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# STANDARDIZED CATCH RATES OF BLUEFIN TUNA FROM THE JAPANESE LONGLINE FISHERY IN THE UNITED STATES EXCLUSIVE ECONOMIC ZONE FOR 1983-1987

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SUMMARY

Data collected by U.S. observers aboard all Japanese longline vessels fishing within the United States Exclusive Economic Zone were used to develop standardized catch rates of bluefin tuna in the western Atlantic, north of 35 degrees latitude, for 1983-1987.

Size was recorded for nearly every bluefin tuna caught and was used to calculate catch rate at age for each set. A general linear model was used to develop standardized catch rates. Separate analyses were conducted for 1-2, 3-7 and 8-9 year old bluefin tuna. An adequate model could not be developed for 1-2 or 8-9 year old bluefin tuna.

RESUME

Les données recueillies par les observateurs américains à bord de tous les palangriers japonais pêchant dans la zone économique exclusive des Etats-Unis ont servi à définir le taux standardisé de capture du thon rouge dans l'Atlantique ouest, au nord de la latitude 35º, pour 1983-87.

La taille de presque tous les thons rouges capturés a été enregistrée, et a servi à calculer le taux de capture à un âge donné pour chaque calée. Un modèle linéaire généralisé a été utilisé pour élaborer le taux standardisé de capture. Des anlyses séparées ont été menées pour le thon rouge de 1-2, 3-7 et 8-9 ans. Il n'a pas été possible de définir un modèle adéquat pour les thons rouges de 1-2 ans ou de 8-9 ans.

RESUMEN

Se emplearon los datos recogidos por los observadores estadounidenses a bordo de todos los palangreros japoneses que pescaban en la Zona Económica Exclusiva de Estados Unidos, para desarrollar tasas estandarizadas de captura de atún rojo en el Atlántico Oeste, a 35 grados de latitud Norte, durante el periodo 1983-1987.

Se registró la talla de casi todos los atunes rojos capturados y esta información se empleó en el cálculo de la tasa de captura por edad en cada lance. Se empleó un modelo lineal generalizado para obtener tasas de captura estandar. Se hicieron análisis separados sobre atunes rojos de 1-2, 3-7 y 8-9 años. No se pudo obtener un modelo adecuado en el caso de los atunes rojos de 1-2 y 8-9 años.

## Introduction

U.S. observers have recorded catch and effort data from all Japanese longline vessels fishing within the U.S. Exclusive Economic Zone (EEZ) since June 1982. The target species are the bluefin and bigeye tuna. The bluefin are targeted during the winter, as quotas permit, otherwise, bigeye are targeted.

Average catch rates may not reflect population trends, because of variation among years in fishing gear, strategy, and environmental factors. The purpose of this paper is to develop a model, using a general linear model (GLM) procedure, to estimate standardized catch rates of bluefin tuna, of which, trends of abundance may be revealed.

## Materials and Methods

U.S. observers record data on each animal caught. Each record contains data on: vessel identification; date, time, temperature, and location of each set and haulback; gear parameters, including floatline length, gangion length, number of floats, number of hooks between floats, distance between hooks, and bait used; as well as size, sex, status (dead or alive), and landing time of each animal. Length units may be recorded as straight or curved and as measured or estimated. Weight, if recorded is measured as round weight.

Observations used in the analysis were single sets. Sets that contained less than 1000 hooks or had measured lengths for less than 34% of the bluefin caught on that set were not used in the analyses. Length was assigned to any unmeasured fish on a set from the length composition of the measured bluefin on that set.

Bluefin were aged with the Parrack and Phares (1979) growth equation and the algorithm used by the Bluefin Working Groups of 1984 and 1985 to age the catch and in recent assessments (Anon. 1985, 1986 and 1987). The equation included the variable $T_o$ (Nichols 1985), using the value of -0.96 for 1985, 1986, and 1987. Catch rates at age were calculated for each set using the catch at length. Bluefin over 9 years old were not included. Age specific mean catch rates by year and month were used to group the bluefin into age groups for analysis (Table 1). The 3-7 year old bluefin were the most frequently caught age group, where as, the 1-2 and 8-9 year old bluefin exhibited low catch rates. Therefore, separate analyses were conducted on 1-2, 3-7 and 8-9 year old bluefin.

