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STANDARDIZATION OF RECREATIONAL FISHING SUCCESS FOR MARLIN IN THE WESTERN NORTH ATLANTIC OCEAN, 1973-1991, USING GENERALIZED LINEAR MODEL TECHNIQUES

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SUMMARY

This report represents an update and expansion of an earlier analysis of recreational fishing success for blue marlin and white marlin from the western North Atlantic Ocean, 1972 through 1986. The previous investigation combined all data within the range of each species under study. Here, an additional five years of data are analyzed for all regions combined, as well as by the appropriate region for each species. A general linear model was applied to marlin tournament and dock (non-tournament) catch and effort data. Indices of abundance for the years 1973-1991 were obtained using numbers of blue marlin and white marlin hooked per unit of fishing time (HPUE) and caught per unit of fishing time (CPUE). The original boat-trip records were aggregated into day-location records for the purpose of this analysis. These records were then weighted according to the number of boat-trips they included. Factors considered in the analysis were year, region, bi-month period, and appropriate two-way interactions. Region-specific r^2 values for HPUE and CPUE, by species, were very similar. The models for white marlin explained more of the variation than did the blue marlin models, with the highest r^2 being about 0.40.

RESUME

Le présent rapport constitue une mise à jour et une prolongation d'une analyse sur le succès de la pêche sportive de makaire bleu et de makaire blanc dans l'Atlantique nord-ouest de 1972 à 1986. La recherche antérieure combinait toutes les données dans le cadre de chaque espèce sous étude. Ici, cinq années supplémentaires de données sont analysées pour toutes les régions combinées, ainsi que par régions appropriées pour chaque espèce. Un modèle linéaire généralisé a été appliqué aux données de prise et effort obtenues sur les makaires lors de championnats et au déchargement (championnats exceptés). Les indices d'abondance des années 1973-91 ont été obtenus en utilisant le nombre de makaires bleus et de makaires blancs ayant mordu par unité de temps de pêche (HPUE) et capturés par unité de temps de pêche (CPUE). Les registres originaux de sortie ont été regroupés en registres de jour/lieu pour les besoins de cette analyse. Ces registres ont ensuite été pondérés selon le nombre de sorties qu'ils comprenaient. Les facteurs considérés dans l'analyse étaient: année, zone, quinzaine et interactions réciproques appropriées. Les valeurs de r^2 spécifiques de la région pour la HPUE et la CPUE, par espèce, étaient très similaires. Les modèles du makaire blanc illustraient mieux la variation que ceux du makaire bleu, la valeur la plus élevée de r^2 étant d'environ 0.40.

RESUMEN

Este informe es una actualización y ampliación de un análisis anterior del éxito de la pesca recreativa de aguja azul y aguja blanca en el Atlántico noroeste, desde 1972 hasta finales de 1986. La investigación llevada a cabo anteriormente combinaba todos los datos dentro de la gama de cada especie en estudio. Aquí, se analizan datos de cinco años adicionales,

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de todas las regiones combinadas, así como por la región apropiada para cada especie. Se aplicó un modelo lineal generalizado a los datos de captura y esfuerzo de torneo de marlines y de muelle (en este caso no eran de torneo). Se obtuvieron índices de abundancia para los años 1973-1991 usando el número de ejemplares de aguja azul y aguja blanca enganchados en el anzuelo por unidad de tiempo de pesca (HPUE) y capturado por unidad de tiempo de pesca (CPUE). Para este análisis, los registros originales de salidas de los barcos se incorporaron a los registros de día /lugar. Después, estos registros se ponderaron de acuerdo con el número de salidas que incluían. Los factores considerados en el análisis fueron año, región, período bimensual, y las interacciones apropiadas en dos direcciones. Los valores r^2 específicos de la región para HPUE y CPUE, por especie, eran muy similares. Los modelos para la aguja blanca aclaraban mejor la variación que los modelos para la aguja azul, siendo el r^2 mas próximo a 0.40.

1. INTRODUCTION

Indices of abundance for blue marlin (*Makaira nigricans*) and white marlin (*Tetrapturus albidus*) were first established from recreational fishing data from the western North Atlantic by Browder and Prince (1988). Prior to that investigation, only nominal rates of recreational fishing success had been reported, the most recent being Prince et al. (1990). Catch rates must be adjusted, i.e., standardized, in order to be considered as a potentially reliable indicator of changes in relative abundance. In this study, the Browder and Prince (1990) analysis of recreational fishing success for blue marlin and white marlin from 1972 through 1986 is updated and expanded to include data from 1987 through 1991. We used a general linear model (Farber 1986; Browder and Prince 1990, and others) to standardize the recreational catch rates for blue marlin and white marlin for three main factors: region, time-period, and type of fishing, i.e., tournament or non-tournament.

Standardized HPUE and CPUE are used as indices of abundance in stock assessment analyses using virtual population analysis (VPA) and surplus production modeling. Standardized estimates from the present study are being applied to production models by Cramer and Prager (1992).

In the present study, we analyzed 19 years of data from individual regions of the study area, as well as the combined-regions. This approach expands the analysis of Browder and Prince (1990), in which all data within the range of each species were combined - regions were not examined separately. The separate regional models provide additional perspective because, although separate regional estimates can be obtained from a combined-regions model, they will all display the same pattern over time. By modeling the regions separately, we can determine how the regional trends differ from each other and from the combined-regions trend. This information is useful in evaluating the trends from the viewpoint of stock assessment.

The recreational billfish survey of the Southeast Fisheries Center, National Marine Fisheries Service (NMFS), was the source of the data. Beardsley and Conser (1981) described the survey and discussed the potential for obtaining indices of abundance from survey data. A comprehensive review of this survey for 1972-1986, including details of time-area coverage, is presented by Prince et al. (1990) and therefore not repeated here. The scope and direction of the survey has remained essentially the same throughout the 19-yr period. Certain aspects of data collection methods were changed in 1986. Budgetary constraints reduced the number of tournaments that could be attended by NMFS personnel. In place of this coverage, the survey team began to actively solicit tournament data on a volunteer basis from cooperative tournament personnel. This proved to be a cost-effective way of obtaining information from tournaments that NMFS representatives were not able to attend and even greatly expanded coverage in certain areas. The data collected, however, were not as comprehensive as that obtained by NMFS representatives.

The pattern of nominal data are presented prior to the standardized indices. This includes the HPUE and CPUE for blue marlin and white marlin for combined areas, as well as the total annual sampled effort and associated number of marlins hooked and caught. Hence, in a limited way, this paper extends the analysis of Prince et al. (1990).

2. DATA AND METHODS

Much of the information involved in defining the source of the data, the preparation of the data, the distribution of blue marlin and white marlin, and the analysis techniques are detailed and presented in Browder and Prince (1990) or Farber (1990), and generally are not repeated in this report unless necessary for continuity, clarity, or comparison.

Standardized estimates of fishing success for blue and white marlin were first obtained from U.S. recreational data for the years 1972-1986 and published in Browder and Prince (1988). A later paper (Browder and Prince 1990) provided a more detailed presentation of the same results. The methods used in the present paper, applied to an extended time series, are identical in many respects to those of the original work.

2.1 Description of the Original Data

The Recreational Billfish Survey of the Southeast Fisheries Science Center, National Marine Fisheries Service (NMFS), is the source of the data used in this analysis and is described in Prince et al. (1990). The data originated from two types of sampling: tournament coverage and non-tournament sampling. Six categories of tournaments, generally specified by the tournament organizers, are covered in the survey: blue marlin, white marlin, marlin, billfish, sailfish, and tuna.

Two measures of fishing success were examined in this study; the number of fish hooked per unit of effort (HPUE) and the number of fish caught per unit of effort (CPUE). The number of fish caught is a subset of the number hooked. It includes only the fish boated, released, or tagged and released. It does not include the number hooked but then lost. The number of fish hooked includes the number hooked and lost, as well as the number boated, released, or tagged and released. Effort is measured in hours of fishing (i.e., trolling) time. Catch rates from recreational billfish data generally are considered more representative of fishing success when expressed as HPUE, and may be more appropriate as an index of relative abundance, because of the unique characteristics of trolling for billfishes (Beardsley and Conser 1981; Prince et al. 1990; Farber 1990).

The 1972-1985 database used in this analysis is the same as that analyzed in Browder and Prince (1990) and consists of one set of yearly files containing the same type of information that was the basis for calculating both HPUE and CPUE. The structure of this database and specific information it contains were described by Browder and Prince (1990). Beginning in 1986, the data used to calculate HPUE and CPUE were recorded in separate databases because records from tournaments not attended by NMFS data collectors began to be included that year. For these tournaments, there was no information on the fish that were hooked and then lost, so HPUE could not be calculated. The two files include most of the same tournaments, but some tournaments included in the CPUE files are not included in the HPUE files. Therefore, beginning in 1986, more sampled nominal effort occurs in the "catch database" than the "hooked database." The Browder and Prince analysis covered the years 1972-1986. The present analysis covers the years 1973-1991. The data from the Mid-Atlantic Bight region (defined below) in 1987 were all reported as CPUE rather than HPUE (Prince et al. 1989). Hence, only those billfish actually caught (boated, released, or tagged and released) were counted, along with the associated effort. Therefore, the general linear model (GLM) for the Mid-Atlantic Bight was not able to estimate an HPUE in 1987 for marlin.

2.2 Preparation of the Data

In most respects, the data were prepared as described in Browder and Prince (1990). Two separate files were created: one for HPUE and another for CPUE. Individual records for each fish were first combined into a record for each trip. Then these records were further combined into a single record for each day and location. The rationale for combining the data into day-location records was given in Browder and Prince (1990).

Seven geographic regions were defined for the present analysis: (1) New England (Massachusetts to Rhode Island), (2) Mid-Atlantic Bight (New York to North Carolina), (3) South Atlantic Bight (South

Carolina to Daytona Beach, FL), (4) South Florida (Cape Canaveral to Key West), (5) the Bahamas, (6) the Caribbean (Puerto Rico, U.S. Virgin Islands, Dominican Republic, Cayman Islands, and Cozumel), and (7) the Gulf of Mexico (Appendix 1 - map). Our numbering of regions is slightly different from that of the previous analysis, in which six regions were defined. The change does not represent an extension in coverage but rather separation of one region into two. In our analysis, New England and the Mid-Atlantic Bight were numbered separately to facilitate working from the same database for both species while excluding New England from the blue marlin analysis but not the white marlin analysis. The region numbers referred to in the present analysis do not correspond to those in the Browder and Prince analysis for this reason.

Some data were excluded from the original databases. We had two rationales for excluding data. First, we excluded data from tournaments in which the fishing grounds or fishing strategy resulted in a low probability of capturing blue or white marlin. We excluded data from sailfish and other live bait tournaments, as was done by Browder and Prince (1990). Additionally, we excluded data from tuna tournaments. The second reason we excluded data was to minimize the number of sparse or empty cells in the analysis. We excluded time periods and regions with small sample sizes for this reason. This led to exclusion of the year 1972 and the months January, February, November, and December of all the other years. Certain geographic areas were excluded from the analysis because of sparsity of data. After exclusion of sailfish and other live bait tournaments, there were so few records in Regions 3 and 4 that these entire regions were excluded from our analysis, although they were not excluded in the Browder and Prince study. The west coast of Florida south of the Panhandle (below Panama City) also was excluded because the tournaments in that area target sailfish almost exclusively or generally are not productive for marlin. New England was excluded from the blue marlin model because few blue marlin are caught in that region.

To further reduce the problem of small sample sizes within a time-area-type stratum, we defined two-month periods, which we called "waves", to take into account the seasonal variation in the data. Waves 1 through 4 begin in March-April and end in September-October. Months, rather than waves, were the time periods in the Browder and Prince analysis.

2.3 Data Analysis

Exploratory Data Analyses

The nominal data, consisting of the mean annual values of HPUE and CPUE in number of fish per 100 hrs, and the sampled number of marlin hooked or caught with their associated sampled fishing effort, were plotted as in Prince et al. (1990) to provide a view of the time-series before any manipulation of the data. Mean values from nominal data can be biased by the distribution of both fishing effort and sampling effort each year. Annual variation in data distribution can produce a spurious pattern of change in mean values over time. The GLMs produce estimates that are not affected by temporal changes in data distribution and therefore can provide a more reliable picture of change over time. On the other hand, standardized annual estimates from a GLM are influenced by the fit of the model to the data. It is therefore useful to compare the pattern of change in standardized estimates from GLMs to that in the original data.

An understanding of hours of fishing per individual trip and hours of fishing per day-location record also was obtained in the exploratory phase of our analysis. Additionally, we looked at fighting time as a proportion of fishing time in our records. The perspective gained was useful in formulating our dependent variables.

General Linear Models

We developed GLMs to obtain standardized estimates of annual HPUE and CPUE, which are generally thought to be indicative of changes in relative annual abundance. These annual estimates were plotted to examine the pattern of change over time. For each species, we constructed a combined-regions model and separate models for the regions yielding most of the sampled catch of that species. Our purpose in constructing separate regional models was to compare the pattern of temporal change in the individual regions to that in the combined data. We wanted to know whether any one region strongly influenced the pattern of change in the combined data and whether the regions differed in their pattern of change. This could only be determined by developing individual regional models.

"Region", "wave", and "type" were the effecting factors included in the combined-regions models. These were the same effects examined in Browder and Prince (1990). "Type" refers to sampling type, tournament or dock. These two types of sampling coverage are described in detail in Browder and Prince (1990). The main effects defined in the regional models were "wave", and "type". Browder and Prince (1990) found that, as independent variables in the blue marlin model, sea state and cloud cover were both highly significant, although they explained little more of the variation in fishing success than models without them. The model with both variables explained only 0.5% more of the variability in blue marlin HPUE. In the white marlin models, cloud cover was not significant. A large portion of the database does not have sea state and cloud cover data. Furthermore, although these two variables are ordinally described, they are subjective in nature. Therefore, we did not include sea state and cloud cover in our models.

In our combined-regions models, each region, wave, and type formed a stratum, or cell, of the analysis. The region-wave interaction also was included in the models to allow regional differences in seasonal patterns of fishing success to be taken into account. One constraint in our selection of data and "effects" to include in the model was to minimize the number of sparse or empty cells, whose presence can compromise an analysis (Searle 1987). "Type" was included as one of the effects, despite the increased number of sparse and empty cells it caused, because it was a highly significant variable (except in the Mid-Atlantic Bight) whose inclusion substantially increased the model's ability to explain the variation in HPUE and CPUE (i.e., yielded higher r^2 values). The distributions of day-location records by strata (i.e., region-wave-type) and numbers of trips associated with those records are presented in Appendix 1 and 2, respectively (a - blue marlin HPUE; b - blue marlin CPUE; c - white marlin HPUE; d - white marlin CPUE). The combined-regions model for blue marlin included regions 2, 5, 6, and 7. The combined-regions model for white marlin included regions 1, 2, 5, 6, and 7. "Type" was not included as an effect in the Bahamas models because all the records from this region were from tournaments.

In formulating our GLMs, we loaded our independent variables explicitly, rather than declaring classes or "effects". We defined a dummy variable for each alternative (or "level") of each effect and then placed each alternative main effect and interaction term in the model as a separate independent variable. This approach allowed us to exclude from each model the terms and interactions that resulted in empty cells in that particular model. For instance, certain wave-region interactions were excluded because there were no records for the particular wave in that region. When classes are declared in formulating GLMs, there is no way to exclude empty cells. Our approach of defining dummy variables and explicitly including all levels of each effect in the GLM was the same as that used by Browder and Prince (1990). However, they used the "new regression backward deletion" module of SPSS (Hull and Nie 1981). In our study we used the "proc glm" module in SAS (SAS 1991).[2] It was not possible to run a class-oriented model in SAS on our data. To take into account the original number of trips making up a record, each record was "weighted" in the GLM analysis by the number of trips it comprised. This is another way in which our analysis conformed to that of Browder and Prince (1990).

The dependent variables of the analysis were of the general form:

$$\ln \{[(M \times N) + c] / E\}$$

where N = number of fish hooked or caught, M is a constant multiplying factor, c is a constant necessary in a logarithmic model of this form when zero values are present in the data, and E is hours of fishing. It was necessary to add a constant to the data before taking the log because there were records in which effort was expended but no fish were caught. Browder and Prince give the rationale for using a multiplying factor when adding a constant to the data prior to taking the log. We used the same method as theirs to calculate the "best" multiplying factor, and found that an M of 300 was best for these data when c= 1 was used, as explained below.

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2 This approach to GLM analysis is not presented in SAS manuals. We were assisted via personal communication with Marje Martin, SAS Institution Regional Education Manager, Chicago,IL.

