPUE/Trip**	**49 lbs/trip**	**56 lbs/trip**
	Nominal effort	2.5 hooks/hr	2.1 hooks/hour
	Average hours per trip	9.9 hours	9.4 hours
	Nominal cpue/hour	**1.9 lbs/hook hour**	**2.88 lbs / hook hour**
	n	100 random trips	100 random trips
Pot	**Nominal CPUE/Trip**	**34 lbs/trip**	**69.6 lbs per trip**
	Number traps per trip	24.5 traps	21.6 trap per trip
	Number days per trip	4.3 days	5.8 days per trip
	Nominal cpue/trap day	**0.32 lbs/trap day**	**0.56 lbs/trap day**
	n	100 random trips	100 random trips
Scuba	**Nominal CPUE/Trip**	**65 lbs/trip**	**48 lbs/trip**
	Number divers/trip	2.3 divers/trip	1.33 divers/trip
	Number hours diving	5 hours per dive	4.2 hours/trip
	Nominal CPUE/diver hour	**5.57 lbs/diver hour**	**8.75 lbs/diver hour**
	n	100 random trips	100 random trips
Beach Seine	**Nominal CPUE/Trip**	**304 lbs/trip**	**166 lbs/trip**
	Number fathoms of net	220 fm net/trip	200 fm net/trip
	Number hours soaked	4.6 hours/soak	6.4 hours/soak
	Nominal CPUE/fathom hour	**0.3 lbs/fm hour**	**0.13 lbs/fm hour**
	n	100 random trips	100 random trips

Figure 1. Fishing Center locations used by Puerto Rico, DNER, FRL, FSP in the commercial data collection system.

**Puerto Rico Mutton Trips Line Fishery 1989−2005 Base Final
Nominal CPUE by year**
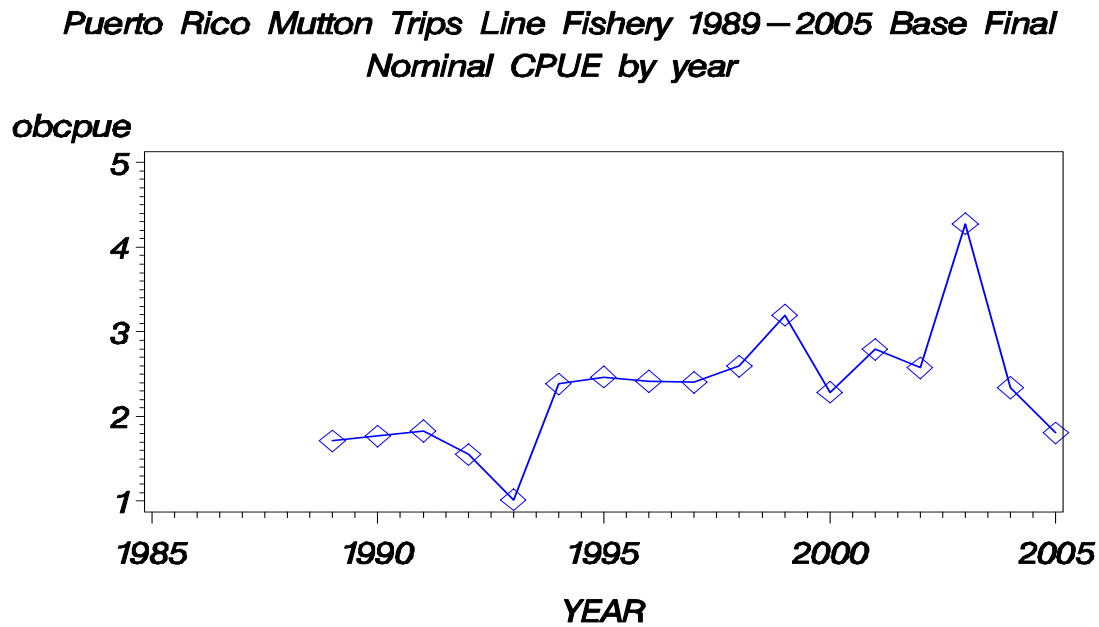
Figure 2a.   Nominal unadjusted CPUE (lbs/trip) for mutton snapper landed in the Puerto Rico commercial line fishery, 1989-2005.