The variables chosen to initiate the analyses were year, month, area, depth, and oceanographic factor. Area was defined as a one degree square of latitude and longitude. Gear depth was stratified as shallow, intermediate or deep. Shallow sets were defined as containing less than nine hooks between floats. Intermediate sets were defined as containing nine to eleven hooks between floats. Deep sets were defined as containing twelve or more hooks between floats. Oceanographic factor was defined as the presence of either the Gulf Stream, a warm water eddy, or continental shelf and/or slope water.

The oceanographic factors were crudely incorporated by examination of the weekly oceanographic analysis charts modified by the National Marine Fisheries Service, Northeast Fisheries Center, Narragansett Laboratory, Marine Climatology Investigation Division. The presence of either warm water eddies, the Gulf Stream, or shelf and/or slope water was recorded for each one degree square of latitude and longitude. These data were then merged with the CPUE data by matching them with the corresponding date and mean position of each set

The data used in the analysis were limited to insure a more balanced design; this was done by generally requiring that for each level of a main effect in the model there had to be at least 5 observations in at least 2 levels of every other main effect. This approach was relaxed for the class variable 1983 in order to include it in the analysis.

A general linear model (Draper and Smith 1966) approach to analysis of variance (ANOVA) was used to examine logged catch rates + 1 for differences among the effects of years, months, areas, depth, oceanographic factors, and their interactions. The frequency distributions of standardized residuals (observed minus predicted divided by standard error of the estimate) were examined to be sure that they approximated the normal distribution. F-tests were conducted on all two-way interactions, except those with the year effect, and on all main effects, and were used to select the best model for developing standardized catch rates.

## Results

After restricting the data to help insure a more balanced design, the following main effects were included in the analysis: **years:** 1983, 1984, 1985, 1986, and 1987; months: January, February, November, and December; **Areas:** 36°N74°W, 39°N66°W, 39°N 67°W, 39°N68°W, 40°N66°W, 40°N67°W (Figure 1); gear depth: shallow, intermediate, deep; oceanographic factor: presence of eddy, presence of Gulf Stream, presence of shelf and/or slope water. There were sufficient data to test the interaction between month and area. No other interactions could be tested.

Analysis was initiated on the 3-7 year old bluefin age group because there were more positive catch rates for that group.

The GLM procedure was applied as follows:

$$\ln(CPUE + 1.0) = Y + M + A + D + O + M*A$$

| | | |
|---|---|---|
| where | CPUE | = catch per 1000 hooks |
| | Y | = year |
| | M | = month |
| | A | = area |
| | D | = depth of set |
| | O | = oceanographic factor |
| | M*A | = interaction of month and area |

Examination of the distribution of standardized residuals among the levels of area showed that area 36°N74°W was quite different, so catch rates from that area were removed from the analysis. The model was tested again; examination of the standardized residuals among the levels of depth revealed that the distribution of deep sets were quite different from shallow and intermediate which seems logical since deep sets target bigeye tuna, therefore catch rates from deep sets were removed from the analysis. ANOVA revealed that the month-area interaction was not significant. The model was tested without the month-area interaction and ANOVA revealed that area was not significant, which seemed logical, because the remaining five 1° square areas constitute one larger area (Figure 1). The model was tested without area and ANOVA revealed that year, month, depth, and oceanographic factor were all highly significant. The distribution of standardized residuals at each level of the main effects appeared to approximate the normal distribution (Figures 2-5). The histogram of standardized residuals for the model appeared normal (Figure 6), thus the model was accepted (Figure 7).

Adequate models could not be developed for 1-2 or 8-9 year old bluefin tuna. Attempts resulted in poorly distributed residuals and coefficients of multiple determination of less than 10%.

## Discussion

The standardized catch rates suggest that the juvenile bluefin tuna population was expanding from 1983 through 1985 and then began declining somewhat in 1986 and remained approximately constant through 1987 (Figure 8). These results are somewhat questionable due to the relatively low $R^2$ (.52) and broad 90% confidence intervals about the standardized means (Figures 7 and 8). The proportion of the total variation explained was higher than that explained in similar analyses of this data set (Turner 1987, Davis and Turner 1988). The inability to explain more of the total variation may have been due to the variability of the catch rates from the Japanese longline fishery, or the lack of other significant information that influences the catch rates.