In our view, the multiplying constant, M, should always be larger than the number of hours fished per trip, because we should not add a constant to data that is expressed as a fraction of the true effort unit (i.e., we should not add a constant to number of fish per one hour of fishing). The true effort unit, within which period either no fish were caught or one or more fish were caught, is the fishing trip, consisting of several hours. We determined that recreational anglers in our data base spent an average of 8 hours of trolling per trip. This is slightly greater than the 6 hours per trip assumed by Browder and Prince.

Departing from Browder and Prince, we did not subtract fighting time from fishing time because doing so would necessitate eliminating records that did not include information on fighting time (the length of time a fish was on the hook). Although records without fighting time make up only a small portion of the database, they may be unevenly distributed among cells. Furthermore, cells with small sample sizes might be disproportionately affected by excluding them. Also, fighting time is a datum often estimated post facto. We found in an exploratory analysis on blue marlin HPUE that exclusion of records without fighting time and the subsequent subtraction of fighting time from fishing time decreased the r^2 by 20%. The scale and pattern of change of the HPUEs computed with and without fighting time were virtually the same. Fighting time probably was not a substantive source of variability in the data we analyzed because each of our records consisted of all trips occurring in the same day and location.

The annual least-squares means produced by the models were back-transformed and divided by three to be expressed in terms of fish hooked or caught per 100 fishing hours trolling. A correction for bias inherent in the back-transformation process was applied (Duan 1983). Approximate 90% confidence bounds were calculated. As was true for Browder and Prince (1990), our residuals were not quite normally distributed; hence our estimated 90% confidence intervals should be viewed as only approximations. For all the graphic presentations (other than nominal values), the standardized annual HPUEs and CPUEs estimated by our models were adjusted to a scale based on 1.00 in 1973 before being plotted. Therefore, patterns of change rather than the absolute magnitude of change are revealed by these plots. The adjustment facilitates plotting on the same scale and making comparisons. The 1973-adjusted standardized values are dimensionless.

In our comparisons of results with those of Browder and Prince (1990), we note patterns of change over time, not absolute values, because our results are adjusted to a basis of 1.00 in 1973. We determined the correlation (r) between standardized HPUE and CPUE over the period 1973 to 1991 for blue marlin and white marlin by region. (Prince et al., 1990, investigated the relationship between nominal success rates over the period 1972 to 1986.)

3. RESULTS

3.1 Nominal Data

Nominal results are presented for the combined-regions for comparison with Prince et al. (1990) and for comparison with the standardized estimates to be presented in a following section. The nominal values for effort and numbers hooked and caught do not reflect the change in total catch or fishing effort. Rather, they represent the changes in tournament sampling effort over time. The number of fish and effort associated with HPUE and CPUE differ because of the previously discussed difference in the data sets. Nominal CPUEs and HPUEs have similar temporal patterns for blue marlin (Fig. 1a) and white marlin (Fig. 1b), and HPUE values are generally greater than those of CPUE for both species. Nominal fishing success for blue marlin increased slightly from 1973 to 1986 (as noted by Prince et al. 1990) and was exceptionally high in 1981 and 1982. This trend continued through 1989, followed by a decrease from 1989 through 1991. For white marlin, nominal rates fluctuated with little trend from 1973 through 1979, increased sharply to a maximum in 1980, and then generally decreased through 1986, reaching a low in 1985, as noted by Prince et al. (1990). Except for an increase in 1987, the decline continued through 1991.

Figures 2 and 3 show how sampled catch (i.e., numbers of billfish hooked and caught) and effort changed from 1973 to 1991. The sampled number of blue marlin hooked (Fig. 2a) and caught (Fig. 3a) followed a general increasing trend through 1988 and then decreased from 1988 to 1991. Sampled effort roughly followed the same general pattern as sampled catch, both reaching maxima in 1983. The magnitude of sampled effort was higher from 1986 to 1991 in the catch database than in the hooked data base and the trend was upward (Fig. 3a). The number of white marlin hooked (Fig. 2b) and caught (Fig. 3b) decreased sharply from 1980 to 1991, except for high values in 1983 and 1984, both associated with high sampled effort. Trends in effort were very similar to those for blue marlin (the difference being due to the addition of Area 1 for white marlin) over the 19-yr period. In general, the sampled numbers of marlin hooked each year was greater than the numbers caught (except during 1987-1991 for white marlin), thereby yielding HPUEs greater than CPUEs (Fig. 1). Had the two databases - HPUE and CPUE - contained the same number of records, the number hooked would always be greater than the number caught. But the CPUE database contains more records, for reasons explained previously.

3.2 Standardized Annual HPUE and CPUE Rates

Adding 5 more years (1987-1991) to the time series of standardized rates of fishing success first prepared by Browder and Prince (1990) provides considerably more perspective on the relative condition of blue and white marlin stocks accessible to the U.S. recreational fishery. Standardized annual fishing success rates resulting from our GLMs, developed for each of the regions and for the combined region, by species, were highly significant (F-prob < 0.001) and explained from 9% to 42% of the variation in the data (Table 1). The Caribbean blue marlin HPUE and CPUE models explained the highest proportion of variation in their data (r^2), although having the fewest number of records (and trips). For white marlin, the combined-regions models had the highest r^2-values. Gulf of Mexico models for both species had the lowest r^2-values, although contributing over 70% of the records and 45-51% of the trips in the combined databases. The white marlin combined-regions models explained roughly 50% or more of the variation in their data than did the blue marlin combined-regions models.

Graphical results from the GLMs are presented in terms of annual 1973-adjusted standardized rates in dimensionless units. Results are presented in the following order: blue marlin HPUE and CPUE from the combined-regions model (Fig. 4) and from the separate region models (Figs. 5-9); white marlin HPUE and CPUE from the combined-regions model (Fig. 10) and from the separate region models (Figs. 11-14); comparisons between blue marlin and white marlin HPUE and CPUE from the combined-regions model (Fig. 15) and from the separate region models (Fig. 16-18). Specific model formulations, in terms of main effects and interaction terms, were explained in the "Data Analysis" section.

Linear regressions quantified the strength of the relationship between the standardized estimates of CPUE and HPUE. The correlation coefficients (r) were above 0.5 for both species, but lower for blue marlin estimates than for white marlin estimates[3], with r-values ranging from 0.67 to 0.90 for blue marlin and from 0.90 to 0.98 for white marlin (Table 2). The correlations between standardized HPUE and CPUE are described by species and by region in presentations of other modeling results (Table 2).

Blue Marlin

Adjusted standardized estimates of blue marlin HPUE and CPUE from the combined-regions GLMs, shown in Figure 4a, had a correlation of r=0.67. The slight increase over time present in both rates in the nominal data (Fig. 1a) was absent from the adjusted standardized HPUEs. In fact, the HPUE series was relatively stable over time, after an upward trend from about 1976 to 1981 (Fig. 4b). The same upward trend, even more pronounced, is present in the adjusted standardized CPUEs and continues through 1991 (Fig. 4c). Note that the approximate confidence limits are fairly narrow (Fig. 4b and c). This extends the findings presented in Browder and Prince (1990, Fig. 2A and B). The percent of variance explained by our models (i.e., r^2) was 24% and 26%, respectively; about the same as found by Browder and Prince (1990).

The two standardized indices for blue marlin in the Mid-Atlantic Bight region were correlated over time, r=0.74. Both decreased from 1973 to 1976 (Fig. 5a). The time-series for HPUE (Fig. 5b) from 1976 to 1991 (there is no 1987 HPUE estimate) fluctuated but was basically stable, exhibiting no long-term trend. Adjusted standardized CPUE fluctuated similarly over the period 1976-1984, increased in 1985, and

3 Prince et al, 1990 reported on nominal success rates, by area, and found similar patterns except for the Gulf of Mexico.

then remained basically stable through 1991 (Fig. 5c). The percent of variance explained by the models was $r^2 = 0.19$ and 0.17, respectively.

The blue marlin HPUE and CPUE time series produced by models for the Bahamas were correlated, with $r = 0.71$. The adjusted standardized HPUE time-series exhibited no long term trend over the 19-yr period (Fig. 6a and b). HPUE increased to a maximum in 1983, then declined to a minimum in 1986, then returned to the pre-1983 level. The adjusted standardized annual CPUE index was basically stable from 1973 to 1980, followed by a generally increasing trend, with some variability, from 1980 to 1991 (Fig. 6c). The percent of variance explained by the models was $r^2 = 0.11$ and 0.12, respectively.

The time-series of adjusted standardized HPUE and CPUE from Caribbean GLMs are very similar over the period 1973-1983, and then diverge slightly through 1991, with $r = 0.90$ (Fig. 7a). Both reflect extremely high fishing success in 1980. Otherwise, the HPUE series is basically stable with minor fluctuations over the 19-yr period (Fig. 7b), while the CPUE series exhibits a slight increasing trend over the period 1983 to 1991 (Fig. 7c). The percent of variance explained by these models was the highest for all GLMs, $r^2 = 0.41$ and 0.42, respectively.

The correlation between the standardized success rates for blue marlin in the Gulf of Mexico was $r = 0.73$. Both adjusted indices were basically stable over the period 1973-1978, except for a high in 1974 (Fig. 8a). The two indices were then fairly constant over the period 1979 to about 1987 at a level higher than in the mid-1970s, followed by a decrease through 1991 to the 1973 level (Fig. 8b and c). The percent of variance explained by these models was the lowest for all GLMs, $r^2 = 0.09$ for both.

To facilitate comparing results of all the blue marlin models, the adjusted standardized indices of abundance from the combined-regions models and all individual region models were re-plotted in Figure 9. The Caribbean dominates the plot in Figure 9b due to the anomalous 1980 success rate. Therefore, results for the other regions are re-plotted without the Caribbean in Figure 9c. The scale on the vertical axis is the same in Figures 9a (HPUE) and 9c (CPUE), but differs in Figure 9b because of the anomalous 1980 Caribbean value.

White Marlin

White marlin adjusted standardized HPUE and CPUE from the combined-regions GLMs were highly correlated, with $r = 0.97$ (Fig. 10a). Both reflect the pattern in the nominal data (Fig. 1b): a continuous decline over the period 1974-1978, followed by a sharp increase from 1978 to 1980, and then a continuous decline over the period 1980 through 1991. The 1991 HPUE and CPUE indices were 19-yr lows, about 0.24 and 0.37, respectively, compared to the 1973 level of 1.00 (Fig. 10b and c). Maxima of 1.49 and 1.81, respectively, were reached in 1981. The approximated confidence limits are fairly narrow. As with blue marlin, this extends the time series prepared by Browder and Prince (1990, Fig. 3A and B). The percent of variance explained by these models was $r^2 = 0.40$ and 0.37, respectively, the highest of all white marlin GLMs. Browder and Prince (1990) reported r^2 values of 0.43 and 0.41, respectively.

The adjusted standardized indices from the Mid-Atlantic Bight GLMs follow very similar patterns over the 19-yr time-series with a correlation of $r = 0.90$ (Fig. 11a). In general, both indices varied from 1973 to 1981, then declined from 1981 to 1991 (there was no 1987 HPUE estimate) (Fig. 11b and c), following 1980 maxima of 2.62 and 3.87, respectively. Extremely low HPUE estimates relative to those in 1973 were generated from 1986 to 1991. The minimum was 0.11 in 1991. CPUE values were lowest, 0.13, in 1986. The percent of variance explained by these models was $r^2 = 0.33$ and 0.35, respectively.

The adjusted standardized HPUE and CPUE success rates from the Bahamas GLM followed very similar patterns over the 19-yr period, correlating with $r = 0.96$ (Fig. 12a). The highest success rates, 1.27 for HPUE and 1.29 for CPUE, occurred in 1975. Except for this one year, there has been a sharply declining trend since 1973 in both success rates, with some small annual oscillations, to the 1991 minima of 0.10 and 0.22, respectively (Fig. 12b and c). The percent of variance explained by these models was $r^2 = 0.34$ and 0.22, respectively.

In the Gulf of Mexico, the adjusted standardized HPUE and CPUE follow nearly identical patterns over the 19-yr time-series with a correlation of $r = 0.98$ (Fig. 13a). The indices each declined from 1974

(1.24 and 1.43, respectively) to 1978 (0.50 and 0.54, respectively), then increased to a maximum in 1980 (1.31 and 1.61, respectively), then they declined again, with fluctuations, through 1991, when indices were 0.20 and 0.18, respectively (Fig. 13b and c). The percent of variance explained by these models was the lowest of all the white marlin GLMs, $r^2 = 0.20$ and 0.19, respectively.

The adjusted standardized HPUEs and CPUEs from the combined-regions models and all individual region models are replotted in Figure 14 to facilitate comparing results of all the white marlin models. A general decline in HPUE (Fig. 14a) and CPUE (Fig. 14b) since at least the early 1980s is apparent in indices produced by both the combined-regions and the regional models.

Blue Marlin vs. White Marlin

Figures 15-18 allow ready comparison of patterns of change over time in adjusted standardized fishing success rates for the two marlin species, by region, over the 19-yr period. Blue marlin and white marlin success rates produced by the combined-regions models (Fig. 15) are roughly similar until about 1980 for both HPUE and CPUE, after which time the white marlin rates decreased through 1991 while the blue marlin rates remain relatively stable.

The Mid-Atlantic Bight GLMs generated blue marlin rates that were roughly stable throughout the time-series (Fig. 16). After about 1980, there was a sharp decline in white marlin HPUE and CPUE.

The Bahamas GLMs generated blue marlin fishing success rates that were stable for HPUE (Fig. 17a) and increasing for CPUE (Fig. 17b). A continuous decline in white marlin catch rates in the Bahamas is evident.

Blue marlin and white marlin catch rates fluctuated considerably in the Gulf of Mexico (Fig. 18). However, after about 1984 the HPUE (Fig. 18a) and CPUE (Fig. 18b) diverged, the blue marlin rates remaining roughly stable and the white marlin rates declining sharply.

4. DISCUSSION

We generated standardized indices of fishing success rates because nominal fishing success rates may not reflect true changes in relative abundance. Uneven sampling coverage can create spurious change in mean success rates if locations with high success rates (or, conversely, low success rates) contribute more records some years than others. We can expect this problem to affect the data from the billfish survey, because coverage is not uniform across areas and tournaments and not consistent from one year to another. Standardized estimates produced by general linear models estimate least square means by weighing all strata equally, regardless of number of records.

The most striking results from our analysis of the U.S. recreational billfish data is that blue marlin fishing success remained fairly stable over the 19-yr period in each region and for all regions combined, whereas white marlin fishing success declined sharply since about 1980. These are the same results initially observed by Browder and Prince (1990) for the period 1972-1986. The spatial and temporal consistency of the decline in fishing success for white marlin suggests it represents a true decline in relative abundance.

Another important aspect of our results concerns the difference in temporal patterns of blue marlin HPUE and CPUE. Our plots of adjusted standardized estimates of blue marlin success rates revealed a departure in the trends of the two estimates of fishing success during the last 10 years. CPUE increased while HPUE remained stable. The disparity between the two trends is apparent not only in the estimates from the combined-regions model (Fig. 4) but also in most of the regional models: Bahamas (Fig. 6), Caribbean (Fig. 7), and, to a lesser extent, the Gulf of Mexico (Fig. 8). The difference might be explained by a decline over the years in the number of hooked fish that are lost. Angler success, defined as the ability to boat, release, or tag and release the fish that is hooked, appears to have increased over the past decade.

The collective experience of both the angler and captain/crew, in conjunction with innovations in fishing techniques and greater exchange of knowledge among fishermen, could be responsible for reducing the probability that a fish, once hooked, is lost. In recent years, double hooks have been used with artificial baits. This arrangement in which the two hooks in series are oriented at a 180° angle to each other has been particularly effective at holding the fish, once the lure is taken. Another obvious change in the blue marlin fishery in recent years has been the introduction of fast trolling with artificial lures in lieu of slow trolling with natural baits. This has increased the effective fishing effort by greatly increasing the area covered during the fishing day and, therefore, the potential marlin encounters. The shift to artificial lures (at faster speeds) may have somewhat increased the proportion of hooked fish that are lost. However, given the trends we observe in the HPUE and CPUE indices, we conclude that countering factors such as increased experience and improved fishing methods override the tendency toward a higher loss rate with faster trolling with artificial lures. These factors have not been quantified and therefore we cannot examine the effect of trolling speed on our results.