**Puerto Rico Mutton Trips Line Fishery 1989−2005 Base Final
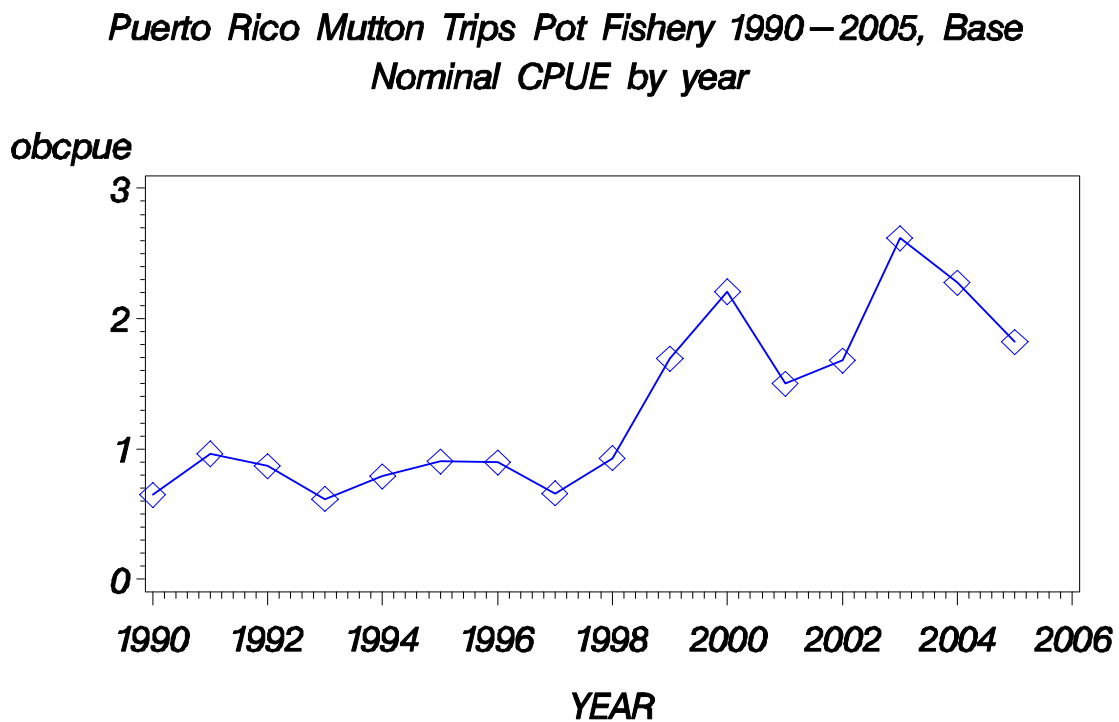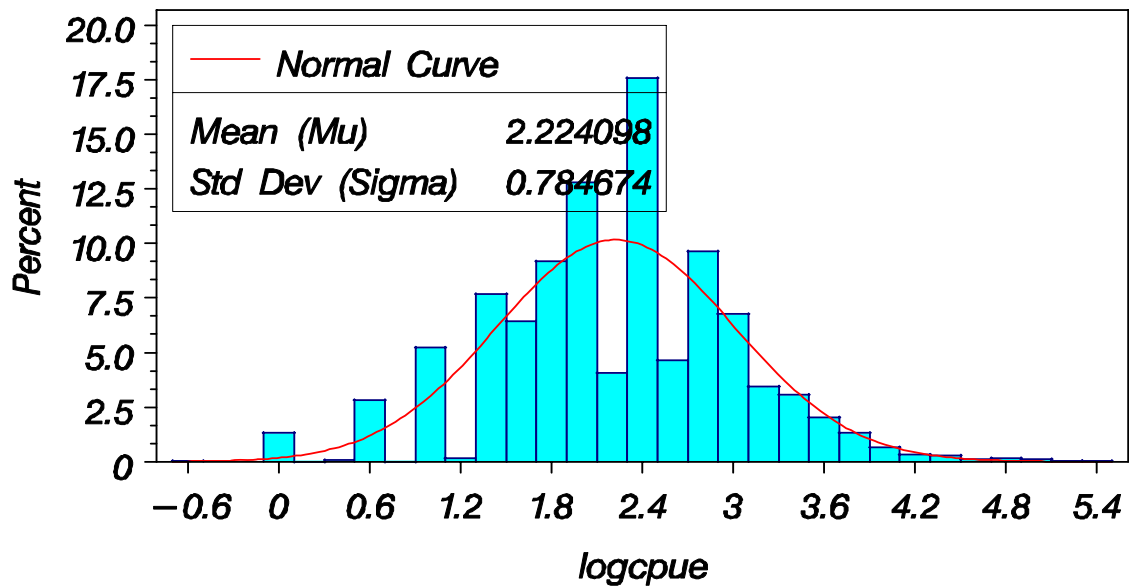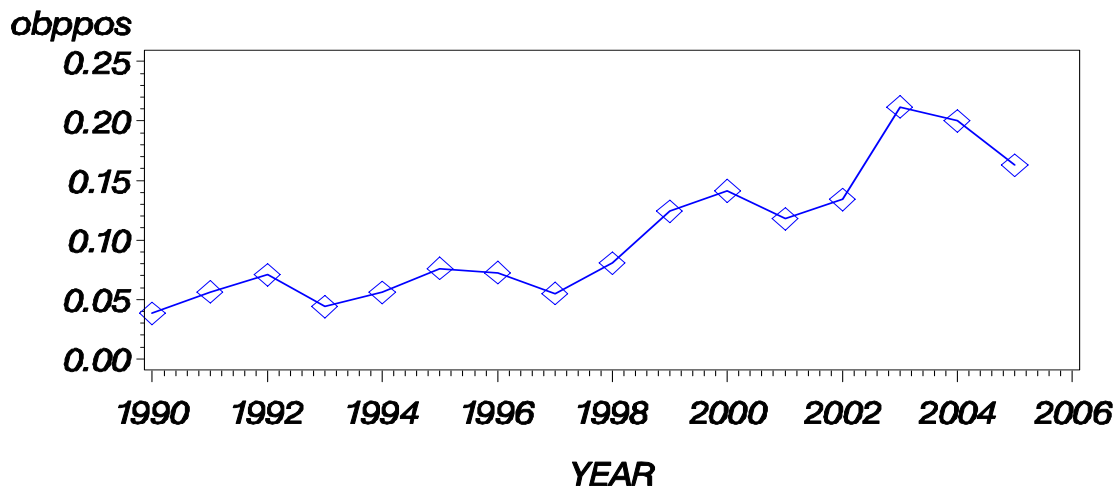Frequency distribution log CPUE positive catches**
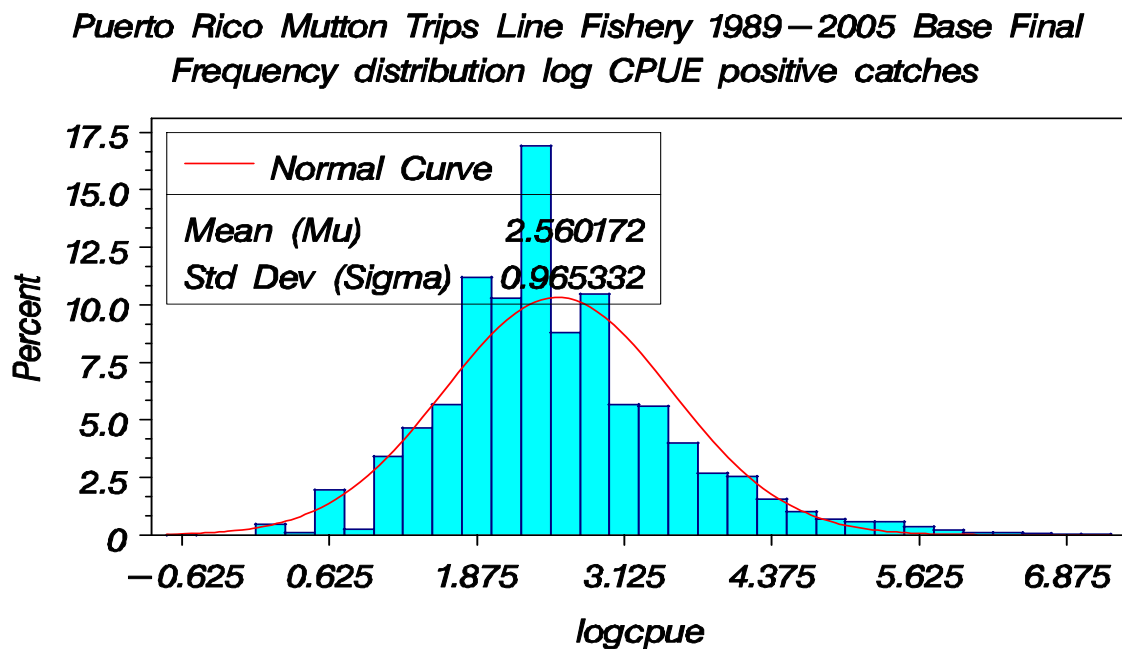
Figure2b. Frequency distribution of log(CPUE) of mutton snapper successful trips from the Puerto Rico commercial line fishery, 1989-2005. CPUE is measured in Lbs per Trip.