## Literature Cited


Anonymous. 1985. Report of the bluefin working group. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 22:1-66.

Anonymous. 1986. Report of the meeting of the bluefin working group. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 24:1-110.

Anonymous. 1987. 1986 SCRS Report A. Int. Comm. Conserv. Atl. Tunas, p. 47-94.

Davis, K.S., and S.C. Turner. 1988. Standardized catch rates of bluefin tuna in the United States fishery Conservation Zone for 1983-1986. Int. Comm. Atl. Tunas, Col. Vol Sci. Pap. 28:243-251.

Draper, N.R., and H. Smith. 1986. Applied Regression Analysis. John Riley and Sons, Inc., New York, 407 p.

Nichols, S. 1985. Variation in mean lengths of modal size groups of bluefin tuna in the Western Atlantic. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 22:185-193.

Parrack, M.L., and P.L. Phares. 1979. Aspects of the growth of Atlantic bluefin tuna determined from mark-recapture data. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 8(2):356-366.

Turner, S.C. 1987. Catch rates of bluefin tuna in the Japanese longline fishery recorded by United States observers. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. 26(2):323-328.

Vaughan, D.S., et. al. 1987. Sensitivity of CAL (Parrack 1986), a method for analyzing catches and abundance indices from a fishery. Int. Comm. Conserv. Atl. Tunas, In Press. 28:221-242.

Table 1. Mean catch rates (CR) of bluefin tuna ages 1-9 caught by Japanese Longline vessels fishing north of 35$^{o}$N in the Western Atlantic from 1983-1987 by year and month.

| YEAR | MONTH | | AGE 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 83 | 2 | MEAN CR | 0.36 | 0.37 | 0.00 | 0.74 | 0.00 | 0.00 | 0.37 | 0.37 | 0.00 |
| 83 | 12 | MEAN CR | 0.61 | 1.09 | 1.37 | 2.29 | 0.74 | 0.74 | 0.56 | 0.48 | 0.43 |
| 84 | 1 | MEAN CR | 0.00 | 0.71 | 1.48 | 4.12 | 6.40 | 1.77 | 0.64 | 0.55 | 0.48 |
| 84 | 2 | MEAN CR | 0.00 | 0.54 | 0.96 | 4.38 | 4.86 | 1.23 | 0.36 | 0.36 | 0.35 |
| 84 | 11 | MEAN CR | 0.34 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 84 | 12 | MEAN CR | 0.91 | 8.84 | 5.54 | 5.07 | 3.33 | 2.97 | 1.51 | 0.69 | 0.72 |
| 85 | 1 | MEAN CR | 0.55 | 0.58 | 5.58 | 2.88 | 2.52 | 5.70 | 3.63 | 1.59 | 0.88 |
| 85 | 2 | MEAN CR | 0.55 | 0.63 | 9.29 | 4.01 | 6.52 | 6.91 | 3.43 | 1.41 | 0.48 |
| 85 | 3 | MEAN CR | 0.38 | 0.64 | 12.32 | 3.47 | 4.76 | 1.98 | 0.82 | 0.72 | 0.48 |
| 85 | 6 | MEAN CR | 0.00 | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 85 | 7 | MEAN CR | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.40 |
| 86 | 1 | MEAN CR | 0.37 | 0.57 | 0.99 | 11.56 | 2.01 | 1.46 | 1.15 | 0.70 | 0.63 |
| 86 | 2 | MEAN CR | 0.00 | 0.38 | 1.35 | 3.38 | 4.91 | 1.70 | 0.89 | 0.44 | 0.00 |
| 86 | 9 | MEAN CR | 0.35 | 0.00 | 0.00 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 86 | 10 | MEAN CR | 0.00 | 0.00 | 0.00 | 0.39 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 86 | 12 | MEAN CR | 0.00 | 0.85 | 4.31 | 6.31 | 4.73 | 1.32 | 0.68 | 0.43 | 0.42 |
| 87 | 1 | MEAN CR | 0.41 | 1.11 | 2.32 | 5.43 | 7.06 | 6.95 | 2.15 | 1.28 | 0.68 |
| 87 | 11 | MEAN CR | 0.00 | 0.50 | 0.39 | 0.37 | 0.44 | 0.38 | 0.00 | 0.00 | 0.00 |
| 87 | 12 | MEAN CR | 0.36 | 0.86 | 2.12 | 2.59 | 1.81 | 1.54 | 0.75 | 0.43 | 0.34 |