The disparity in the trends of HPUE and CPUE for blue marlin suggests that the upward trend in CPUE is an artifact of factors described above; with a higher proportion of the fishery changing to high speed trolling over the past decade, catchability increased as fishermen and captains/crews gained proficiency at catching, as opposed to just hooking and subsequently losing, the fish. This emphasizes the importance of collecting data to estimate HPUE as well as CPUE in this fishery. The CPUE estimates may present a false picture of change in relative abundance of blue marlin over time. These findings support the observations of Beardsley and Conser (1981) and Farber (1990) that HPUE should be a more reliable index of abundance than CPUE.

Our Gulf of Mexico and Bahamas GLMs for blue marlin explain only about 10% of the variation in HPUE and CPUE, whereas the r^2s of the Mid-Atlantic Bight GLMs explain about 18% of variation and the Caribbean GLMs explain over 40% of the variation in the data (Table 1). At present we have no explanation for the relatively poor explanatory power of the Gulf of Mexico and Bahamas models. It is not a problem of sparse coverage, since more than half the records (and the trips) utilized in this study were from the Gulf of Mexico (Appendices 2 and 3). We thought that the high percentage of non-tournament sampling (Appendices 2 and 3) in the Gulf of Mexico might have caused the low r^2 of the Gulf of Mexico GLMs. However, in an exploratory GLM in which non-tournament records were excluded, the r^2 for Gulf of Mexico blue marlin HPUE was even lower. The Gulf of Mexico covers a large area with diverse fishing conditions. This may be the reason for the low explanatory power of the Gulf of Mexico GLMs.

Bahamas GLMs also had low r^2s, and all the Bahamian records are from tournaments. Billfish tournaments are held on many islands throughout the Bahamas. Perhaps the variability between fishing conditions on the various islands is the source of unexplained variance in the Bahamas models.

The Caribbean GLMs were the models that explained the highest proportion of data variance. Since the contributing locations are widely separated geographically, one would think that the explanatory ability of these models would be detrimentally affected by locational differences in fishing conditions and opportunities. The Caribbean is the center of the distribution of blue marlin (Rivas 1975). For this reason, the probability of raising a fish may be consistently higher there than elsewhere, and this may bring about less overall variation in fishing success and result in a larger proportion explainable by the models.

Weather conditions and sea state may influence fishing success rates, and conditions may be more consistently favorable during the fishing season in the Caribbean than elsewhere. Browder and Prince (1990) tested the sea state and cloud cover variables recorded with the catch and effort data and found them highly significant, but poor explanatory variables in GLMs. It is possible that actual weather data obtained from instruments and recorded in NOAA or National Weather Service databases would be better explanatory variables than the subjective, though ordinally ranked, variables included in the survey database.

White marlin HPUE and CPUE both display the same declining trends (Fig. 10), beginning about 1980. Our results reveal a 5-yr continuation in the decline in white marlin standardized indices initially observed for the period 1980-1986 by Browder and Prince (1990). Now 11 years of almost consistent decline is apparent. The additional five years of data add considerable reliability to the suggestion that a significant decline in stock abundance is in progress.

In recent years, some tournaments in the Bahamas, the Caribbean, and Gulf of Mexico have started giving greater emphasis to blue marlin, which may have caused a spurious decline in white marlin catch rates. But the decline in white marlin occurred in all regions we examined, including the Mid-Atlantic Bight. The Mid-Atlantic Bight is traditionally known for its local availability of white marlin throughout the summer months (Farber 1990). In recent years, some tournaments in this region have begun providing awards to encourage targeting species other than white marlin, but despite this, most of the tournament effort remains directed at white marlin. The decline in standardized HPUE and CPUE in this area of the historic fishery may reflect a true decrease in the abundance or availability of the stock.

In general, improvements in angler experience and equipment should generate higher encounter rates and angler success rates in the white marlin recreational fishery as well as in the blue marlin fishery. The parallelism between white marlin HPUE and CPUE and the downward trend in both rates suggest that either (1) there have been no improvements in experience and/or technique or (2) the decline in abundance or availability has more than counteracted these improvements.

Uneven coverage of tournaments within an area can bias estimates of fishing success from GLMs. Figure 7, in which very high indices were estimated in 1980 for blue marlin in the Caribbean, shows the influence of uneven tournament coverage. These high 1980 estimates are due to coverage of only one tournament in the Caribbean that year, resulting in only four day-location records. The tournament was in the U.S. Virgin Islands, which consistently has some of the higher blue marlin catch rates in the Caribbean. Whether that particular tournament is sampled and how many other tournaments in the region are sampled during any given year clearly affects the regional estimates. This effect is masked in the combined-regions model (Fig. 4) and hence was not detected in the Browder and Prince (1990) analysis.

5. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be drawn from this analysis:

1. Standardized annual values of HPUE and CPUE suggest that fishing success for white marlin declined almost consistently since 1980. This is evident for all regions combined as well as on a region-by-region basis.

2. The pattern of annual variation in white marlin fishing success indicated by this analysis agrees with the patterns presented by Beardsley and Conser (1981) through 1978 and Browder and Prince (1990) through 1986.

3. The HPUE index for blue marlin remained fairly stable over the 19-yr period of the analysis, while CPUE climbed slightly. The gradual departure between standardized HPUE and CPUE may indicate improved angler success, i.e., an improvement in the ability to catch the fish once it is hooked.

4. General linear models for the combined regions for white marlin explained a greater proportion of variation in HPUE and CPUE than did the models for blue marlin. The Caribbean model explained the greatest proportion of variation in blue marlin fishing success. The combined regions, Mid-Atlantic Bight, and Bahamas models explained the greatest proportion of variation in white marlin fishing success. Gulf of Mexico models yielded the lowest r^2s for both species.

5. In accord with Browder and Prince (1990), we conclude that part of the unexplained variation undoubtedly is due to unquantified differences in anglers, captains/crews, equipment, and fishing locations within regions. A low number of trips per day-location is more common in the non-tournament data than in the tournament sampling. This condition might be improved by non-tournament sampling during periods of more concentrated fishing, namely weekends and holidays, rather than weekdays or randomly.

The following recommendations are made based on our analysis:

1. Tournament coverage should be more consistent. The major tournaments important to a species in terms of target and production should be given major emphasis and covered every year.

2. More tournament sampling emphasis should be placed in the Caribbean, particularly in the Virgin Islands and Puerto Rico for blue marlin and in the Dominican Republic (Cabeza de Toro Tournament) for white marlin.

3. Attempts should be made to obtain historical data from the files of tournament sponsors, particularly in Puerto Rico and other Caribbean islands, for inclusion in the recreational billfish database.

4. Data collection should include "trolling speed".

5. Non-tournament sampling should be conducted on weekends and holidays, rather than weekdays, so that more records will be collected from the same location on the same day. This will allow more trips to be included in the day-location records for non-tournament sampling, thereby lowering one source of variability.

6. Detailed regional analyses should be conducted to determine whether to fine-tune the region definitions. For instance, the Gulf of Mexico may need to be examined as two or three distinct regions, rather than just one.

7. A method for obtaining more reliable estimates of the total annual recreational catch of blue marlin and white marlin should be devised.

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Table 1. General linear models developed from the 1973-1991 U.S. billfish survey data for blue marlin and white marlin: number of records, number of trips, and percent of the total variance explained by the model (r^2). Regions are: MAB - Mid Atlantic Bight; BAH - Bahamas; CARIB - Caribbean; and GOM - Gulf of Mexico. Combined-regions models for white marlin also include data from New England and the Caribbean.

SPECIES	SUCCESS TYPE	REGION	NUMBER OF RECORDS	NUMBER OF TRIPS	r^2
Blue	HPUE	Combined	11,296	113,507	0.24
		MAB	1,275	16,781	0.19
		BAH	983	27,192	0.11
		CARIB	579	11,772	0.41
		GOM	8,459	57,762	0.09
Blue	CPUE	Combined	11,579	127,095	0.26
		MAB	1,526	29,100	0.17
		BAH	983	27,192	0.12
		CARIB	611	13,041	0.42
		GOM	8,459	57,762	0.09
White	HPUE	Combined	11,406	114,339	0.40
		MAB	1,275	16,781	0.33
		BAH	983	27,192	0.34
		GOM	8,459	57,762	0.20
White	CPUE	Combined	11,733	129,241	0.37
		MAB	1,526	29,100	0.35
		BAH	983	27,192	0.22
		GOM	8,459	57,762	0.19

Table 2. Correlation (r) between standardized HPUE and CPUE, by region, from the U.S. recreational billfish survey over the period 1973-1991. Regions are: MAB - Mid Atlantic Bight; BAH - Bahamas; CARIB - Caribbean; and GOM - Gulf of Mexico. Combined-regions models for white marlin also include data from New England and the Caribbean.

SPECIES	REGION	r
Blue Marlin	Combined	0.67
Blue Marlin	MAB	0.74
Blue Marlin	BAH	0.71
Blue Marlin	CARIB	0.90
Blue Marlin	GOM	0.73
White Marlin	Combined	0.97
White Marlin	MAB	0.90
White Marlin	BAH	0.96
White Marlin	GOM	0.98

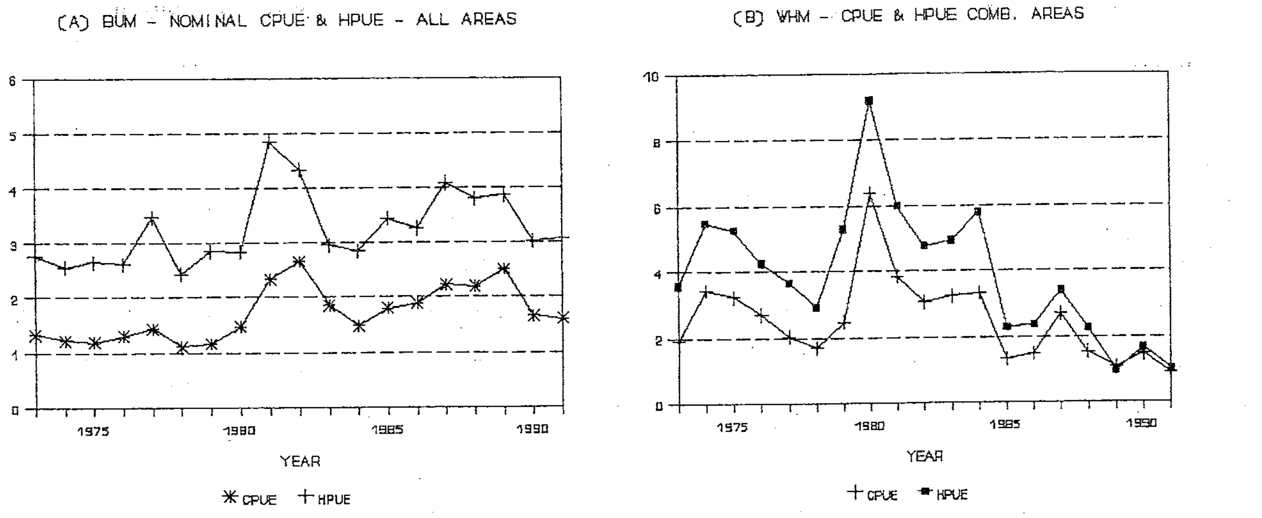


Figure 1. Nominal CPUE and HPUE (number of fish per 100 hrs trolling) for blue marlin (a) and white marlin (b) over the period 1973-1991 from the U.S. recreational billfish survey, from the combined-regions database.

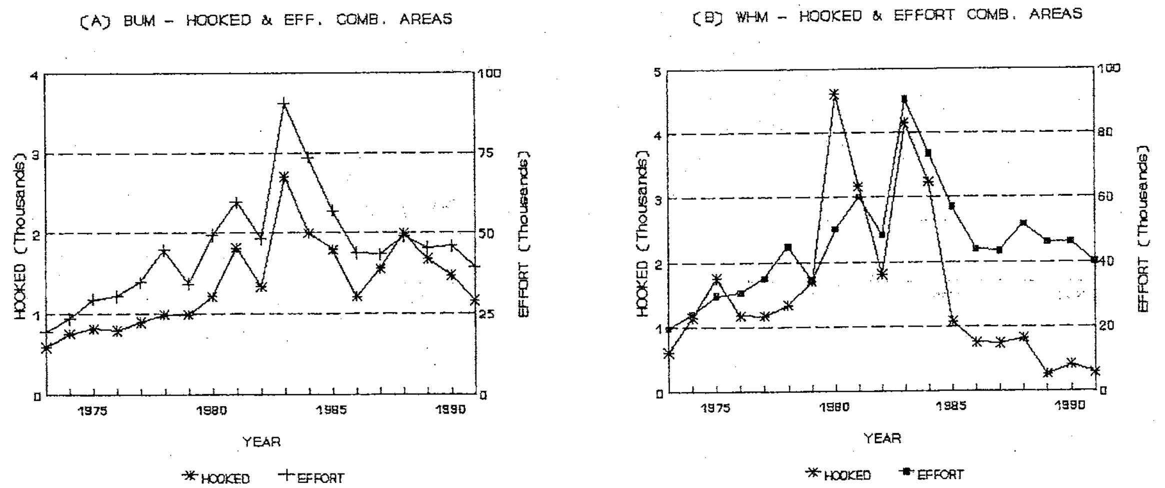


Figure 2. Nominal values for numbers of blue marlin hooked (a) and white marlin hooked (b), with associated sampled effort (hrs), over the period 1973-1991 from the U.S. recreational billfish survey, from the combined-regions database.

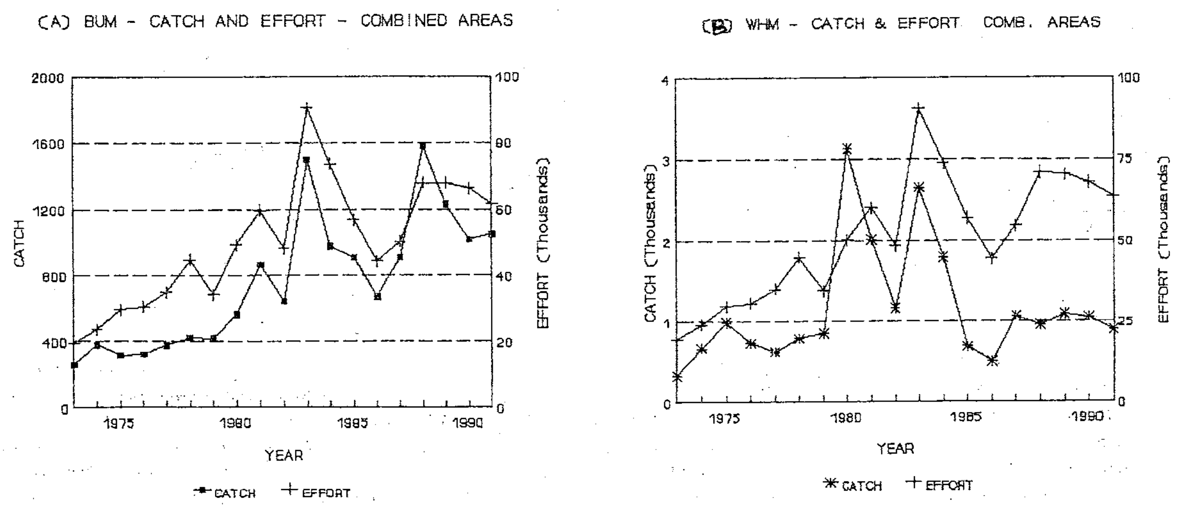


Figure 3. Nominal values for numbers of blue marlin caught (a) and white marlin caught (b), with associated sampled effort (hrs), over the period 1973-1991 from the U.S. recreational billfish survey, from the combined-regions database.