Puerto Rico Mutton Trips Line Fishery 1989—2005 Base Final
Observed proportion pos/total by year
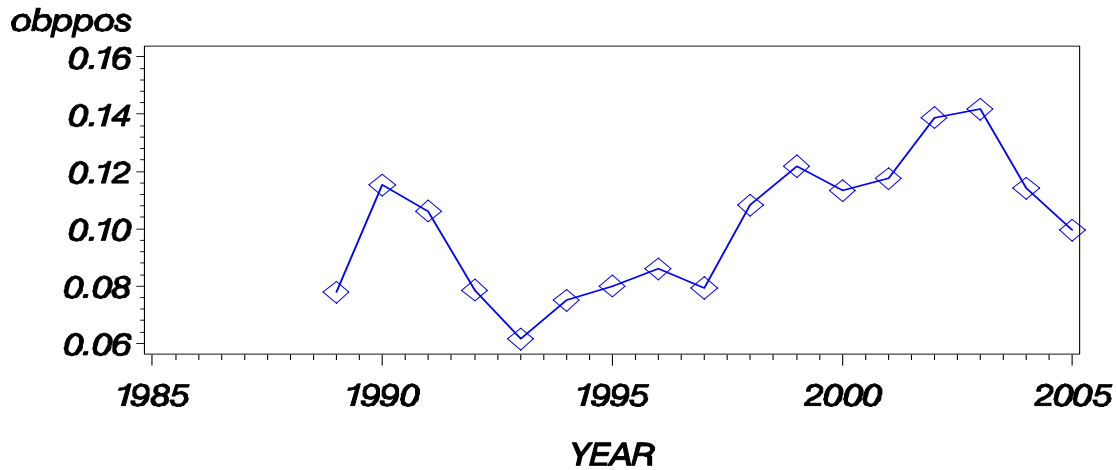
If prop pos=[1 or 0] Binomial model will not estimate a value for that year

Figure 3a. Observed average annual proportion of positive (successful) trips for mutton snapper from the commercial line fishery in Puerto Rico, 1989-2005.

Puerto Rico Mutton Trips Line Fishery 1989—2005 Base Final
Frequency distribution proportion positive catches summary by YEAR Area Mc
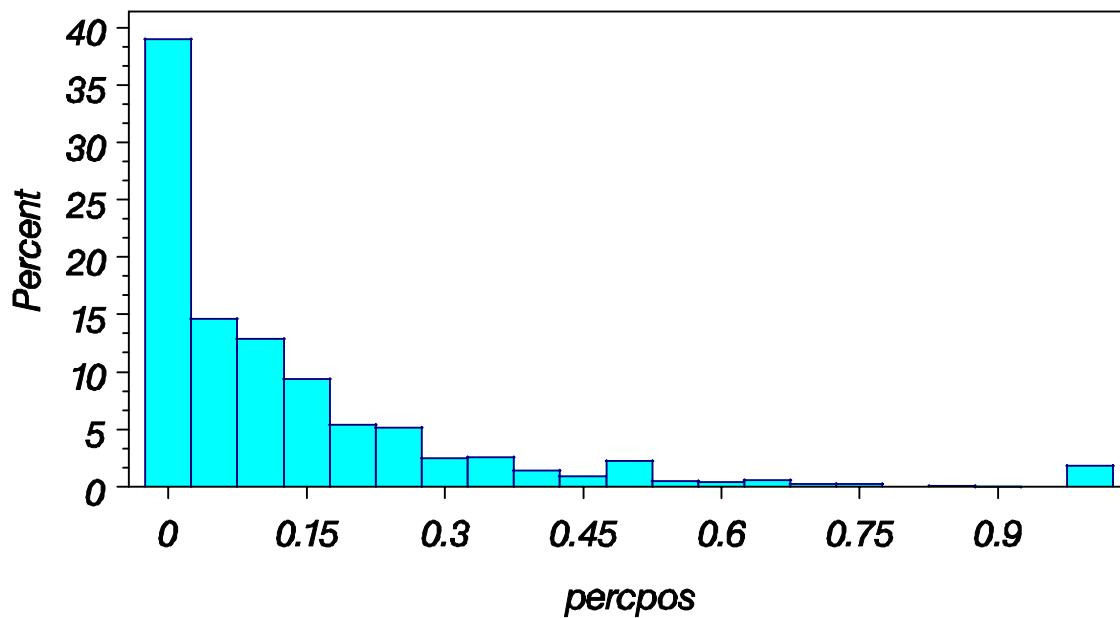
Figure 3b. Frequency distribution of the proportion of positive (successful) trips for mutton snapper trips in the Puerto Rico commercial line fishery, 1989-2005.

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Puerto Rico Mutton Trips Line Fishery 1989−2005 Base Final Diagnostic plots: 3) Obs vs Pred CPUE Input units
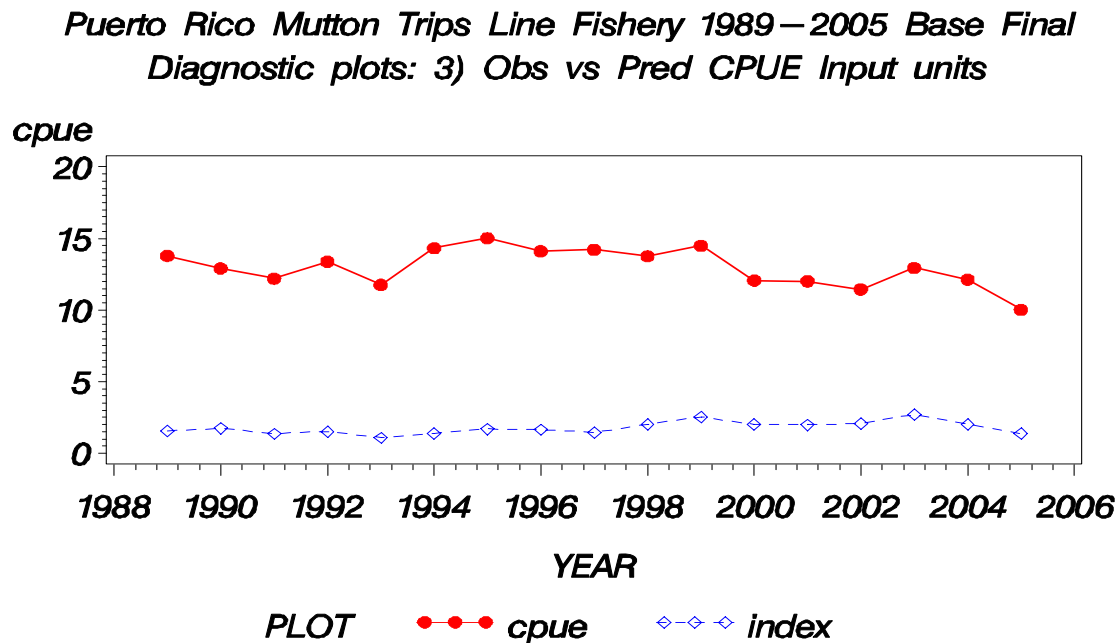
Figure 4a. Nominal and standardized CPUE of mutton snapper from the Puerto Rico commercial line fishery, 1989-2005. CPUE is measured in Lbs per Trip.