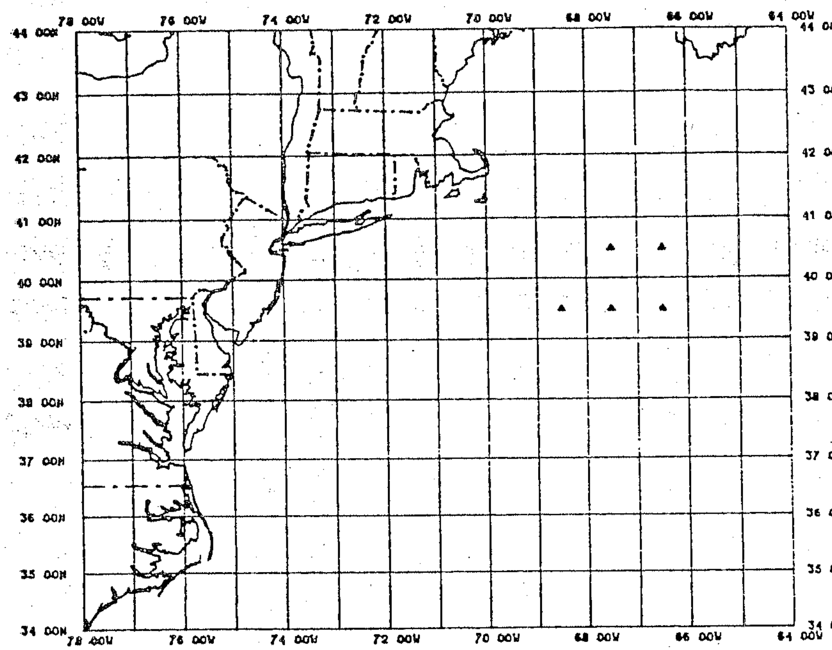
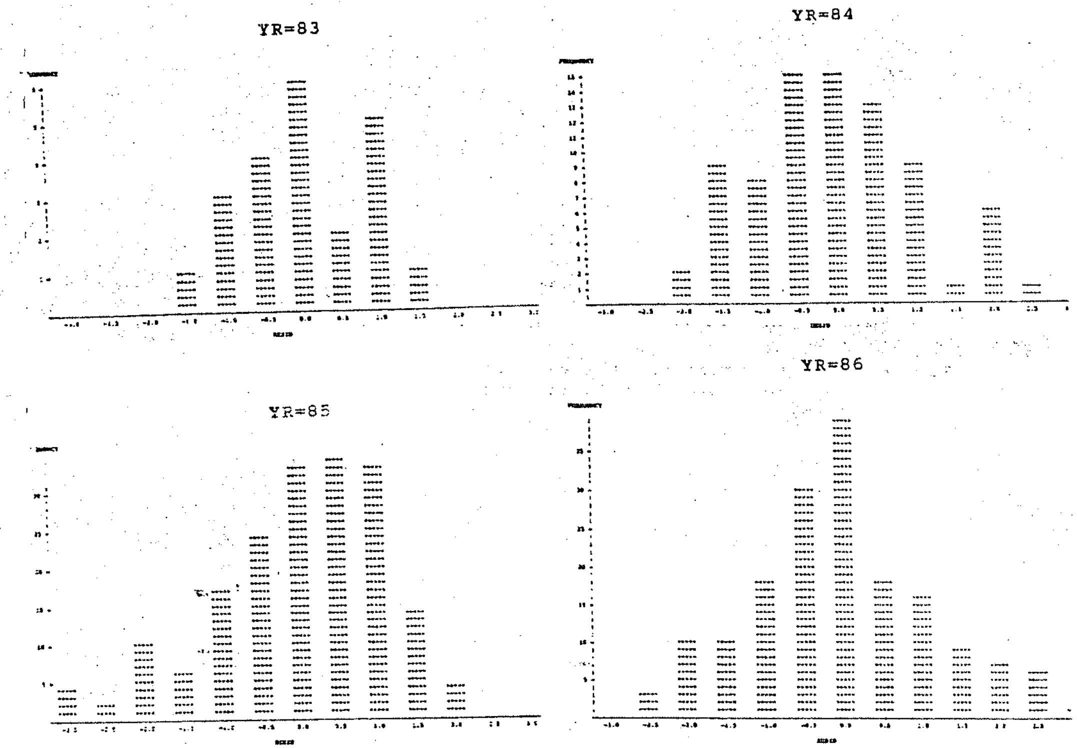