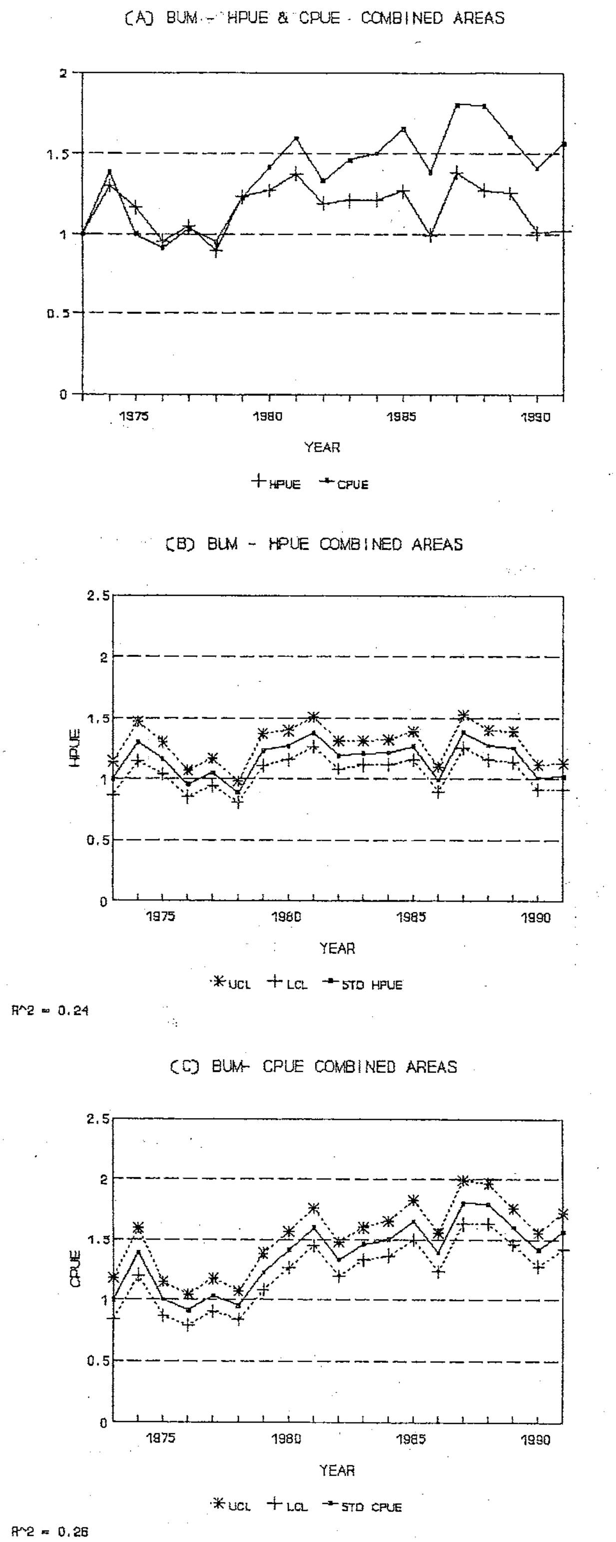


Figure 4. Annual 1973-adjusted standardized mean HPUE and CPUE values for blue marlin from the U.S. recreational billfish survey, from the combined-regions GLMs. The mean rates are plotted together in (a). The individual mean rates with associated approximate 90% confidence bounds are presented for HPUE in (b) and CPUE in (c). Units are dimensionless.

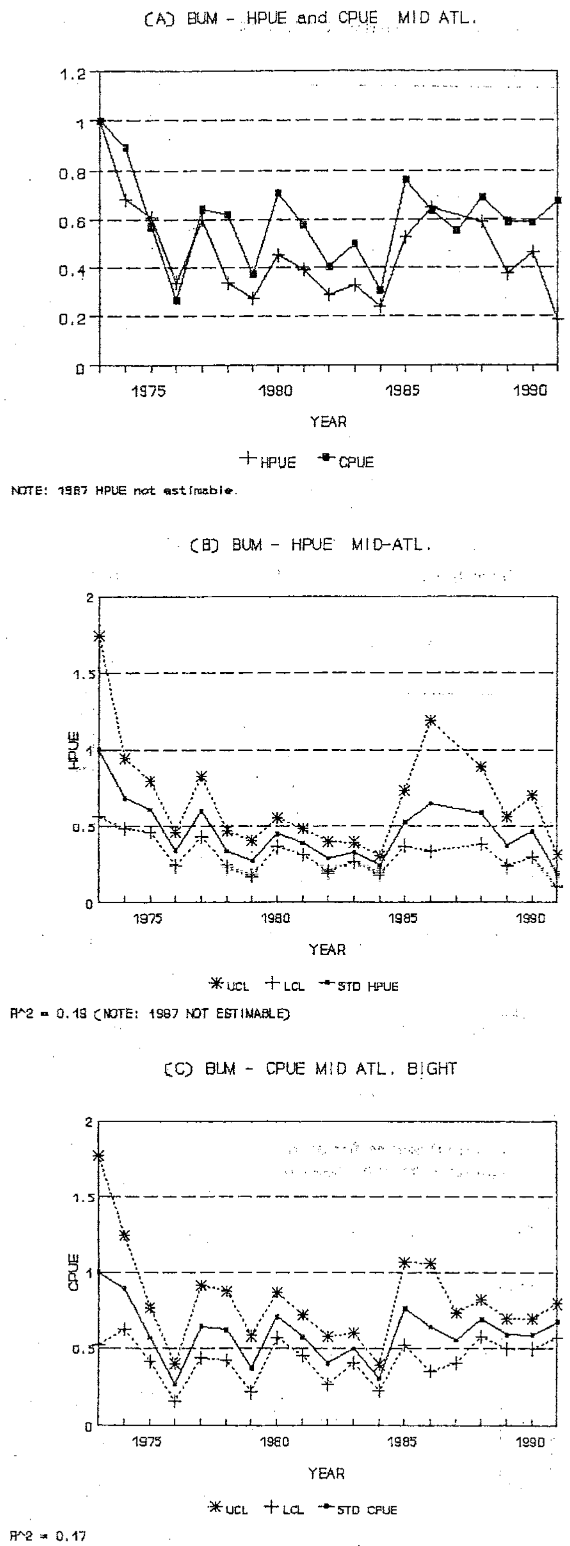


Figure 5. Annual 1973-adjusted standardized mean HPUE and CPUE values for blue marlin from the U.S. recreational billfish survey, from the Mid Atlantic Bight GLMs. The mean rates are plotted together in (a). The individual mean rates with associated approximate 90% confidence bounds are presented for HPUE in (b) and CPUE in (c). Units are dimensionless.

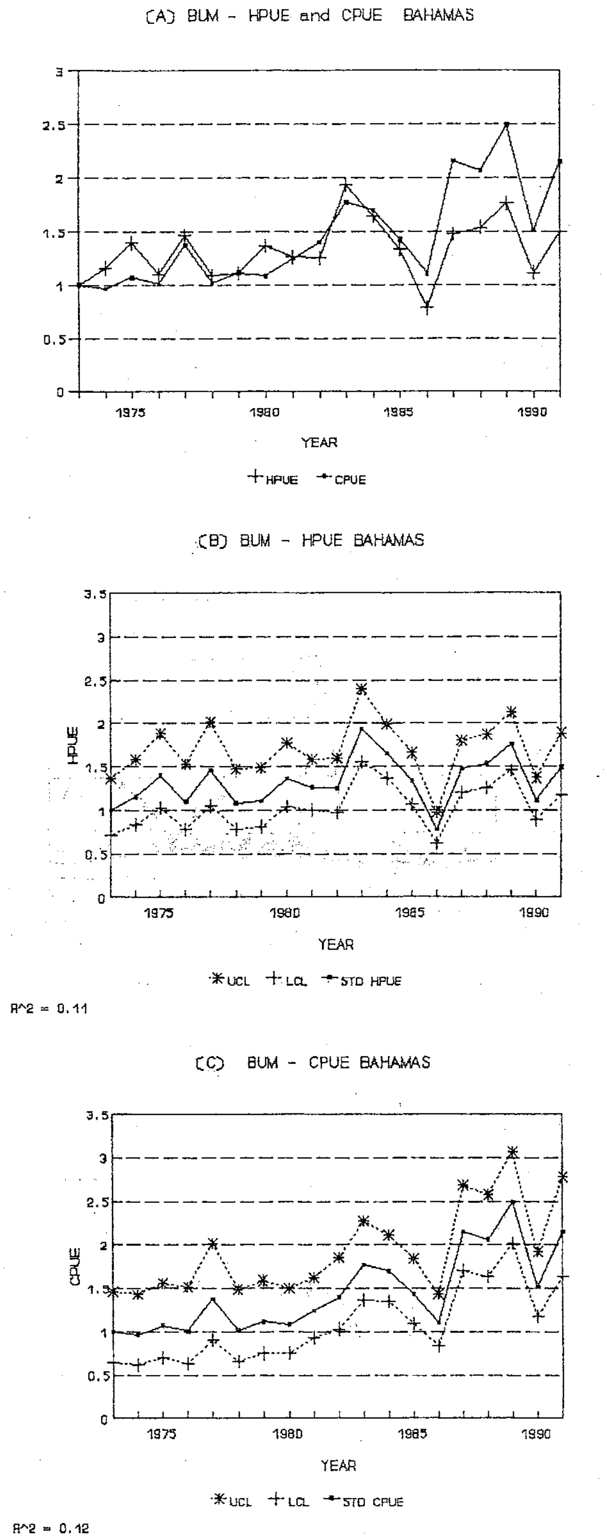


Figure 6. Annual 1973-adjusted standardized mean HPUE and CPUE values for blue marlin from the U.S. recreational billfish survey, from the Bahamas GLMs. The mean rates are plotted together in (a). The individual mean rates with associated approximate 90% confidence bounds are presented for HPUE in (b) and CPUE in (c). Units are dimensionless.

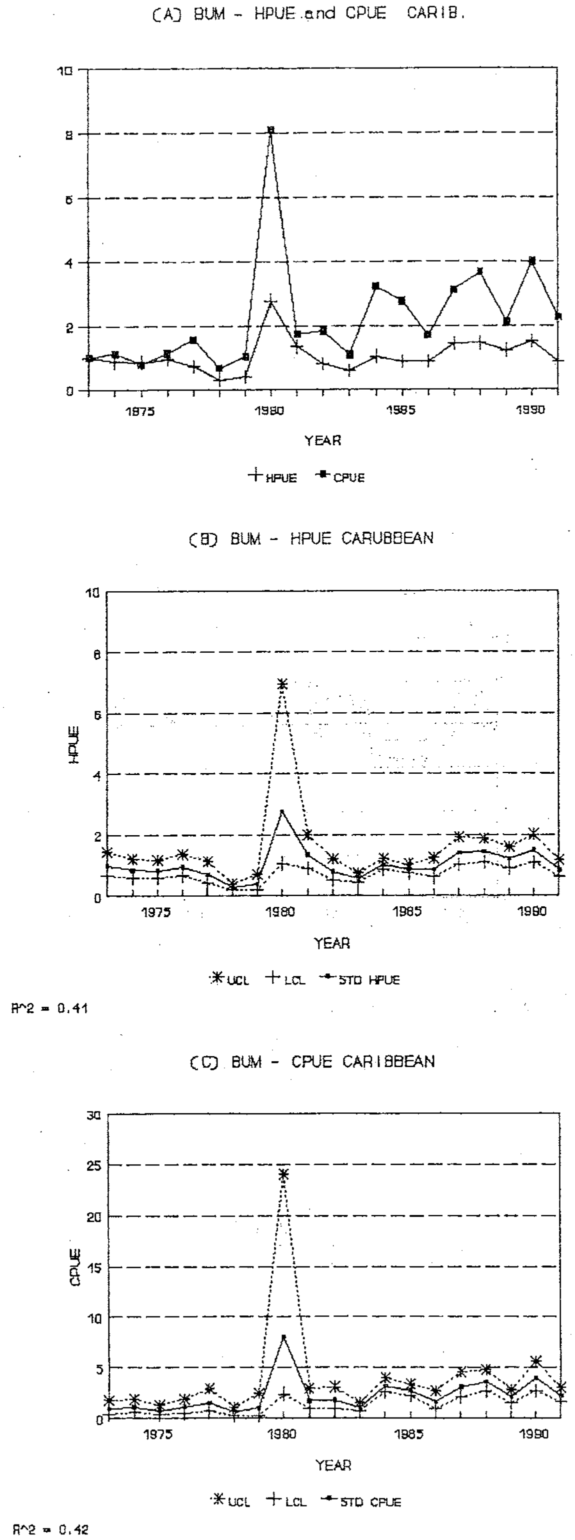


Figure 7. Annual 1973-adjusted standardized mean HPUE and CPUE values for blue marlin from the U.S. recreational billfish survey, from the Caribbean GLMs. The mean rates are plotted together in (a). The individual mean rates with associated approximate 90% confidence bounds are presented for HPUE in (b) and CPUE in (c). Units are dimensionless.

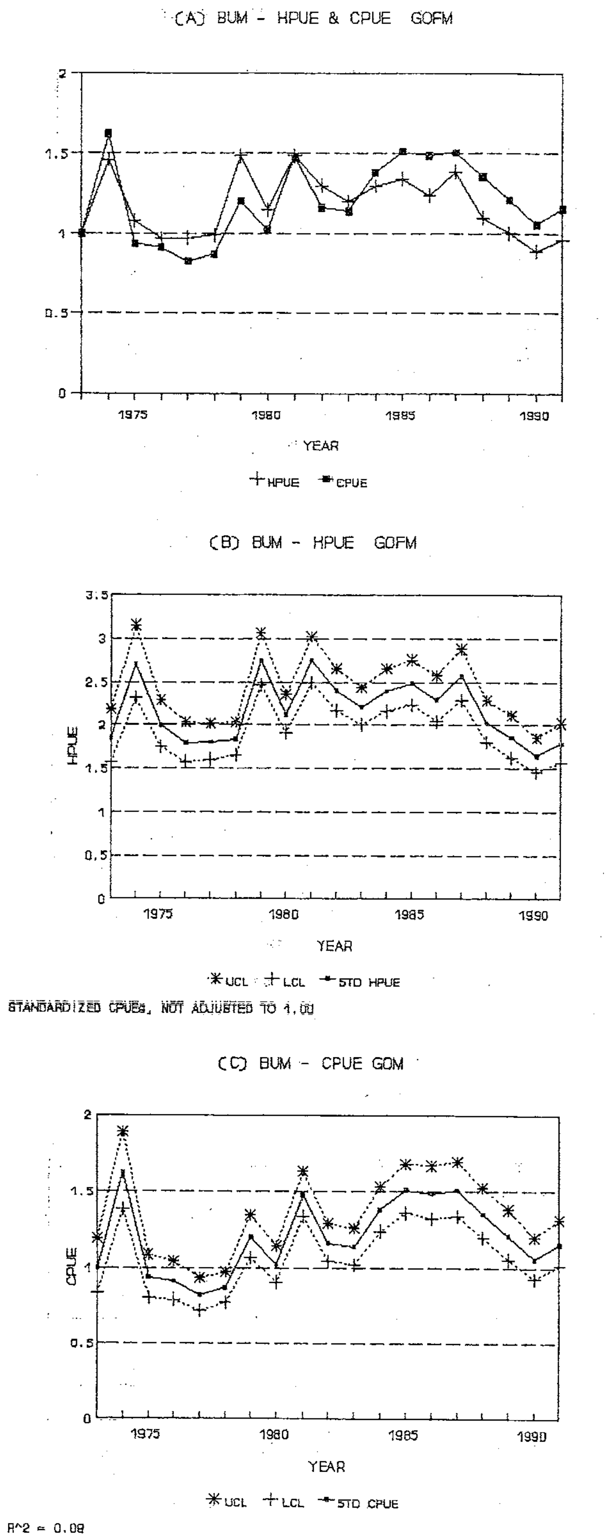


Figure 8. Annual 1973-adjusted standardized mean HPUE and CPUE values for blue marlin from the U.S. recreational billfish survey, from the Gulf of Mexico GLMs. The mean rates are plotted together in (a). The individual mean rates with associated approximate 90% confidence bounds are presented for HPUE in (b) and CPUE in (c). Units are dimensionless.