Puerto Rico Mutton Trips Line Fishery 1989−2005 Base Final Observed and Standardized CPUE (95% CI)
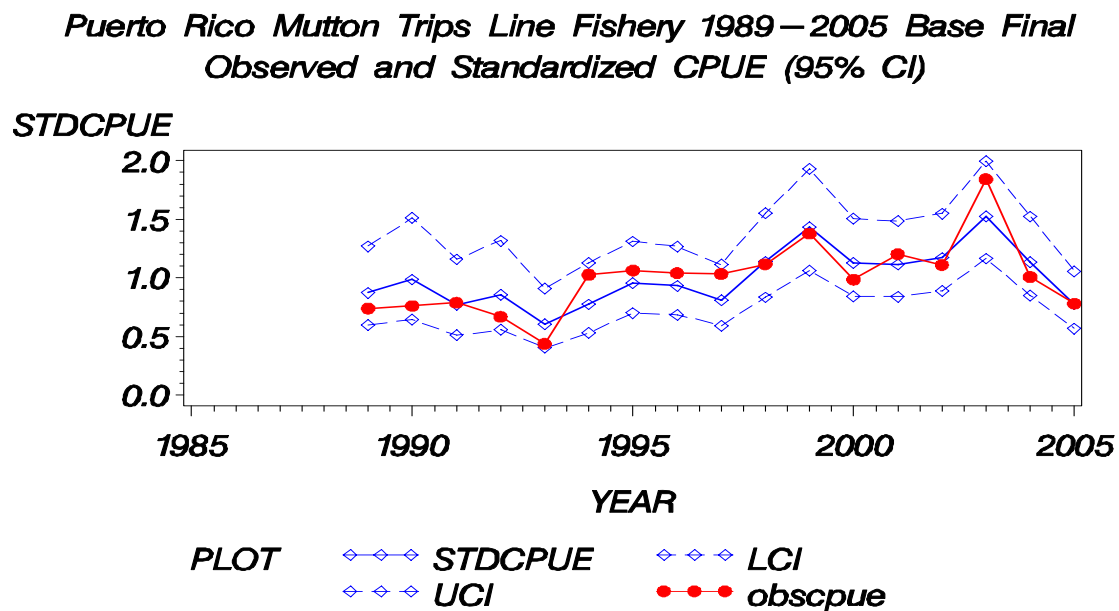
Figure 4b. Standardized mutton snapper CPUE, 95% confidence interval and, nominal CPUE of mutton snapper from the Puerto Rico line fishery, 1989-2005. CPUE is measured in Lbs per trip.

Puerto Rico Mutton Trips Line Fishery 1989−2005 Base Final Diagnostic plots: 1) Obs vs Pred Proport Posit
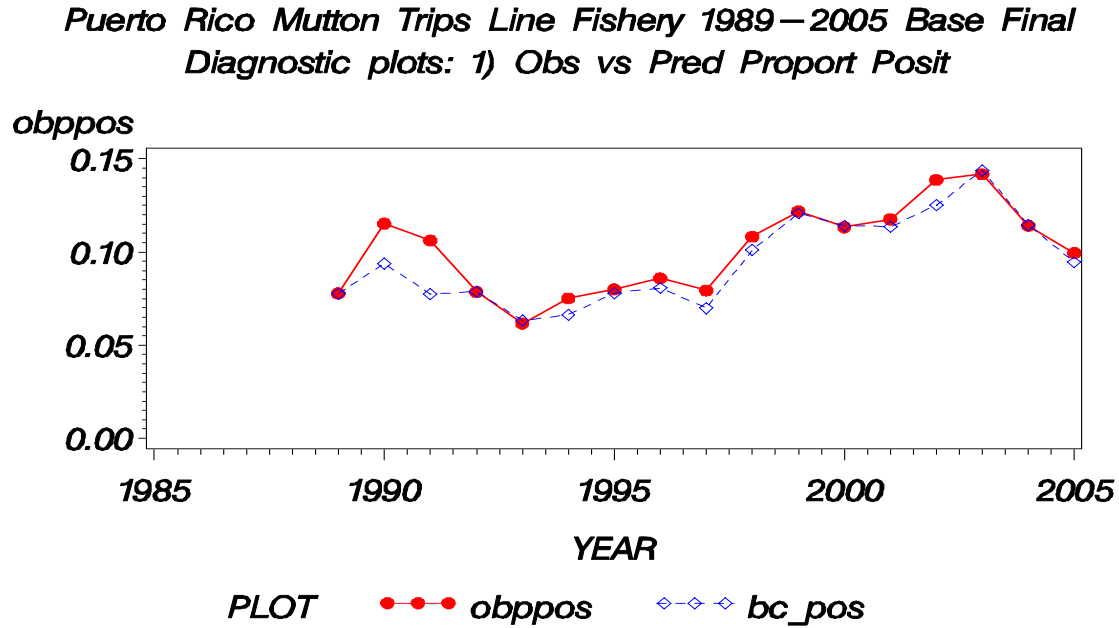
Figur 4c. Nominal proportion of positive (successful) trips and the model predicted proportion of positive (successful) trips for Puerto Rico mutton snapper commercial line fishery, 1989-2005.