Figure 1. Map of the areas used in the 3-7 year old bluefin tuna catch rate analysis (triangles represent areas used in the final model).



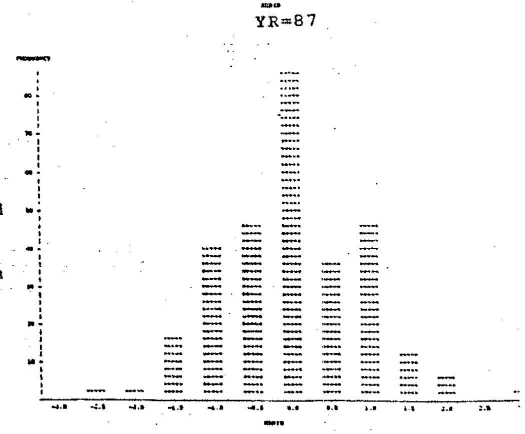




Figure 2. Distributions of standardized residuals (resid) at each level of year (YR) used in the 3-7 year old bluefin tuna catch rate analysis.

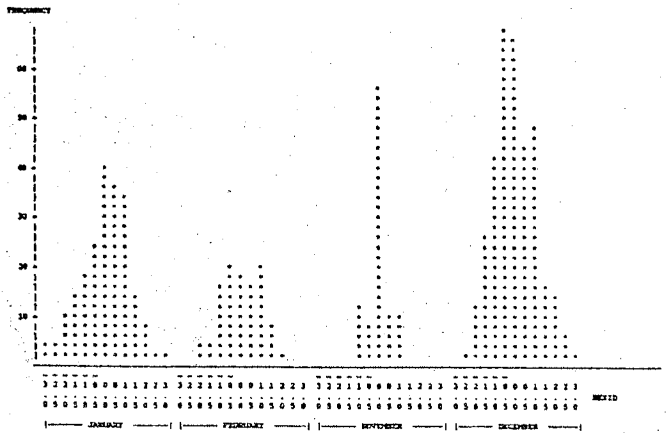


Figure 3. Distributions of standardized residuals (resid) at each level of month used in the 3-7 year old bluefin tuna catch rate analysis.

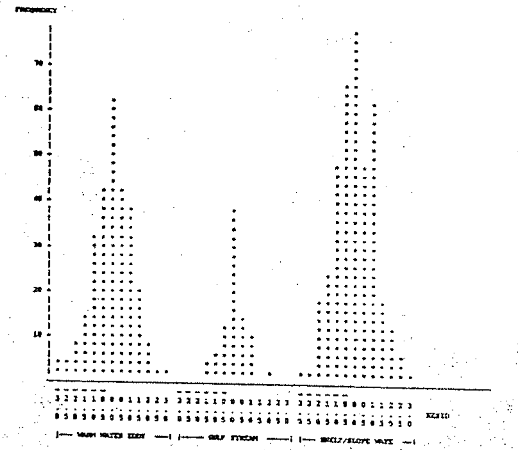


Figure 5. Distributions of standardized residuals (resid) at each level of oceanographic factor used in the 3-7 year old bluefin tuna catch rate analysis.