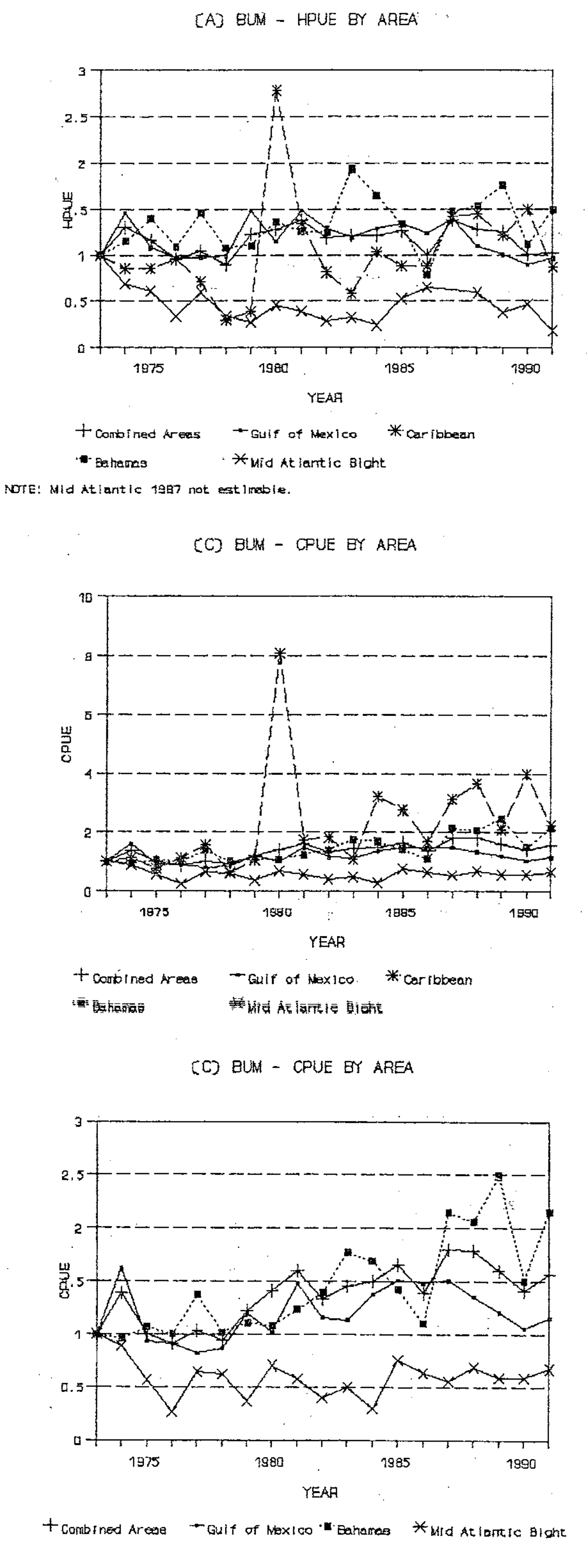


Figure 9. Annual 1973-adjusted standardized mean HPUE (a) and CPUE (b and c) values for blue marlin from the U.S. recreational billfish survey, for combined areas, Mid Atlantic Bight, Bahamas, Caribbean, and the Gulf of Mexico. Figure (c) excludes the Caribbean for scaling purposes. Units are dimensionless.

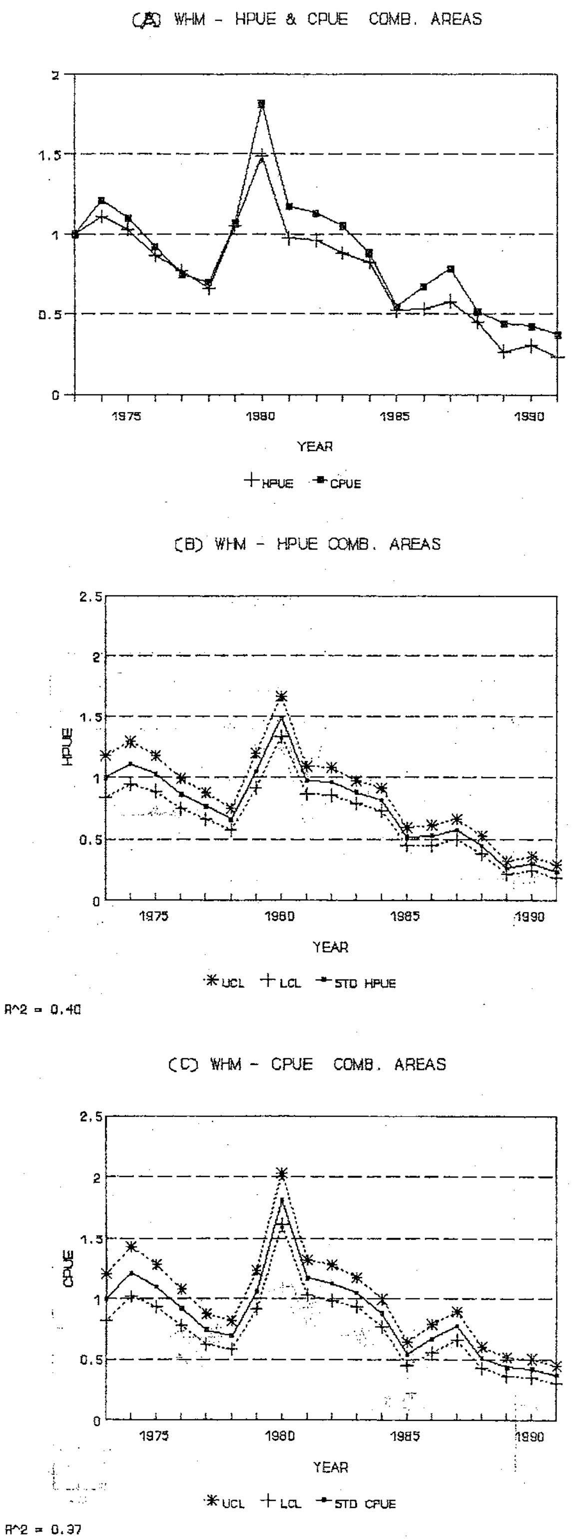


Figure 10. Annual 1973-adjusted standardized mean HPUE and CPUE values for white marlin from the U.S. recreational billfish survey, from the combined-regions GLMs. The mean rates are plotted together in (a). The individual mean rates with associated approximate 90% confidence bounds are presented for HPUE in (b) and CPUE in (c). Units are dimensionless.

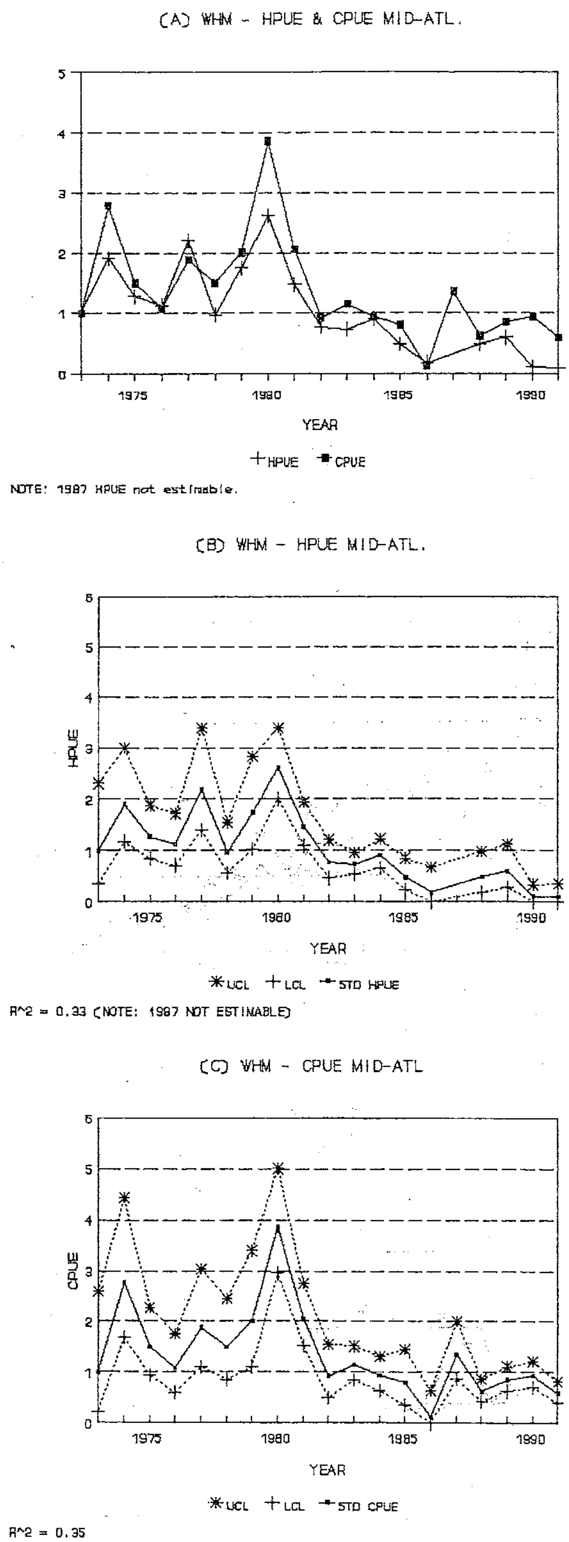


Figure 11. Annual 1973-adjusted standardized mean HPUE and CPUE values for white marlin from the U.S. recreational billfish survey, from the Mid Atlantic Bight GLMs. The mean rates are plotted together in (a). The individual mean rates with associated approximate 90% confidence bounds are presented for HPUE in (b) and CPUE in (c). Units are dimensionless.

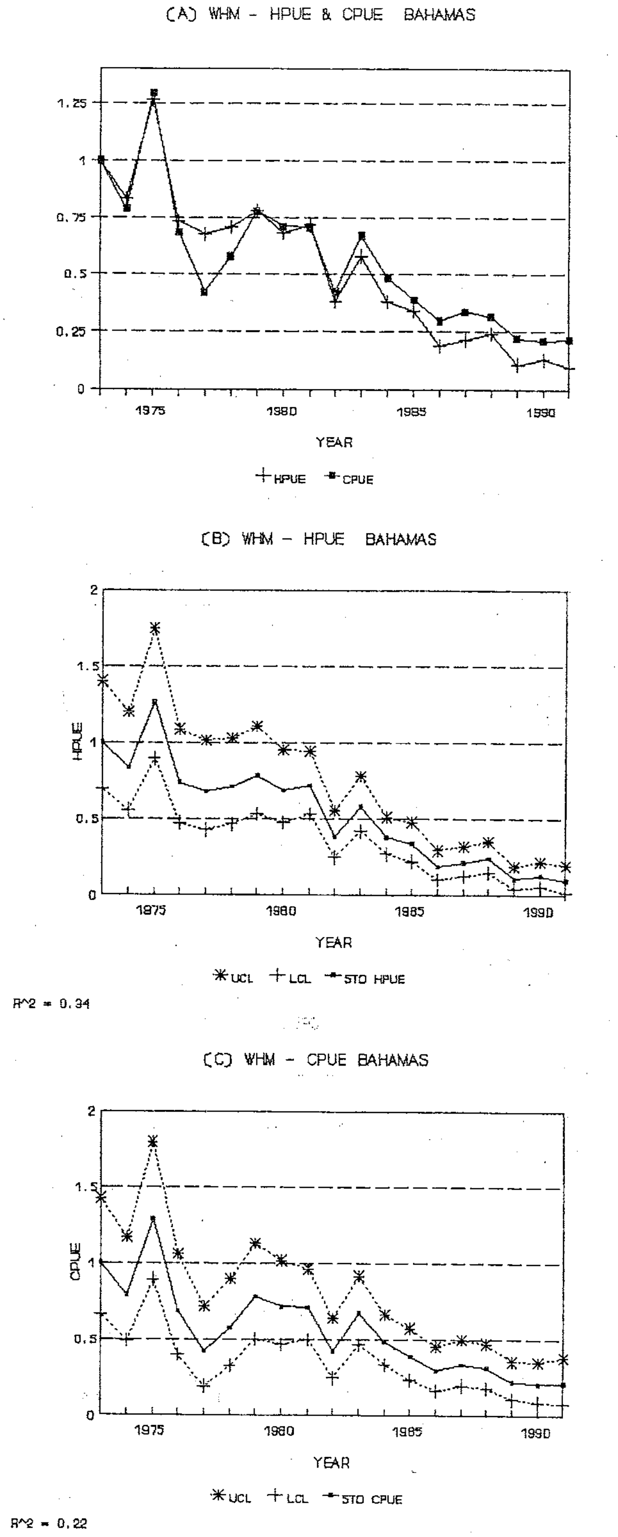


Figure 12. Annual 1973-adjusted standardized mean HPUE and CPUE values for white marlin from the U.S. recreational billfish survey, from the Bahamas GLMs. The mean rates are plotted together in (a). The individual mean rates with associated approximate 90% confidence bounds are presented for HPUE in (b) and CPUE in (c). Units are dimensionless.

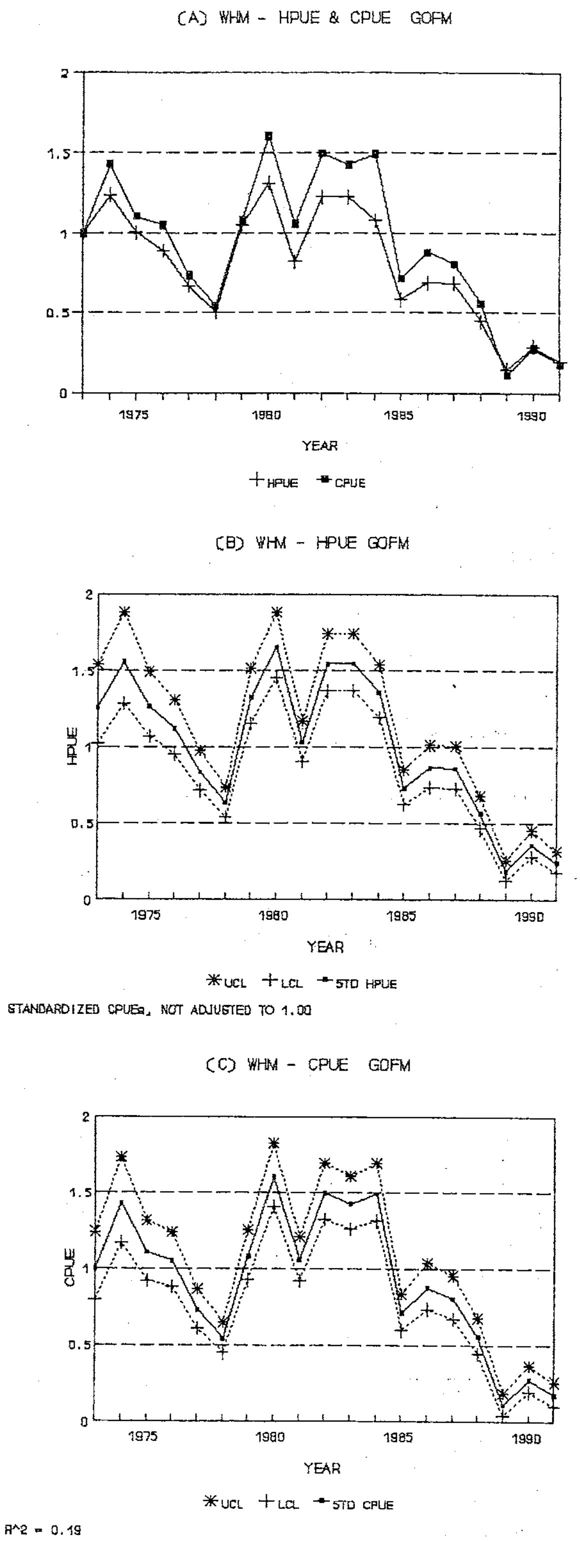


Figure 13. Annual 1973-adjusted standardized mean HPUE and CPUE values for white marlin from the U.S. recreational billfish survey, from the Gulf of Mexico GLMs. The mean rates are plotted together in (a). The individual mean rates with associated approximate 90% confidence bounds are presented for HPUE in (b) and CPUE in (c). Units are dimensionless.

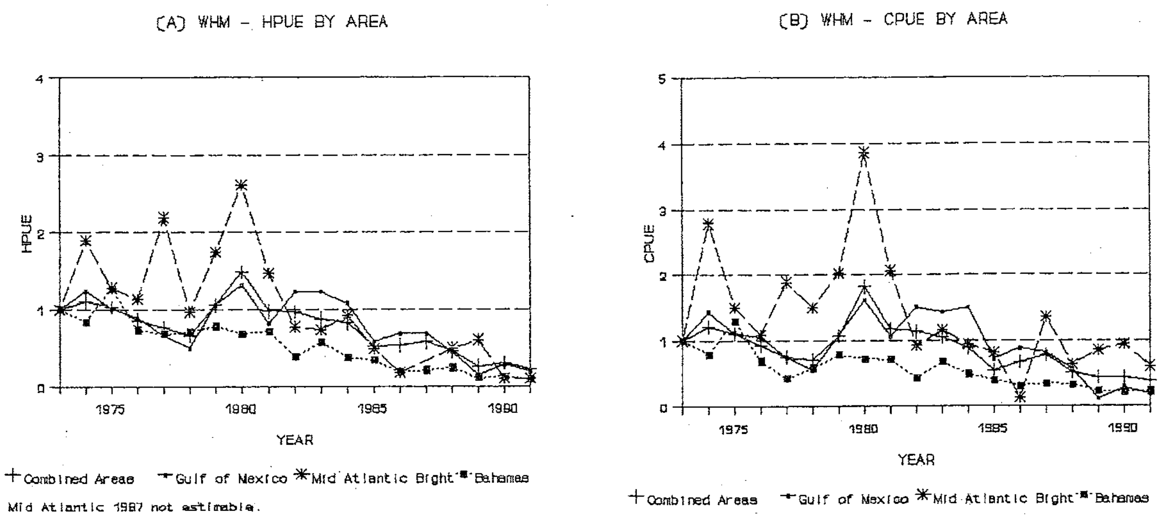


Figure 14. Annual 1973-adjusted standardized mean HPUE (a) and CPUE (b) values for white marlin from the U.S. recreational billfish survey, for combined areas, Mid Atlantic Bight, Bahamas, and Gulf of Mexico. Units are dimensionless.