Puerto Rico Mutton Trips Line Fishery 1989−2005 Base Final Residuals positive CPUEs * Year
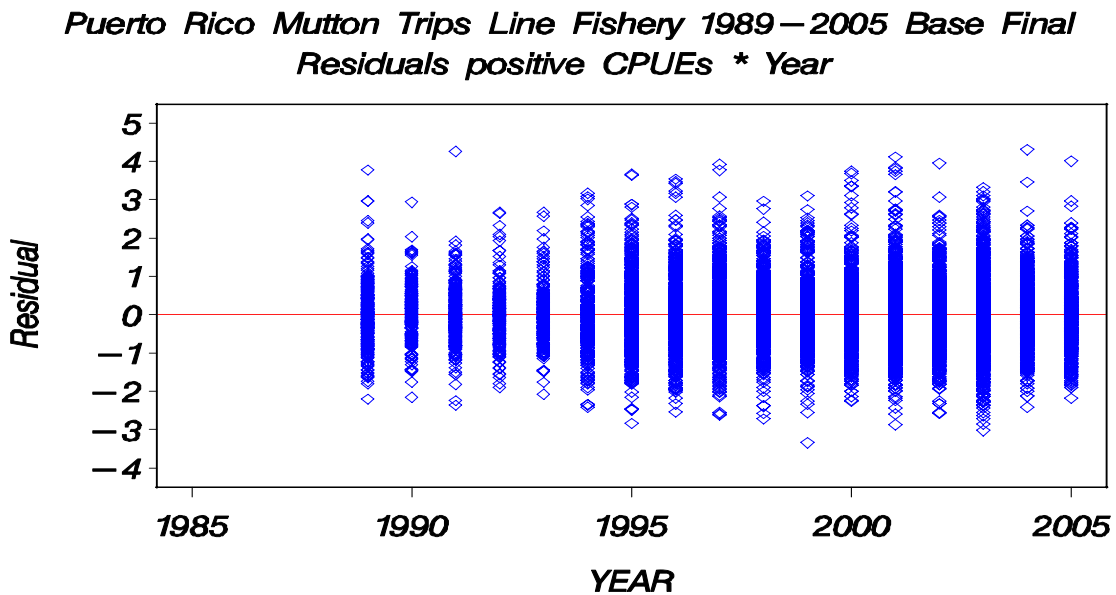
Figure 5a. Residual distribution of the final delta lognormal model for the positive (successful) observations for mutton snapper from the Puerto Rico commercial line fishery, 1989-2005..

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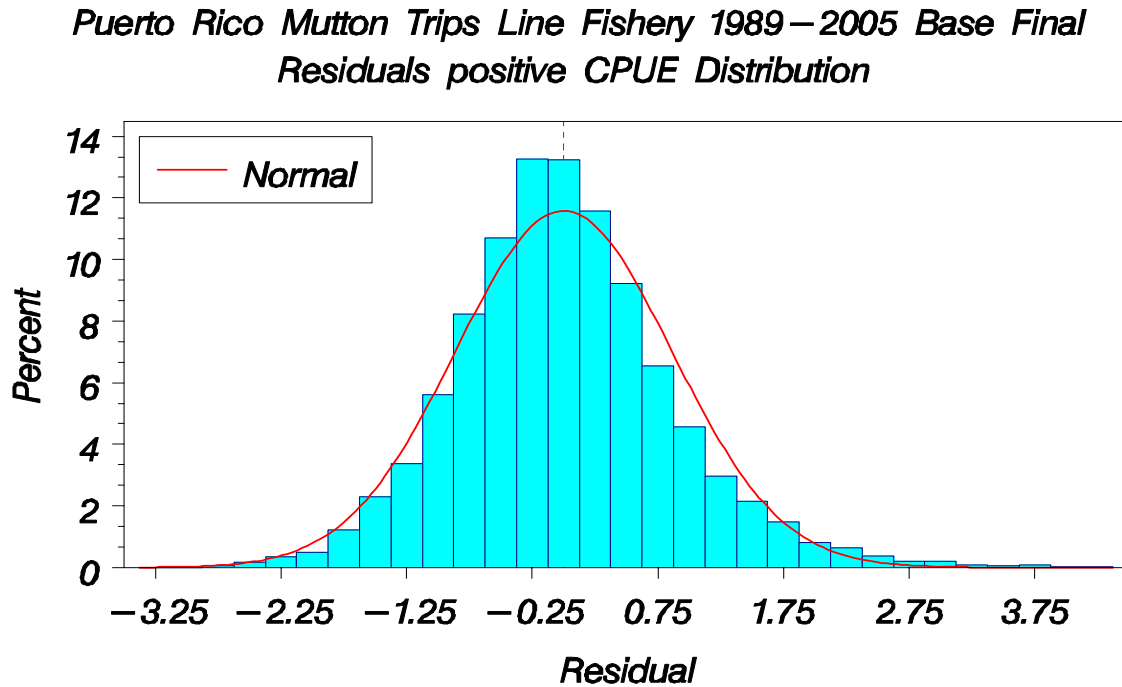
Figure 5b. Fitted error distribution from the final delta lognormal model fitted to the mutton snapper positive (successful) CPUE observations from thePuerto Rico commercial line fishery, 1989-2005.
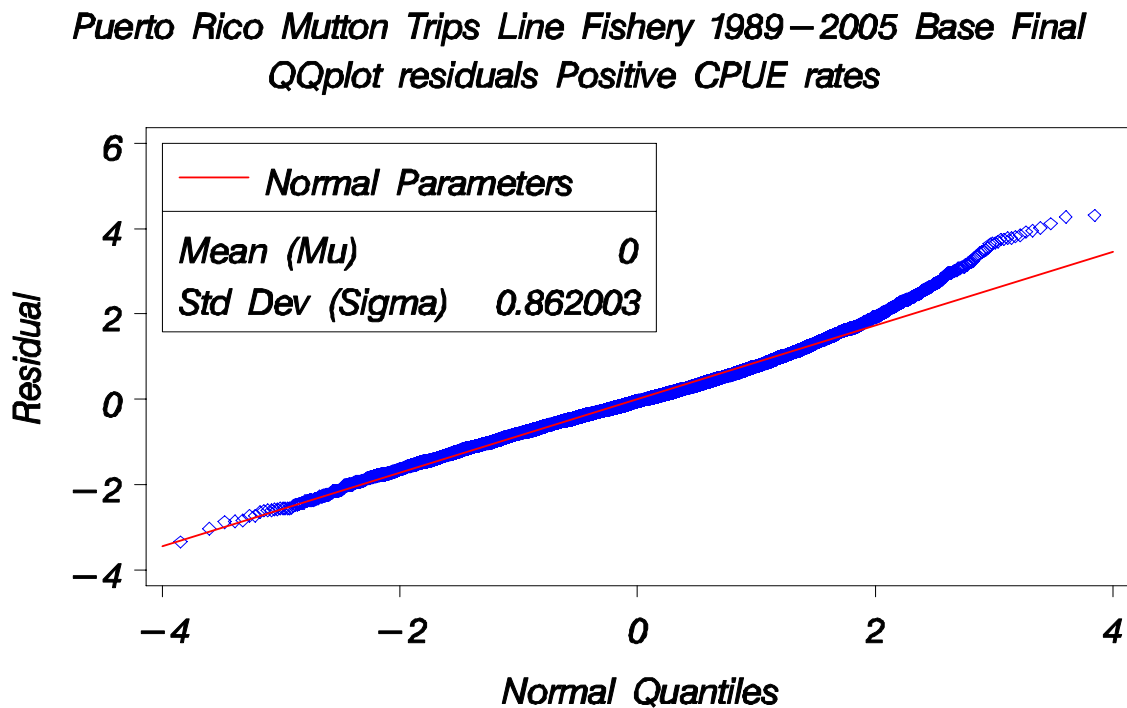
Figure 5c. Cumulative normalized residuals (qq-plot) from the delta lognormal assumed error distribution for log (CPUE). For mutton snapper from the Puerto Rico line fishery, 1989-2005.
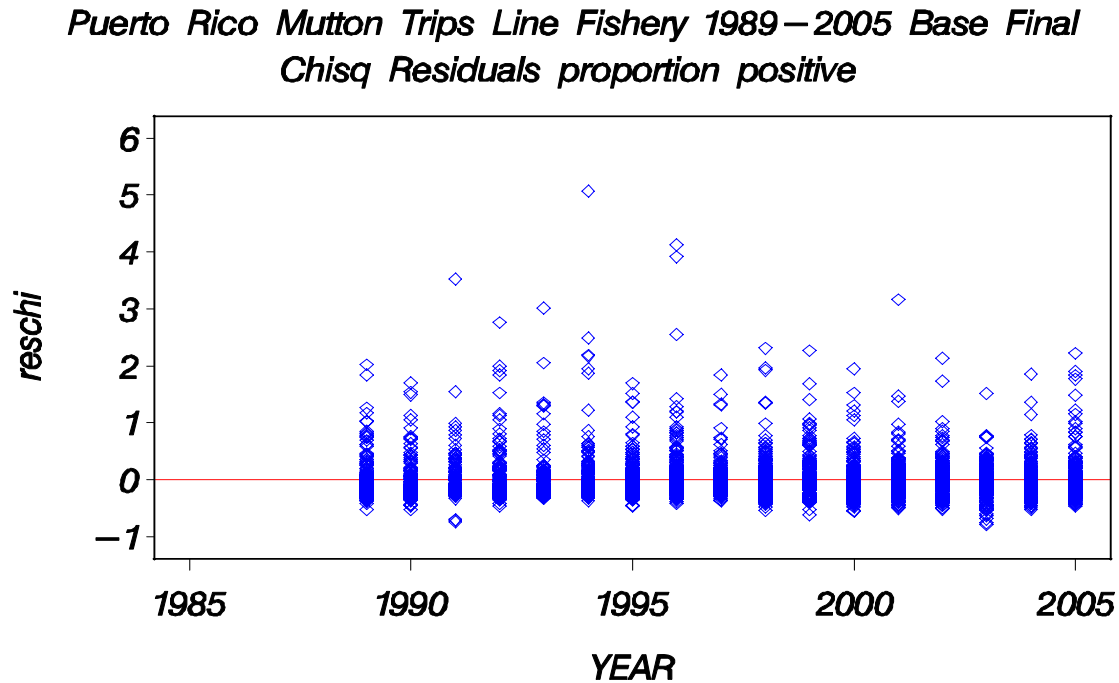
Figure 5d. Residual distribution of proportion positives from the final delta lognormal model by year, for mutton snapper from the Puerto Rico line fishery, 1989-2005.