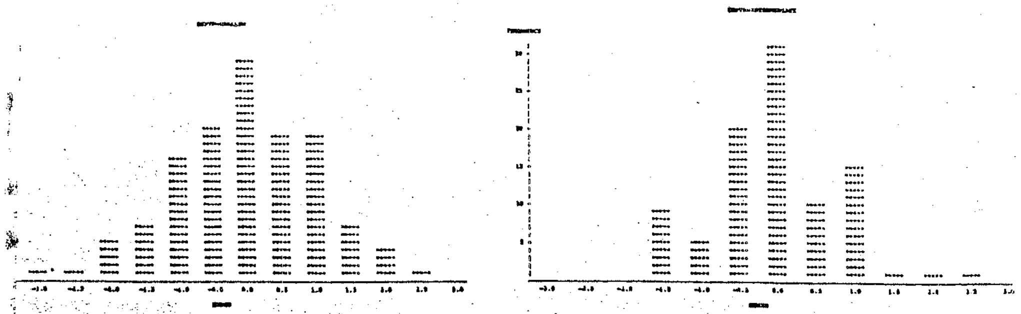


Figure 4. Distributions of standardized residuals (resid) at each level of depth used in the 3-7 year old bluefin tuna catch rate analysis.

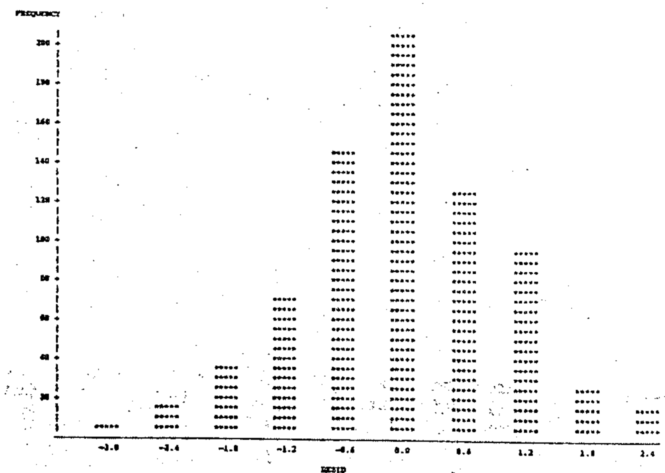


Figure 6. Distribution of the standardized residuals (resid) of the final model for 3-7 year old bluefin tuna catch rates.

Class Level Information

| Class | Levels | Number Observations |
|---|---|---|
| Year (Y) | 1983 | 22 |
| | 1984 | 79 |
| | 1985 | 181 |
| | 1986 | 167 |
| | 1987 | 290 |
| Month (M) | January | 203 |
| | February | 102 |
| | November | 93 |
| | December | 341 |
| Depth (D) | Shallow | 645 |
| | Intermediate | 493 |
| Oceanographic (O) factor | Warm water eddy | 273 |
| | Gulf stream | 83 |
| | shelf/slope water | 383 |

Final model: ln (CPUE+1) = Y + M + D + O

$R^2$ = .52
Standard error of estimate = .876
Number observations = 739

Figure 7. Final model used to estimate catch rates for 3-7 year old bluefin tuna with class level information (CPUE = catch per 1000 hooks).

| Year | Estimated Catch Rate |
|---|---|
| 83 | 1.28 |
| 84 | 3.91 |
| 85 | 4.06 |
| 86 | 3.00 |
| 87 | 2.74 |

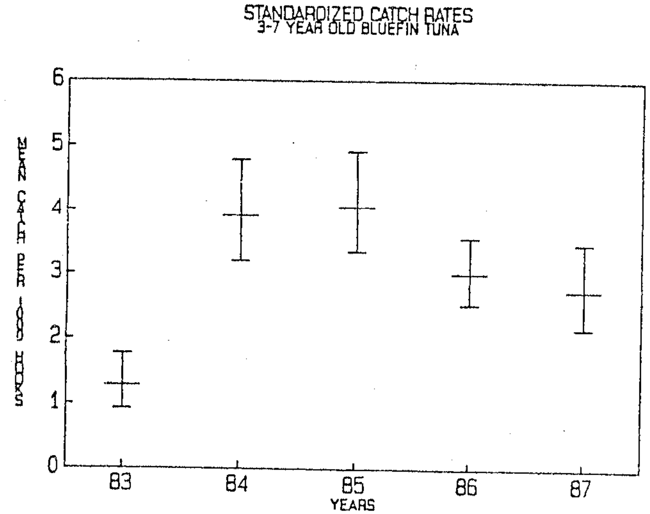



Figure 8. Annual standardized catch rates (catch per 1000 hooks) with approximate 90% confidence intervals for 3-7 year old bluefin tuna caught by the Japanese longline fishery in the U.S. EEZ. Units have been transformed from logged units back to standard units.