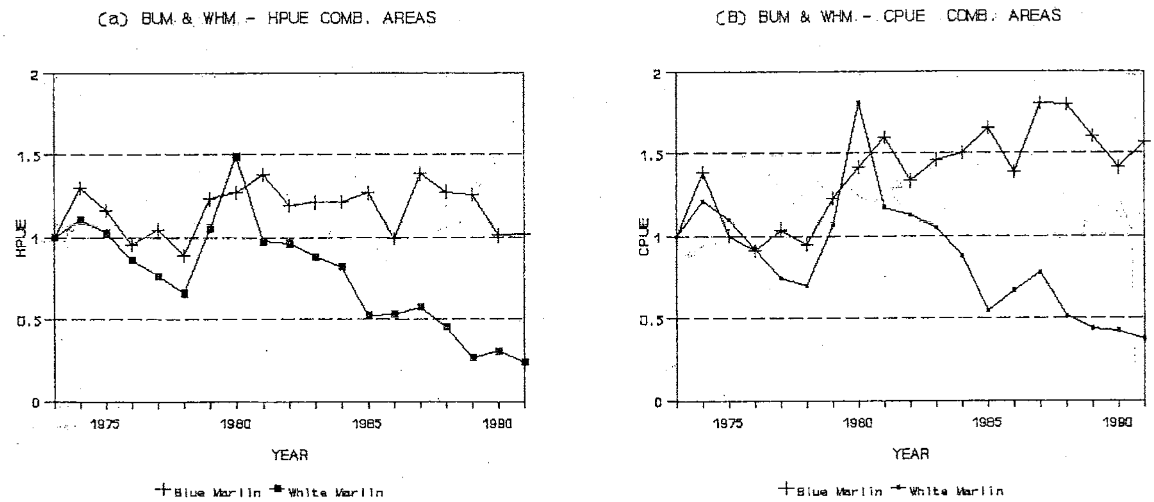


Figure 15. Annual 1973-adjusted standardized mean HPUE (a) and CPUE (b) values for blue marlin and white marlin from the U.S. recreational billfish survey, from the combined-regions GLMs. Units are dimensionless.

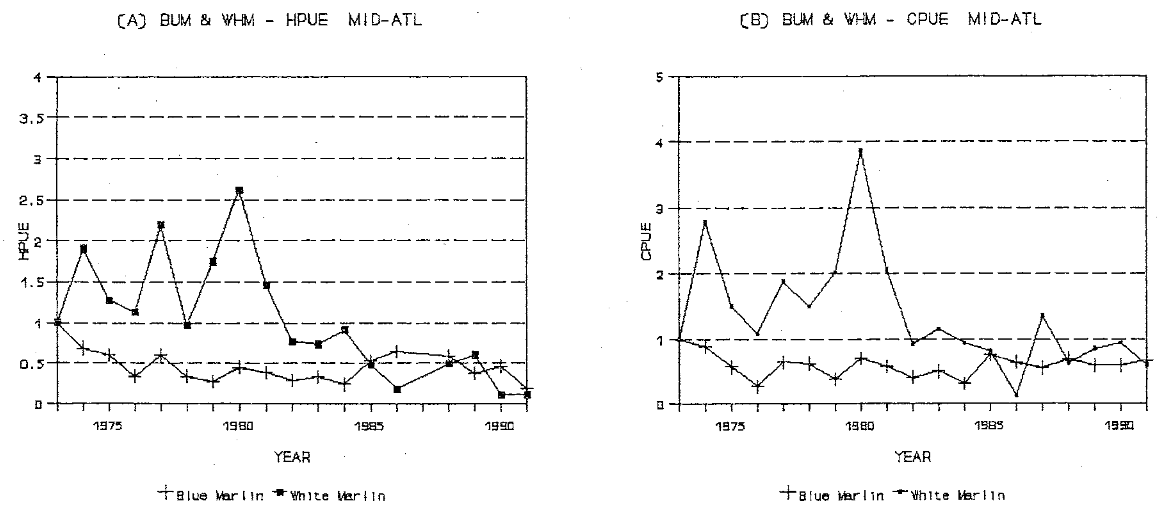


Figure 16. Annual 1973-adjusted standardized mean HPUE (a) and CPUE (b) values for blue marlin and white marlin from the U.S. recreational billfish survey, from the Mid Atlantic GLMs. Units are dimensionless.

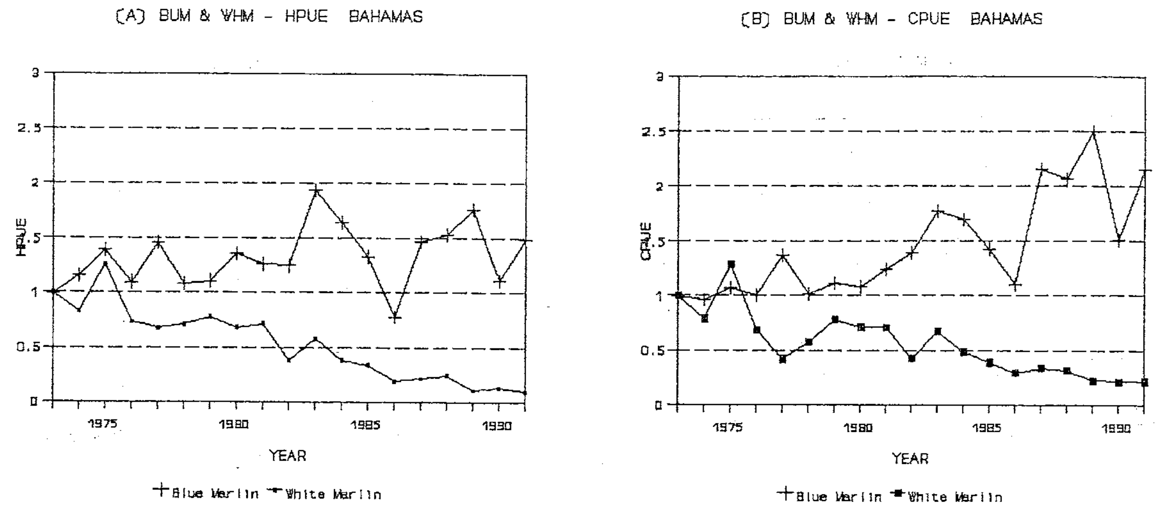


Figure 17. **Annual 1973-adjusted standardized mean HPUE (a) and CPUE (b) values for blue marlin and white marlin from the U.S. recreational billfish survey, from the Bahamas GLMs. Units are dimensionless.**

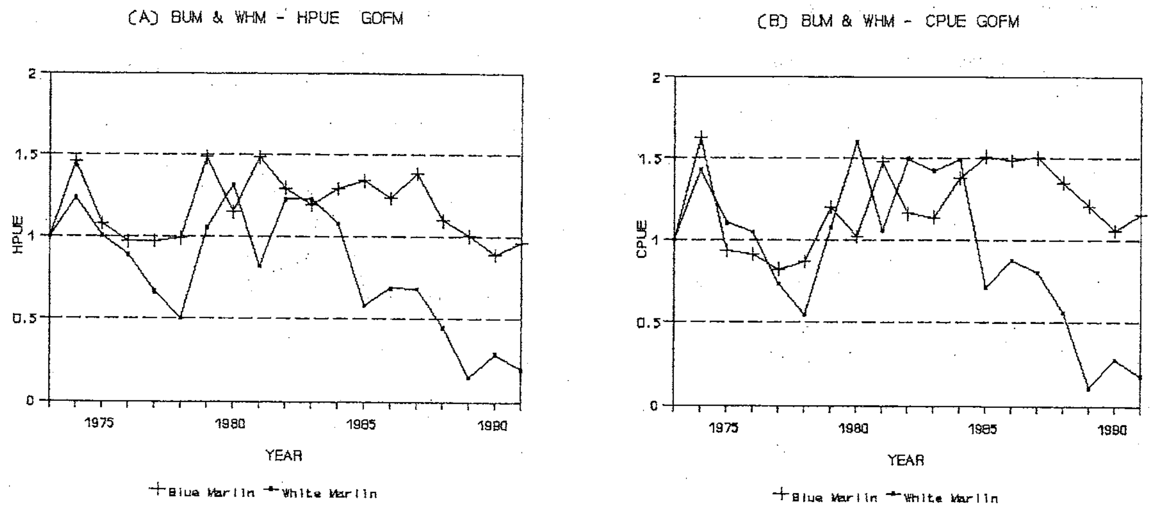
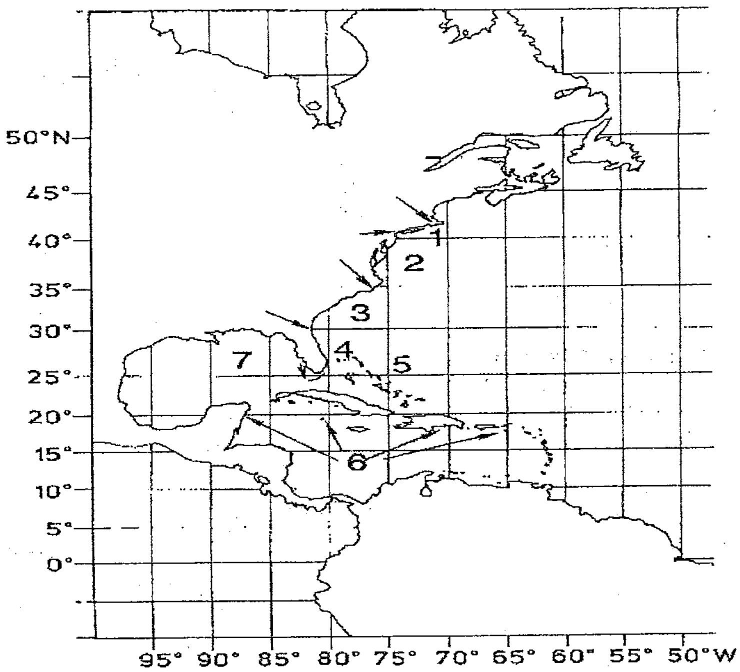


Figure 18. **Annual 1973-adjusted standardized mean HPUE (a) and CPUE (b) values for blue marlin and white marlin from the U.S. recreational billfish survey, from the Gulf of Mexico GLMs. Units are dimensionless.**

Appendix 1. Seven geographic regions defined for the present analysis: (1) New England (Massachusetts to Rhode Island), (2) Mid Atlantic Bight (New York to North Carolina), (3) South Atlantic Bight (South Carolina to Daytona Beach, FL), (4) South Florida (Cape Canaveral to Key West), (5) the Bahamas, (6) the Caribbean (Puerto Rico, U.S. Virgin Islands, Dominican Republic, Cayman Islands, and Cozumel), and (7) the Gulf of Mexico.



Appendix 2a. Number of records, by region, wave, and type, in the blue marlin HPU analysis.

	WAVE							
	1		2		3		4	
AREA/	TYPE		TYPE		TYPE		TYPE	
YEAR	1	2	1	2	1	2	1	2
MAB								
1973	0	0	0	4	0	0	0	0
1974	0	0	0	4	17	7	4	0
1975	0	0	0	7	0	11	0	4
1976	0	0	0	8	0	5	0	5
1977	0	0	0	5	0	8	0	0
1978	0	0	0	8	0	7	0	3
1979	0	0	0	9	0	5	0	4
1980	0	0	27	13	114	21	13	3
1981	0	0	41	13	68	14	15	11
1982	0	0	8	11	65	8	15	0
1983	0	0	52	12	196	29	62	8
1984	0	0	20	7	174	28	29	8
1985	0	0	0	5	0	5	0	4
1986	0	0	0	1	0	4	0	0
1987	0	0	0	0	0	0	0	0
1988	0	0	0	6	0	5	0	0
1989	0	0	0	9	0	2	0	0
1990	0	0	0	5	0	8	0	0
1991	0	0	0	5	0	6	0	0

	WAVE							
	1		2		3		4	
AREA/	TYPE		TYPE		TYPE		TYPE	
YEAR	1	2	1	2	1	2	1	2
BAH								
1973	0	31	0	4	0	8	0	0
1974	0	19	0	7	0	8	0	0
1975	0	17	0	9	0	9	0	0
1976	0	23	0	9	0	10	0	0
1977	0	17	0	10	0	9	0	0
1978	0	24	0	14	0	9	0	0
1979	0	15	0	19	0	9	0	0
1980	0	23	0	14	0	10	0	0
1981	0	21	0	21	0	10	0	0
1982	0	23	0	17	0	10	0	0
1983	0	26	0	16	0	8	0	0
1984	0	31	0	20	0	10	0	0
1985	0	21	0	15	0	8	0	0
1986	0	30	0	24	0	5	0	0
1987	0	24	0	33	0	4	0	0
1988	0	27	0	31	0	14	0	0
1989	0	36	0	34	0	8	0	0
1990	0	36	0	30	0	5	0	0
1991	0	29	0	24	0	5	0	0

Appendix 2a. Continued..

AREA/ YEAR	WAVE 1 TYPE 1	WAVE 1 TYPE 2	WAVE 2 TYPE 1	WAVE 2 TYPE 2	WAVE 3 TYPE 1	WAVE 3 TYPE 2	WAVE 4 TYPE 1	WAVE 4 TYPE 2
CAR								
1973	0	0	0	0	0	4	0	15
1974	0	0	0	0	0	4	0	14
1975	0	0	0	0	0	6	0	13
1976	0	0	0	0	0	7	0	8
1977	0	0	0	0	0	7	0	0
1978	0	0	0	4	0	4	0	3
1979	0	0	0	0	0	8	0	0
1980	0	0	0	0	0	4	0	0
1981	0	0	13	0	23	5	0	3
1982	0	0	4	0	34	4	6	3
1983	32	0	40	4	49	13	45	15
1984	0	0	0	28	0	6	0	4
1985	3	0	0	30	0	9	0	1
1986	0	0	0	0	0	10	0	0
1987	0	0	0	0	0	11	0	4
1988	0	0	0	0	0	14	0	9
1989	0	0	0	0	0	12	0	8
1990	0	0	0	0	0	14	0	4
1991	0	0	0	0	0	13	0	5

AREA/ YEAR	WAVE 1 TYPE 1	WAVE 1 TYPE 2	WAVE 2 TYPE 1	WAVE 2 TYPE 2	WAVE 3 TYPE 1	WAVE 3 TYPE 2	WAVE 4 TYPE 1	WAVE 4 TYPE 2
GOM								
1973	0	0	42	6	151	6	85	0
1974	3	0	99	0	153	6	82	2
1975	8	0	79	16	124	25	93	8
1976	8	0	116	16	188	42	105	18
1977	32	0	130	19	156	53	84	16
1978	29	0	153	17	180	59	139	16
1979	8	0	124	24	163	60	98	13
1980	8	0	132	29	137	60	94	12
1981	24	0	156	30	250	60	136	20
1982	18	0	150	29	157	72	69	15
1983	20	0	124	38	177	62	83	21
1984	5	1	114	34	151	62	63	18
1985	5	0	121	32	159	76	41	17
1986	6	1	71	27	101	74	77	6
1987	3	0	98	39	94	48	48	14
1988	1	0	87	33	161	56	74	13
1989	10	0	70	34	108	51	68	17
1990	7	0	126	32	124	55	90	12
1991	4	0	115	26	103	54	73	12

Regions: MAB - Mid Atlantic Bight; BAH - Bahamas; CAR - Caribbean; GOM - Gulf of Mexico.
Waves: 1 = March-April; 2 = May-June; 3 = July-August; 4 = September-October.
Types: 1 = non-tournament sampling; 2 = tournament.

Appendix 2b. Number of records, by region, wave, and type, in the blue marlin CPUE analysis.