Figure 6a. Nominal unadjusted CPUE (lbs/trip) for mutton snapper landed in the commercial pot fishery in Puerto Rico, 1990—2005.

Puerto Rico Mutton Trips Pot Fishery 1990−2005, Base
Frequency distribution log CPUE positive catches

Normal Curve

Mean (Mu)　　　　2.224098
Std Dev (Sigma)　　0.784674

Figure 6b. Frequency distribution of log(CPUE) of mutton snapper positive (successful) trips from the Puerto Rico commercial pot fishery, 1990-2005.

Puerto Rico Mutton Trips Pot Fishery 1990−2005, Base
Observed proportion pos/total by year

If prop pos = [1 or 0] Binomial model will not estimate a value for that year

Figure7a.   Observed average proportion of positive (successful) trips for mutton snapper from the Puerto Rico commercial pot fishery, 1990-2005.

Figure 7b. Frequency distribution of the proportion of positive (successful) trips for mutton snapper from the commercial pot fishery in Puerto Rico, 1989-2005.

Figure 8a. Nominal and standardized CPUE of mutton snapper from the Puerto Rico commercial pot fishery, 1990-2005. CPUE is measured in Lbs per Trip.

Puerto Rico Mutton Trips Pot Fishery 1990−2005, Base Observed and Standardized CPUE (95% CI)

Figure 8b. Standardized mutton snapper CPUE, 95% confidence interval, and nominal CPUE from the Puerto Rico commercial pot fishery, 1990-2005. CPUE is measured in Lbs per Trip.