AREA/ YEAR	WAVE 1 TYPE 1	WAVE 1 TYPE 2	WAVE 2 TYPE 1	WAVE 2 TYPE 2	WAVE 3 TYPE 1	WAVE 3 TYPE 2	WAVE 4 TYPE 1	WAVE 4 TYPE 2
MAB								
1973	0	0	0	4	0	0	0	0
1974	0	0	0	4	17	7	4	0
1975	0	0	0	7	0	11	0	4
1976	0	0	0	8	0	5	0	5
1977	0	0	0	5	0	8	0	0
1978	0	0	0	8	0	7	0	3
1979	0	0	0	9	0	5	0	4
1980	0	0	27	13	114	21	13	3
1981	0	0	41	13	68	14	15	11
1982	0	0	8	11	65	8	15	0
1983	0	0	52	12	196	29	62	8
1984	0	0	20	7	174	28	29	8
1985	0	0	0	5	0	5	0	4
1986	0	0	0	1	0	4	0	3
1987	0	0	0	3	0	17	0	7
1988	0	0	0	20	0	25	0	8
1989	0	0	0	20	0	35	0	13
1990	0	0	0	17	0	44	0	11
1991	0	0	0	15	0	53	0	6
BAH								
1973	0	31	0	4	0	8	0	0
1974	0	19	0	7	0	8	0	0
1975	0	17	0	9	0	9	0	0
1976	0	23	0	9	0	10	0	0
1977	0	17	0	10	0	9	0	0
1978	0	24	0	14	0	9	0	0
1979	0	15	0	19	0	9	0	0
1980	0	23	0	14	0	10	0	0
1981	0	21	0	21	0	10	0	0
1982	0	23	0	17	0	10	0	0

AREA/ YEAR	WAVE 1 TYPE 1	WAVE 1 TYPE 2	WAVE 2 TYPE 1	WAVE 2 TYPE 2	WAVE 3 TYPE 1	WAVE 3 TYPE 2	WAVE 4 TYPE 1	WAVE 4 TYPE 2
CAR								
1973	0	0	0	0	0	4	0	15
1974	0	0	0	0	0	4	0	14
1975	0	0	0	0	0	6	0	13
1976	0	0	0	0	0	7	0	8
1977	0	0	0	0	0	7	0	0
1978	0	0	0	4	0	4	0	3
1979	0	0	0	0	0	8	0	0
1980	0	0	0	0	0	4	0	0
1981	0	0	13	0	23	5	0	3
1982	0	0	4	0	34	4	6	3
1983	32	0	40	4	49	13	45	15
1984	0	0	0	28	0	6	0	4
1985	3	0	0	30	0	9	0	1
1986	0	0	0	0	0	10	0	0
1987	0	0	0	0	0	11	0	4
1988	0	0	0	0	0	16	0	16
1989	0	0	0	4	0	12	0	18
1990	0	0	0	0	0	14	0	4
1991	0	0	0	4	0	13	0	10
1983	0	26	0	16	0	8	0	0
1984	0	31	0	20	0	10	0	0
1985	0	21	0	15	0	8	0	0
1986	0	30	0	24	0	5	0	0
1987	0	24	0	33	0	4	0	0
1988	0	27	0	31	0	14	0	0
1989	0	36	0	34	0	8	0	0
1990	0	36	0	30	0	5	0	0
1991	0	29	0	24	0	5	0	0

Appendix 2b. Continued..

AREA/ YEAR	WAVE 1 TYPE 1	WAVE 1 TYPE 2	WAVE 2 TYPE 1	WAVE 2 TYPE 2	WAVE 3 TYPE 1	WAVE 3 TYPE 2	WAVE 4 TYPE 1	WAVE 4 TYPE 2
GOM								
1973	0	0	42	6	151	6	85	0
1974	3	0	99	0	153	6	82	2
1975	8	0	79	16	124	25	93	8
1976	8	0	116	16	188	42	105	18
1977	32	0	130	19	156	53	84	16
1978	29	0	153	17	180	59	139	16
1979	8	0	124	24	163	60	98	13
1980	8	0	132	29	137	60	94	12
1981	24	0	156	30	250	60	136	20
1982	18	0	150	29	157	72	69	15
1983	20	0	124	38	177	62	83	21
1984	5	1	114	34	151	62	63	18
1985	5	0	121	32	159	76	41	17
1986	6	1	71	27	101	74	77	6
1987	3	0	98	39	94	48	48	14
1988	1	0	87	33	161	56	74	13
1989	10	0	70	34	108	51	68	17
1990	7	0	126	32	124	55	90	12
1991	4	0	115	26	103	54	73	12

Regions: MAB - Mid Atlantic Bight; BAH - Bahamas; CAR - Caribbean; GOM - Gulf of Mexico.
Waves: 1 = March-April; 2 = May-June; 3 = July-August; 4 = September-October.
Types: 1 = non-tournament sampling; 2 = tournament.

Appendix 2c. Number of records, by region, wave, and type, in the white marlin HPUE analysis.

AREA/ YEAR	WAVE 1 TYPE 1	WAVE 1 TYPE 2	WAVE 2 TYPE 1	WAVE 2 TYPE 2	WAVE 3 TYPE 1	WAVE 3 TYPE 2	WAVE 4 TYPE 1	WAVE 4 TYPE 2
NEL								
1973	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	3	0	0
1975	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0
1980	0	0	0	0	24	0	12	0
1981	0	0	2	0	26	0	1	0
1982	0	0	0	0	3	0	0	0
1983	0	0	0	0	2	0	0	0
1984	0	0	0	0	19	0	0	0
1985	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	11	0	0
1989	0	0	0	0	0	3	0	0
1990	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	4	0	0
MAB								
1973	0	0	0	4	0	0	0	0
1974	0	0	0	4	17	7	4	0
1975	0	0	0	7	0	11	0	4
1976	0	0	0	8	0	5	0	5
1977	0	0	0	5	0	8	0	0
1978	0	0	0	8	0	7	0	3
1979	0	0	0	9	0	5	0	4
1980	0	0	27	13	114	21	13	3
1981	0	0	41	13	68	14	15	11
1982	0	0	8	11	65	8	15	0
1983	0	0	52	12	196	29	62	8
1984	0	0	20	7	174	28	29	8
1985	0	0	0	5	0	5	0	4
1986	0	0	0	1	0	4	0	0
1987	0	0	0	0	0	0	0	0
1988	0	0	0	6	0	5	0	0
1989	0	0	0	9	0	2	0	0
1990	0	0	0	5	0	8	0	0
1991	0	0	0	5	0	6	0	0
BAH								
1973	0	31	0	4	0	8	0	0
1974	0	19	0	7	0	8	0	0
1975	0	17	0	9	0	9	0	0
1976	0	23	0	9	0	10	0	0
1977	0	17	0	10	0	9	0	0
1978	0	24	0	14	0	9	0	0
1979	0	15	0	19	0	9	0	0
1980	0	23	0	14	0	10	0	0
1981	0	21	0	21	0	10	0	0
1982	0	23	0	17	0	10	0	0
1983	0	26	0	16	0	8	0	0
1984	0	31	0	20	0	10	0	0
1985	0	21	0	15	0	8	0	0
1986	0	30	0	24	0	5	0	0
1987	0	24	0	33	0	4	0	0
1988	0	27	0	31	0	14	0	0
1989	0	36	0	34	0	8	0	0
1990	0	36	0	30	0	5	0	0
1991	0	29	0	24	0	5	0	0
CAR								
1973	0	0	0	0	0	4	0	15
1974	0	0	0	0	0	4	0	14
1975	0	0	0	0	0	6	0	13
1976	0	0	0	0	0	7	0	8
1977	0	0	0	0	0	7	0	0
1978	0	0	0	4	0	4	0	3
1979	0	0	0	0	0	8	0	0
1980	0	0	0	0	0	4	0	0
1981	0	0	13	0	23	5	0	3
1982	0	0	4	0	34	4	6	3
1983	32	0	40	4	49	13	45	15
1984	0	0	0	28	0	6	0	4
1985	3	0	0	30	0	9	0	1
1986	0	0	0	0	0	10	0	0
1987	0	0	0	0	0	11	0	4
1988	0	0	0	0	0	14	0	9
1989	0	0	0	0	0	12	0	8
1990	0	0	0	0	0	14	0	4
1991	0	0	0	0	0	13	0	5

Appendix 2c. Continued..

AREA/ YEAR	WAVE 1 TYPE 1	WAVE 1 TYPE 2	WAVE 2 TYPE 1	WAVE 2 TYPE 2	WAVE 3 TYPE 1	WAVE 3 TYPE 2	WAVE 4 TYPE 1	WAVE 4 TYPE 2
GOM								
1973	0	0	42	6	151	6	85	0
1974	3	0	99	0	153	6	82	2
1975	8	0	79	16	124	25	93	8
1976	8	0	116	16	188	42	105	18
1977	32	0	130	19	156	53	84	16
1978	29	0	153	17	180	59	139	16
1979	8	0	124	24	163	60	98	13
1980	8	0	132	29	137	60	94	12
1981	24	0	156	30	250	60	136	20
1982	18	0	150	29	157	72	69	15
1983	20	0	124	38	177	62	83	21
1984	5	1	114	34	151	62	63	18
1985	5	0	121	32	159	76	41	17
1986	6	1	71	27	101	74	77	6
1987	3	0	98	39	94	48	48	14
1988	1	0	87	33	161	56	74	13
1989	10	0	70	34	108	51	68	17
1990	7	0	126	32	124	55	90	12
1991	4	0	115	26	103	54	73	12

Regions: NEL - New England; MAB - Mid Atlantic Bight; BAH - Bahamas; CAR - Caribbean; GOM - Gulf of Mexico.
Waves: 1 = March-April; 2 = May-June; 3 = July-August; 4 = September-October.
Types: 1 = non-tournament sampling; 2 = tournament.

Appendix 2d. Number of records, by region, wave, and type, in the white marlin CPUE analysis.

AREA/ YEAR	WAVE 1 TYPE 1	WAVE 1 TYPE 2	WAVE 2 TYPE 1	WAVE 2 TYPE 2	WAVE 3 TYPE 1	WAVE 3 TYPE 2	WAVE 4 TYPE 1	WAVE 4 TYPE 2
NEL								
1973	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	3	0	0
1975	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0
1980	0	0	0	0	24	0	12	0
1981	0	0	2	0	26	0	1	0
1982	0	0	0	0	3	0	0	0
1983	0	0	0	0	2	0	0	0
1984	0	0	0	0	19	0	0	0
1985	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	12	0	0
1988	0	0	0	0	0	13	0	0
1989	0	0	0	0	0	10	0	0
1990	0	0	0	0	0	11	0	0
1991	0	0	0	0	0	16	0	0
MAB								
1973	0	0	0	4	0	0	0	0
1974	0	0	0	4	17	7	4	0
1975	0	0	0	7	0	11	0	4
1976	0	0	0	8	0	5	0	5
1977	0	0	0	5	0	8	0	0
1978	0	0	0	8	0	7	0	3
1979	0	0	0	9	0	5	0	4
1980	0	0	27	13	114	21	13	3
1981	0	0	41	13	68	14	15	11
1982	0	0	8	11	65	8	15	0
1983	0	0	52	12	196	29	62	8
1984	0	0	20	7	174	28	29	8
1985	0	0	0	5	0	5	0	4
1986	0	0	0	1	0	4	0	3
1987	0	0	0	3	0	17	0	7
1988	0	0	0	20	0	25	0	8
1989	0	0	0	20	0	35	0	13
1990	0	0	0	17	0	44	0	11
1991	0	0	0	15	0	53	0	6
BAH								
1973	0	31	0	4	0	8	0	0
1974	0	19	0	7	0	8	0	0
1975	0	17	0	9	0	9	0	0
1976	0	23	0	9	0	10	0	0
1977	0	17	0	10	0	9	0	0
1978	0	24	0	14	0	9	0	0
1979	0	15	0	19	0	9	0	0
1980	0	23	0	14	0	10	0	0
1981	0	21	0	21	0	10	0	0
1982	0	23	0	17	0	10	0	0
1983	0	26	0	16	0	8	0	0
1984	0	31	0	20	0	10	0	0
1985	0	21	0	15	0	8	0	0
1986	0	30	0	24	0	5	0	0
1987	0	24	0	33	0	4	0	0
1988	0	27	0	31	0	14	0	0
1989	0	36	0	34	0	8	0	0
1990	0	36	0	30	0	5	0	0
1991	0	29	0	24	0	5	0	0
CAR								
1973	0	0	0	0	0	4	0	15
1974	0	0	0	0	0	4	0	14
1975	0	0	0	0	0	6	0	13
1976	0	0	0	0	0	7	0	8
1977	0	0	0	0	0	7	0	0
1978	0	0	0	4	0	4	0	3
1979	0	0	0	0	0	8	0	0
1980	0	0	0	0	0	4	0	0
1981	0	0	13	0	23	5	0	3
1982	0	0	4	0	34	4	6	3
1983	32	0	40	4	49	13	45	15
1984	0	0	0	28	0	6	0	4
1985	3	0	0	30	0	9	0	1
1986	0	0	0	0	0	10	0	0
1987	0	0	0	0	0	11	0	4
1988	0	0	0	0	0	16	0	16
1989	0	0	0	4	0	12	0	18
1990	0	0	0	0	0	14	0	4
1991	0	0	0	4	0	13	0	10

Appendix 2d. Continued..

AREA/YEAR	Wave 1 Type 1	Wave 1 Type 2	Wave 2 Type 1	Wave 2 Type 2	Wave 3 Type 1	Wave 3 Type 2	Wave 4 Type 1	Wave 4 Type 2
GOM								
1973	0	0	42	6	151	6	85	0
1974	3	0	99	0	153	6	82	2
1975	8	0	79	16	124	25	93	8
1976	8	0	116	16	188	42	105	18
1977	32	0	130	19	156	53	84	16
1978	29	0	153	17	180	59	139	16
1979	8	0	124	24	163	60	98	13
1980	8	0	132	29	137	60	94	12
1981	24	0	156	30	250	60	136	20
1982	18	0	150	29	157	72	69	15
1983	20	0	124	38	177	62	83	21
1984	5	1	114	34	151	62	63	18
1985	5	0	121	32	159	76	41	17
1986	6	1	71	27	101	74	77	6
1987	3	0	98	39	94	48	48	14
1988	1	0	87	33	161	56	74	13
1989	10	0	70	34	108	51	68	17
1990	7	0	126	32	124	55	90	12
1991	4	0	115	26	103	54	73	12

Regions: NEL - New England; MAB - Mid Atlantic Bight; BAH - Bahamas; CAR - Caribbean; GOM - Gulf of Mexico.
Waves: 1 = March-April; 2 = May-June; 3 = July-August; 4 = September-October.
Types: 1 = non-tournament sampling; 2 = tournament.

Appendix 3a. Number of trips, by region, wave, and type, in the blue marlin HPUE analysis.

AREA/YEAR	Wave 1 Type 1	Wave 1 Type 2	Wave 2 Type 1	Wave 2 Type 2	Wave 3 Type 1	Wave 3 Type 2	Wave 4 Type 1	Wave 4 Type 2
MAB								
1973	0	0	0	157	0	0	0	0
1974	0	0	0	181	113	176	53	0
1975	0	0	0	302	0	370	0	163
1976	0	0	0	280	0	190	0	218
1977	0	0	0	238	0	306	0	0
1978	0	0	0	324	0	134	0	97
1979	0	0	0	261	0	67	0	105
1980	0	0	206	333	924	521	47	81
1981	0	0	298	332	604	228	136	295
1982	0	0	13	259	198	187	38	0
1983	0	0	385	430	1451	899	583	232
1984	0	0	45	212	1070	695	181	188
1985	0	0	0	211	0	212	0	106
1986	0	0	0	4	0	140	0	0
1987	0	0	0	0	0	0	0	0
1988	0	0	0	198	0	114	0	0
1989	0	0	0	302	0	54	0	0
1990	0	0	0	170	0	167	0	0
1991	0	0	0	170	0	127	0	0
BAH								
1973	0	669	0	46	0	203	0	0
1974	0	442	0	204	0	192	0	0
1975	0	413	0	217	0	248	0	0
1976	0	410	0	105	0	263	0	0
1977	0	303	0	215	0	219	0	0
1978	0	297	0	300	0	251	0	0
1979	0	308	0	338	0	302	0	0
1980	0	484	0	396	0	261	0	0
1981	0	486	0	807	0	265	0	0
1982	0	737	0	476	0	182	0	0
1983	0	892	0	580	0	180	0	0
1984	0	1080	0	966	0	216	0	0
1985	0	788	0	738	0	189	0	0
1986	0	1154	0	747	0	48	0	0
1987	0	1069	0	866	0	40	0	0
1988	0	1006	0	894	0	107	0	0
1989	0	992	0	1071	0	71	0	0
1990	0	1324	0	670	0	40	0	0
1991	0	782	0	579	0	64	0	0
CAR								
1973	0	0	0	0	0	24	0	291
1974	0	0	0	0	0	28	0	415
1975	0	0	0	0	0	79	0	377
1976	0	0	0	0	0	86	0	268
1977	0	0	0	0	0	193	0	0
1978	0	0	0	208	0	32	0	237
1979	0	0	0	0	0	116	0	0
1980	0	0	0	0	0	38	0	0
1981	0	0	13	0	23	44	0	183
1982	0	0	4	0	34	28	6	206
1983	88	0	128	141	483	449	148	622
1984	0	0	0	839	0	110	0	305
1985	18	0	0	1058	0	322	0	67
1986	0	0	0	0	0	451	0	0
1987	0	0	0	0	0	191	0	357
1988	0	0	0	0	0	748	0	157
1989	0	0	0	0	0	323	0	577
1990	0	0	0	0	0	288	0	335
1991	0	0	0	0	0	289	0	345
GOM								
1973	0	0	183	131	645	207	359	0
1974	5	0	421	0	747	71	398	13
1975	10	0	274	293	588	521	402	117
1976	8	0	285	322	570	752	360	328
1977	53	0	344	454	589	1372	257	268
1978	67	0	491	637	670	1363	458	467
1979	8	0	377	578	503	1204	298	260
1980	19	0	365	594	459	1472	213	392
1981	32	0	388	799	706	1545	389	462
1982	25	0	464	840	462	1613	182	381
1983	35	0	300	1041	560	1558	189	550
1984	7	13	224	929	396	1516	131	402
1985	7	0	287	772	421	1604	111	272
1986	6	12	182	697	228	1412	153	162
1987	8	0	235	666	234	1187	128	271
1988	1	0	190	542	400	1306	213	154
1989	16	0	122	553	231	948	174	263
1990	7	0	263	660	252	1083	255	173
1991	5	0	260	430	269	1270	191	95

Regions: MAB - Mid Atlantic Bight; BAH - Bahamas; CAR - Caribbean; GOM - Gulf of Mexico.
Waves: 1 = March-April; 2 = May-June; 3 = July-August; 4 = September-October.
Types: 1 = non-tournament sampling; 2 = tournament.