Puerto Rico Mutton Trips Pot Fishery 1990−2005, Base Diagnostic plots: 1) Obs vs Pred Proport Posit
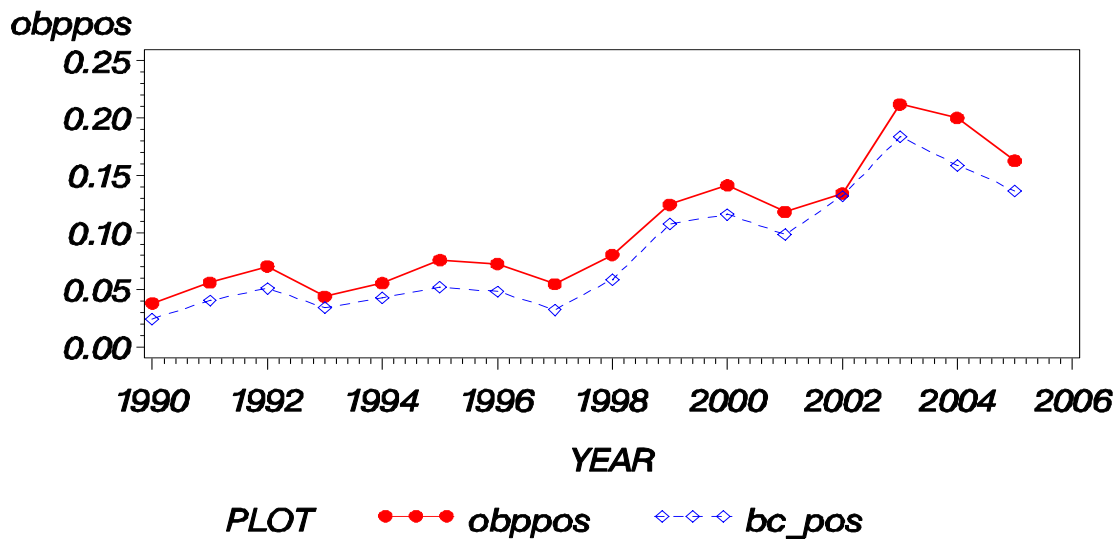
Figure 8c. Nominal proportion of positive (successful) trips and predicted proportion of Positives of mutton snapper trips for the Puerto Rico pot fishery, 1990-2005.
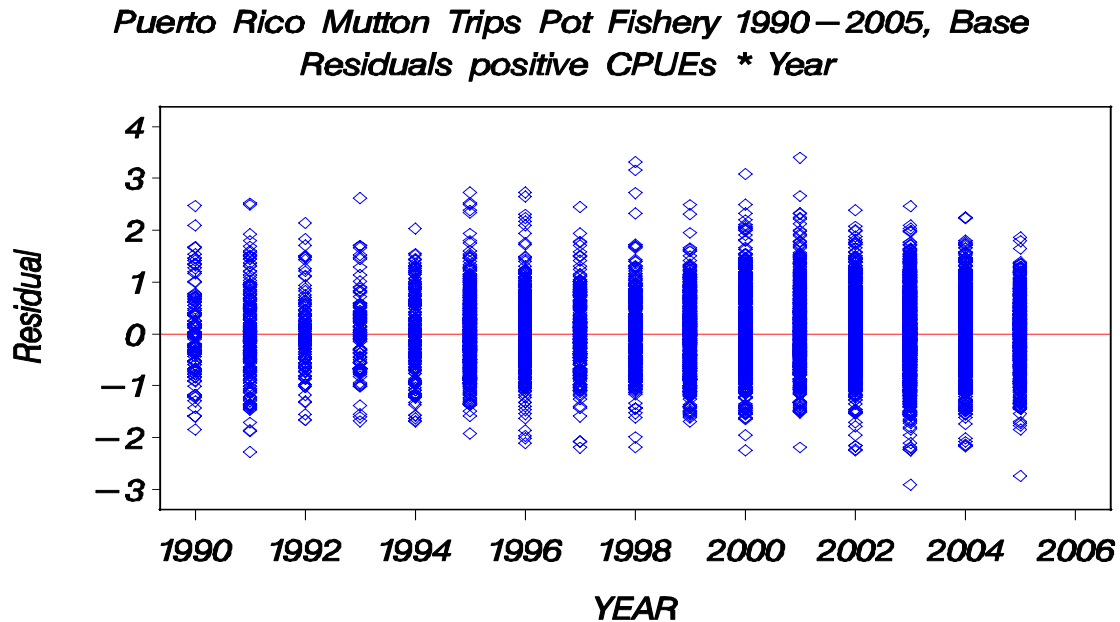
Figure 9a Residual distribution from the final delta lognormal model for the positive (successful) observations, for mutton snapper pot fishery in Puerto Rico, 1990-2005.
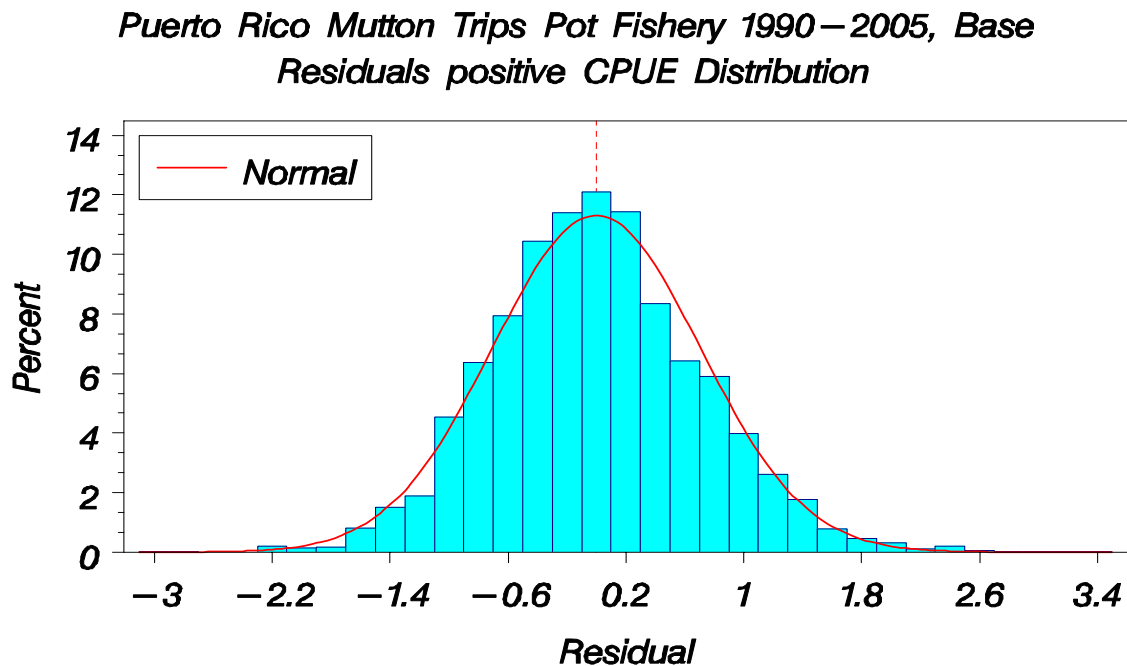
Figure 9b. Fitted error distribution from the final delta lognormal model for the positive (successful) CPUE observations, for mutton snapper from the Puerto Rico pot fishery, 1990-2005.