Appendix 3b. Number of trips, by region, wave, and type, in the blue marlin CPUE analysis.

	WAVE							
	1		2		3		4	
AREA/	TYPE		TYPE		TYPE		TYPE	
YEAR	1	2	1	2	1	2	1	2
MAB								
1973	0	0	0	157	0	0	0	0
1974	0	0	0	181	113	176	53	0
1975	0	0	0	302	0	370	0	163
1976	0	0	0	280	0	190	0	218
1977	0	0	0	238	0	306	0	0
1978	0	0	0	324	0	134	0	97
1979	0	0	0	261	0	67	0	105
1980	0	0	206	333	924	521	47	81
1981	0	0	298	332	604	228	136	295
1982	0	0	13	259	198	187	38	0
1983	0	0	385	430	1451	899	583	232
1984	0	0	45	212	1070	695	181	188
1985	0	0	0	211	0	212	0	106
1986	0	0	0	4	0	140	0	104
1987	0	0	0	42	0	846	0	181
1988	0	0	0	114	0	1159	0	271
1989	0	0	0	1156	0	1820	0	360
1990	0	0	0	976	0	2061	0	356
1991	0	0	0	989	0	2024	0	135
BAH								
1973	0	669	0	46	0	203	0	0
1974	0	442	0	204	0	192	0	0
1975	0	413	0	217	0	248	0	0
1976	0	410	0	105	0	263	0	0
1977	0	303	0	215	0	219	0	0
1978	0	297	0	300	0	251	0	0
1979	0	308	0	338	0	302	0	0
1980	0	484	0	396	0	261	0	0
1981	0	486	0	807	0	265	0	0
1982	0	737	0	476	0	182	0	0
1983	0	892	0	580	0	180	0	0
1984	0	1080	0	966	0	216	0	0
1985	0	788	0	738	0	189	0	0
1986	0	1154	0	747	0	48	0	0
1987	0	1069	0	866	0	40	0	0
1988	0	1006	0	894	0	107	0	0
1989	0	992	0	1071	0	71	0	0
1990	0	1324	0	670	0	40	0	0
1991	0	782	0	579	0	64	0	0

	WAVE							
	1		2		3		4	
AREA/	TYPE		TYPE		TYPE		TYPE	
YEAR	1	2	1	2	1	2	1	2
CAR								
1973	0	0	0	0	0	24	0	291
1974	0	0	0	0	0	28	0	415
1975	0	0	0	0	0	79	0	377
1976	0	0	0	0	0	86	0	268
1977	0	0	0	0	0	193	0	0
1978	0	0	0	208	0	32	0	237
1979	0	0	0	0	0	116	0	0
1980	0	0	0	0	0	38	0	0
1981	0	0	13	0	23	44	0	183
1982	0	0	4	0	34	28	6	206
1983	88	0	128	141	483	449	148	622
1984	0	0	0	839	0	110	0	305
1985	18	0	0	1058	0	322	0	67
1986	0	0	0	0	0	451	0	0
1987	0	0	0	0	0	191	0	357
1988	0	0	0	0	0	872	0	532
1989	0	0	0	205	0	323	0	721
1990	0	0	0	0	0	288	0	335
1991	0	0	0	209	0	289	0	557
GOM								
1973	0	0	183	131	645	207	359	0
1974	5	0	421	0	747	71	398	13
1975	10	0	274	293	588	521	402	117
1976	8	0	285	322	570	752	360	328
1977	53	0	344	454	589	1372	257	268
1978	67	0	491	637	670	1363	458	467
1979	8	0	377	578	503	1204	298	260
1980	19	0	365	594	459	1472	213	392
1981	32	0	388	799	706	1545	389	462
1982	25	0	464	840	462	1613	182	381
1983	35	0	300	1041	560	1558	189	550
1984	7	13	224	929	396	1516	131	402
1985	7	0	287	772	421	1604	111	272
1986	6	12	182	697	228	1412	153	162
1987	8	0	235	666	234	1187	128	271
1988	1	0	190	542	400	1306	213	154
1989	16	0	122	553	231	948	174	263
1990	7	0	263	660	252	1083	255	173
1991	5	0	260	430	269	1270	191	95

Regions: MAB - Mid Atlantic Bight; BAH - Bahamas; CAR - Caribbean; GOM - Gulf of Mexico.
Waves: 1 = March-April; 2 = May-June; 3 = July-August; 4 = September-October.
Types: 1 = non-tournament sampling; 2 = tournament.

Appendix 3c. Number of trips, by region, wave, and type, in the white marlin HPUE analysis.

	WAVE							
	1		2		3		4	
AREA/	TYPE		TYPE		TYPE		TYPE	
YEAR	1	2	1	2	1	2	1	2
NEL								
1973	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	55	0	0
1975	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0
1980	0	0	0	0	71	0	26	0
1981	0	0	3	0	67	0	1	0
1982	0	0	0	0	4	0	0	0

	WAVE							
	1		2		3		4	
AREA/	TYPE		TYPE		TYPE		TYPE	
YEAR	1	2	1	2	1	2	1	2
1983	0	0	0	0	2	0	0	0
1984	0	0	0	0	24	0	0	0
1985	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	0	0	0
1988	0	0	0	0	0	394	0	0
1989	0	0	0	0	0	94	0	0
1990	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	91	0	0

Appendix 3c. Continued..

	WAVE 1		WAVE 2		WAVE 3		WAVE 4	
AREA/	TYPE		TYPE		TYPE		TYPE	
YEAR	1	2	1	2	1	2	1	2
MAB								
1973	0	0	0	157	0	0	0	0
1974	0	0	0	181	113	176	53	0
1975	0	0	0	302	0	370	0	163
1976	0	0	0	280	0	190	0	218
1977	0	0	0	238	0	306	0	0
1978	0	0	0	324	0	134	0	97
1979	0	0	0	261	0	67	0	105
1980	0	0	206	333	924	521	47	81
1981	0	0	298	332	604	228	136	295
1982	0	0	13	259	198	187	38	0
1983	0	0	385	430	1451	899	583	232
1984	0	0	45	212	1070	695	181	188
1985	0	0	0	211	0	212	0	106
1986	0	0	0	4	0	140	0	0
1987	0	0	0	0	0	0	0	0
1988	0	0	0	198	0	114	0	0
1989	0	0	0	302	0	54	0	0
1990	0	0	0	170	0	167	0	0
1991	0	0	0	170	0	127	0	0
BAH								
1973	0	669	0	46	0	203	0	0
1974	0	442	0	204	0	192	0	0
1975	0	413	0	217	0	248	0	0
1976	0	410	0	105	0	263	0	0
1977	0	303	0	215	0	219	0	0
1978	0	297	0	300	0	251	0	0
1979	0	308	0	338	0	302	0	0
1980	0	484	0	396	0	261	0	0
1981	0	486	0	807	0	265	0	0
1982	0	737	0	476	0	182	0	0
1983	0	892	0	580	0	180	0	0
1984	0	1080	0	966	0	216	0	0
1985	0	788	0	738	0	189	0	0
1986	0	1154	0	747	0	48	0	0
1987	0	1069	0	866	0	40	0	0
1988	0	1006	0	894	0	107	0	0
1989	0	992	0	1071	0	71	0	0
1990	0	1324	0	670	0	40	0	0
1991	0	782	0	579	0	64	0	0

	WAVE 1		WAVE 2		WAVE 3		WAVE 4	
AREA/	TYPE		TYPE		TYPE		TYPE	
YEAR	1	2	1	2	1	2	1	2
CAR								
1973	0	0	0	0	0	24	0	291
1974	0	0	0	0	0	28	0	415
1975	0	0	0	0	0	79	0	377
1976	0	0	0	0	0	86	0	268
1977	0	0	0	0	0	193	0	0
1978	0	0	0	208	0	32	0	237
1979	0	0	0	0	0	116	0	0
1980	0	0	0	0	0	38	0	0
1981	0	0	13	0	23	44	0	183
1982	0	0	4	0	34	28	6	206
1983	88	0	128	141	483	449	148	622
1984	0	0	0	839	0	110	0	305
1985	18	0	0	1058	0	322	0	67
1986	0	0	0	0	0	451	0	0
1987	0	0	0	0	0	191	0	357
1988	0	0	0	0	0	748	0	157
1989	0	0	0	0	0	323	0	577
1990	0	0	0	0	0	288	0	335
1991	0	0	0	0	0	289	0	345
GOM								
1973	0	0	183	131	645	207	359	0
1974	5	0	421	0	747	71	398	13
1975	10	0	274	293	588	521	402	117
1976	8	0	285	322	570	752	360	328
1977	53	0	344	454	589	1372	257	268
1978	67	0	491	637	670	1363	458	467
1979	8	0	377	578	503	1204	298	260
1980	19	0	365	594	459	1472	213	392
1981	32	0	388	799	706	1545	389	462
1982	25	0	464	840	462	1613	182	381
1983	35	0	300	1041	560	1558	189	550
1984	7	13	224	929	396	1516	131	402
1985	7	0	287	772	421	1604	111	272
1986	6	12	182	697	228	1412	153	162
1987	8	0	235	666	234	1187	128	271
1988	1	0	190	542	400	1306	213	154
1989	16	0	122	553	231	948	174	263
1990	7	0	263	660	252	1083	255	173
1991	5	0	260	430	269	1270	191	95

Regions: NEL - New England; MAB - Mid Atlantic Bight; BAH - Bahamas; CAR - Caribbean; GOM - Gulf of Mexico.
Waves: 1 = March-April; 2 = May-June; 3 = July-August; 4 = September-October.
Types: 1 = non-tournament sampling; 2 = tournament.

Appendix 3d. Number of trips, by region, wave, and type, in the white marlin CPUE analysis.

AREA/	WAVE 1		WAVE 2		WAVE 3		WAVE 4	
	TYPE		TYPE		TYPE		TYPE	
YEAR	1	2	1	2	1	2	1	2
NEL								
1973	0	0	0	0	0	0	0	0
1974	0	0	0	0	0	55	0	0
1975	0	0	0	0	0	0	0	0
1976	0	0	0	0	0	0	0	0
1977	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0
1980	0	0	0	0	71	0	26	0
1981	0	0	3	0	67	0	1	0
1982	0	0	0	0	4	0	0	0
1983	0	0	0	0	2	0	0	0
1984	0	0	0	0	24	0	0	0
1985	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0
1987	0	0	0	0	0	576	0	0
1988	0	0	0	0	0	466	0	0
1989	0	0	0	0	0	364	0	0
1990	0	0	0	0	0	229	0	0
1991	0	0	0	0	0	258	0	0
MAB								
1973	0	0	0	157	0	0	0	0
1974	0	0	0	181	113	176	53	0
1975	0	0	0	302	0	370	0	163
1976	0	0	0	280	0	190	0	218
1977	0	0	0	238	0	306	0	0
1978	0	0	0	324	0	134	0	97
1979	0	0	0	261	0	67	0	105
1980	0	0	206	333	924	521	47	81
1981	0	0	298	332	604	228	136	295
1982	0	0	13	259	198	187	38	0
1983	0	0	385	430	1451	899	583	232
1984	0	0	45	212	1070	695	181	188
1985	0	0	0	211	0	212	0	106
1986	0	0	0	4	0	140	0	104
1987	0	0	0	42	0	846	0	181
1988	0	0	0	114	0	1159	0	271
1989	0	0	0	1156	0	1820	0	360
1990	0	0	0	976	0	2061	0	356
1991	0	0	0	989	0	2024	0	135
GOM								
1973	0	0	183	131	645	207	359	0
1974	5	0	421	0	747	71	398	13
1975	10	0	274	293	588	521	402	117
1976	8	0	285	322	570	752	360	328
1977	53	0	344	454	589	1372	257	268
1978	67	0	491	637	670	1363	458	467
1979	8	0	377	578	503	1204	298	260
1980	19	0	365	594	459	1472	213	392
1981	32	0	388	799	706	1545	389	462
1982	25	0	464	840	462	1613	182	381

AREA/	WAVE 1		WAVE 2		WAVE 3		WAVE 4	
	TYPE		TYPE		TYPE		TYPE	
YEAR	1	2	1	2	1	2	1	2
BAH								
1973	0	669	0	46	0	203	0	0
1974	0	442	0	204	0	192	0	0
1975	0	413	0	217	0	248	0	0
1976	0	410	0	105	0	263	0	0
1977	0	303	0	215	0	219	0	0
1978	0	297	0	300	0	251	0	0
1979	0	308	0	338	0	302	0	0
1980	0	484	0	396	0	261	0	0
1981	0	486	0	807	0	265	0	0
1982	0	737	0	476	0	182	0	0
1983	0	892	0	580	0	180	0	0
1984	0	1080	0	966	0	216	0	0
1985	0	788	0	738	0	189	0	0
1986	0	1154	0	747	0	48	0	0
1987	0	1069	0	866	0	40	0	0
1988	0	1006	0	894	0	107	0	0
1989	0	992	0	1071	0	71	0	0
1990	0	1324	0	670	0	40	0	0
1991	0	782	0	579	0	64	0	0
CAR								
1973	0	0	0	0	0	24	0	291
1974	0	0	0	0	0	28	0	415
1975	0	0	0	0	0	79	0	377
1976	0	0	0	0	0	86	0	268
1977	0	0	0	0	0	193	0	0
1978	0	0	0	208	0	32	0	237
1979	0	0	0	0	0	116	0	0
1980	0	0	0	0	0	38	0	0
1981	0	0	13	0	23	44	0	183
1982	0	0	4	0	34	28	6	206
1983	88	0	128	141	483	449	148	622
1984	0	0	0	839	0	110	0	305
1985	18	0	0	1058	0	322	0	67
1986	0	0	0	0	0	451	0	0
1987	0	0	0	0	0	191	0	357
1988	0	0	0	0	0	872	0	532
1989	0	0	0	205	0	323	0	721
1990	0	0	0	0	0	288	0	335
1991	0	0	0	209	0	289	0	557
1983	35	0	300	1041	560	1558	189	550
1984	7	13	224	929	396	1516	131	402
1985	7	0	287	772	421	1604	111	272
1986	6	12	182	697	228	1412	153	162
1987	8	0	235	666	234	1187	128	271
1988	1	0	190	542	400	1306	213	154
1989	16	0	122	553	231	948	174	263
1990	7	0	263	660	252	1083	255	173
1991	5	0	260	430	269	1270	191	95

Regions: NEL - New England; MAB - Mid Atlantic Bight; BAH - Bahamas; CAR - Caribbean; GOM - Gulf of Mexico.
Waves: 1 = March-April; 2 = May-June; 3 = July-August; 4 = September-October.
Types: 1 = non-tournament sampling; 2 = tournament.