Puerto Rico Mutton Trips Pot Fishery 1990−2005, Base
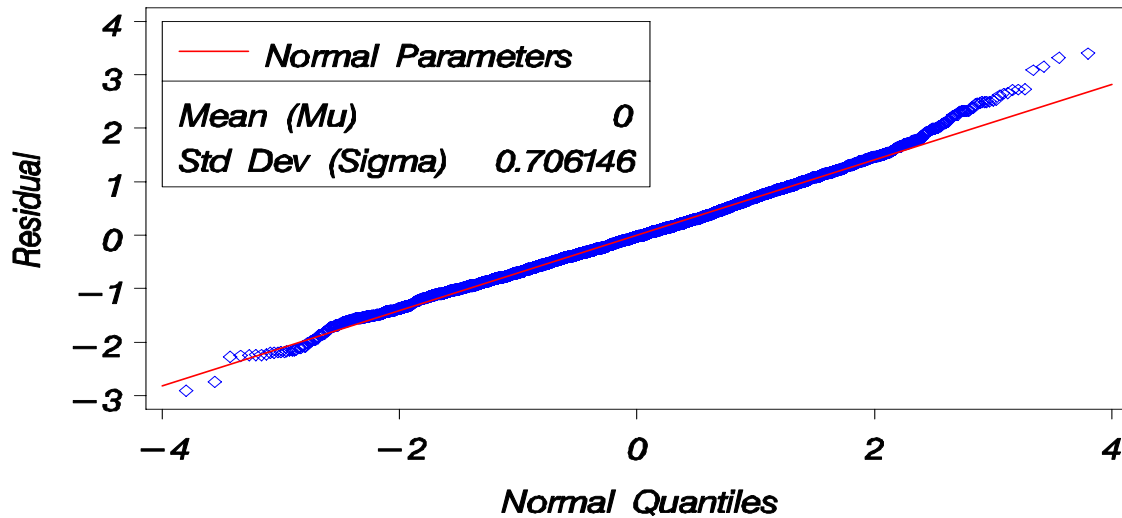**QQplot residuals Positive CPUE rates**

Figure 9c. Cumulative normalized residuals (qq-plot) from the delta lognormal assumed error distribution for log (CPUE) for mutton snapper positive (successful) trips from the Puerto Rico pot fishery, 1990-2005.

Puerto Rico Mutton Trips Pot Fishery 1990−2005, Base
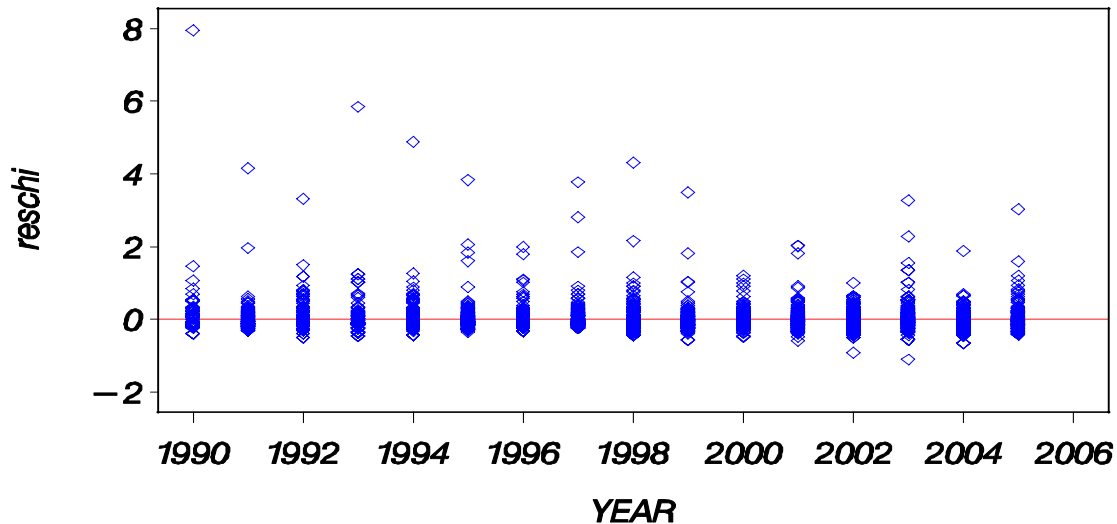**Chisq Residuals proportion positive**

Figure 9d. Residual distribution from the final delta lognormal model by year, of the proportion positives (successful) for mutton snapper from the Puerto Rico pot fishery, 1990-2005.
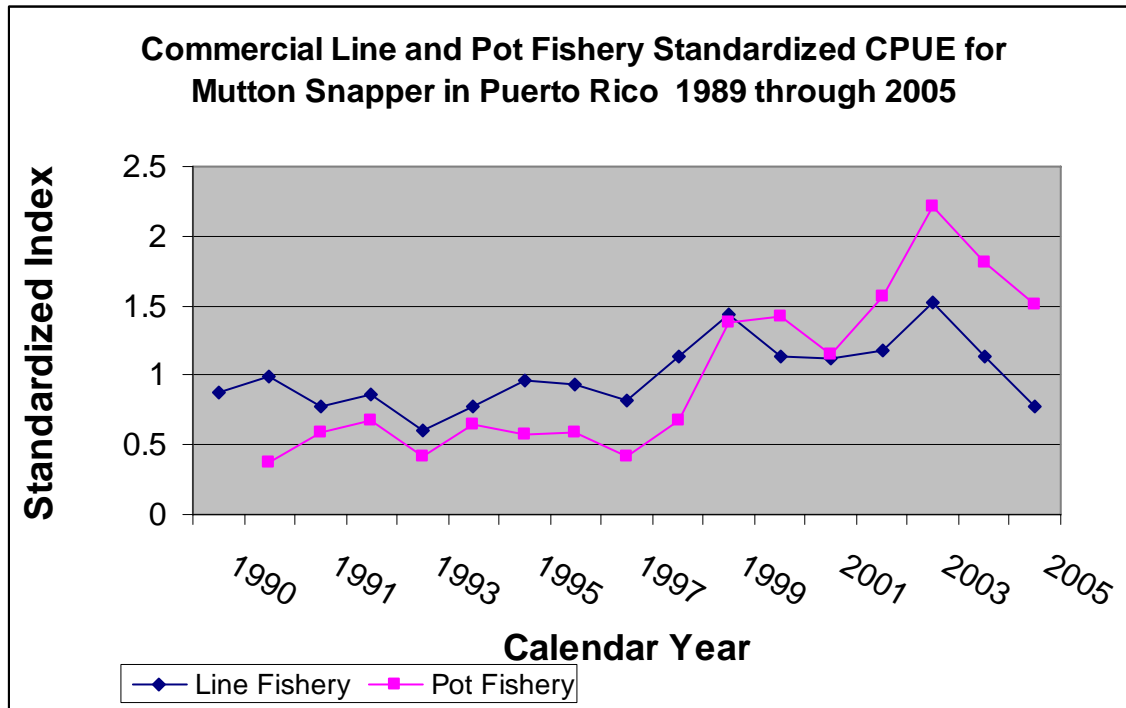
Figure 10. Standardized Indices of mutton snapper commercial CPUE for the line and pot fisheries in Puerto Rico, 1989-2005. Pot Fishery Index only calculated for 1990-2005. See text for details.