# APPLICATION OF GENERALIZED PRODUCTION MODEL TO BIGEYE STOCK IN THE ATLANTIC OCEAN

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**SUMMARY**

In the Atlantic Ocean bigeye tuna are caught by three main fisheries: longline, purse seine and baitboat. The bigeye catch has been increasing since the late 1950s with some fluctuation. During the past two decades, this increase has been brought about by both longline and purse seine fisheries although the purse seine catch was low from 1985 to 1990. CPUE standardized by both GLM (General Linear Model, log-normal error structure) and GM (Generalized Linear Model, over-dispersed Poisson error structure) showed a gradual declining trend from 1961 to the most recent year (Miyabe, 1995, ICCAT 1995). This tendency, coupled with the sharp increase in catch, is a matter of concern for the bigeye stock. ICCAT (1995) analyzed the Atlantic bigeye stock by using two production models, a non-equilibrium surplus production model (ASPIC) and an equilibrium production model (PRODFIT), and MSYs were estimated to be from 55,000 to 86,000 MT by ASPIC and from 69,000 to 79,000 MT by PRODFIT, respectively. At last year's SCRS, PRODFIT gave more optimistic MSY estimates than ASPIC (ICCAT, 1995). In plotting the catch-effort relationship shown in Figure 1, it appears that catch has never substantially exceeded the MSY level. In this condition, it is hard to estimate correctly the whole shape of the production curve. Since ASPIC assumes a logistic growth model (that is equal to the shape parameter of 2.0), there is the possibility that bigeye data do not fit enough to the ASPIC model. In this study, the generalized production model, in which shape parameter can be estimable (Pella and Tomlinson, 1969), is applied to Atlantic bigeye, and the results are compared with those of the ASPIC and PRODFIT analyses.

**RÉSUMÉ**

Dans l'Océan Atlantique, le thon obèse est capturé par les palangriers, les senneurs et les canneurs. Les captures de thon obèse augmentent depuis la fin des années cinquante avec quelques fluctuations. Au cours des deux dernières décennies, cette augmentation a été le fait des palangriers et des senneurs. Toutefois, les captures des senneurs ont été peu élevées entre 1985 et 1990. La CPUE standardisée avec le Modèle Linéaire Généralisé (structure log-normale de l'erreur et Poisson sur-dispersée) indique une tendance progressive à la baisse depuis 1961 (Miyabe 1995, ICCAT 1995). Cette tendance, associée à une forte augmentation des captures, est préoccupante pour le stock de thon obèse. En 1995, l'ICCAT a analysé le stock de thon obèse en utilisant deux modèles de production : un modèle de production excédentaire en état de non-équilibre (ASPIC) et un modèle de production en état d'équilibre (PRODFIT). Les PME ont été estimées entre 55000 et 86000 TM avec ASPIC et entre 69000 et 79000 TM avec PRODFIT. Lors du SCRS de l'année précédente, le modèle PRODFIT avait donné des estimations plus optimistes de la PME que le modèle ASPIC (ICCAT, 1995). Lorsque l'on calcule le rapport prise-effort (Figure 1), on s'aperçoit que la capture n'a jamais été beaucoup plus élevée que le niveau de la PME. Dans ces conditions, il est difficile d'estimer correctement la forme globale de la courbe de production. Dans la mesure où le modèle ASPIC suppose un mode logistique de croissance (c'est-à-dire égal à la forme du paramètre 2.0), il est possible que les données sur le thon obèse ne s'ajustent pas suffisamment au modèle ASPIC. Dans cette étude, le modèle de production généralisé, dans lequel on peut estimer la forme du paramètre (Pella & Tomlinson, 1969), a été appliqué au thon obèse de l'Atlantique et les résultats sont comparés avec ceux des analyses ASPIC et PRODFIT.

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## RESUMEN

El patudo es capturado en el Atlántico por tres principales pesquerías, palangre, cerco y barcos de cebo. Desde finales de los años 50 la captura de esta especie ha ido en aumento, con alguna fluctuación. En los dos últimas décadas, este aumento corresponde a las pesquerías de palangre y cerco, si bien la captura de esta última ha sido escasa de 1985 a 1990. La CPUE estandarizada tanto por GLM (Modelo Lineal Generalizado, estructura de error logarítmico normal) y GM (Modelo Lineal Generalizado, estructura de error Poison dispersa) presentaba una tendencia gradual al descenso desde 1961 hasta el año mas reciente (Miyabe 1995, ICCAT 1995). Esta tendencia junto con el brusco incremento de la captura es motivo de preocupación en relación con el stock de patudo. ICCAT (1995) analizó el stock de patudo atlántico mediante dos modelos de producción: ASPIC, modelo de producción en condiciones de no equilibrio y PRODFIT, modelo de producción en condiciones de equilibrio, estimándose el RMSs entre 55.000 y 86.000 t con ASPIC y entre 69.000 y 79.000 t con PRODFIT. Durante el SCRS del pasado año, PRODFIT dio estimaciones mas optimistas de RMS que las de ASPIC (ICCAT, 1995). En la representación de la relación captura/esfuerzo de la Figura 1,se observa que la captura nunca ha sobrepasado mucho el nivel del RMS. En estas condiciones resulta difícil estimar correctamente la forma de la curva de producción en su conjunto. Dado que ASPIC asume un modelo logístico de crecimiento (que es igual al parámetro de forma 2.0) existe la posibilidad de que los datos de patudo no se ajusten bien al modelo ASPIC. En este estudio, el modelo de producción generalizado, en el cual se puede estimar el parámetro de forma (Pella y Tomlinson, 1969) se aplica al patudo del Atlántico y los resultados se comparan a los de los análisis PRODFIT y ASPIC.


### Materials and methods

For generalized production model analysis, a program, which was coded and made available by Dr. P. K. Tomlinson, was used. CPUE series from 1961 to 1994 (standardized by GM model and GLM for total and central Atlantic data) estimated by Miyabe (1995) and ICCAT (1995) were used in this study. Additionally, data omitting the most recent two years (1993 and 1994) were also attempted to use in order to see the effect of these tow data points, which indicated the large increase of catch. Initial values and range of parameters are shown in Table 1, where Fopt is effort level that produce MSY, q is catchability coefficient, r is P(1)/Pmax, P(1) is initial population size, and Umax is the maximum catch per effort theoretically possible. Shape parameter was scanned from 0.6 to 2.4 by interval of 0.1. The results which have too small -H (smaller than 0.001) were ignored.

### Results and discussion

Results with the lowest sum of square (SS) value in each CPUE series are shown in Table 2 . MSY ranged from 54,100 MT to 62,200 MT for CPUE series standardized by GLM model, and from 47,200 MT to 50,500 MT for those standardized by GM model. Shape parameters ranged from 1.3 to 1.7 for the former, and from 1.1 to 1.3 for the latter, respectively.

MSY obtained in this study are similar to those of ASPIC analysis in spite of the fact that most of the estimated shape parameters in this study are closer to 1 rather than ASPIC shape parameter (=2). The intrinsic growth rate ( -H in GENPRO, equal to r in ASPIC) and catchability coefficients (q) obtained in this study are much smaller than ASPIC. It seems difficult to judge from these results which model's result is more likely to reflect the real bigeye stock feature. Optimum efforts (effort that gives MSY) estimated by GENPRO ranged from 96.56 to 144.5(mostly 100-120, see Table 2). Recent effort level is near to this level and clearly exceeds this level from 1993.

### Reference


ICCAT 1995. Bigeye tuna --Detailed report. ICCAT SCRS: BET detailed report, version: final.

Miyabe N. 1995. Standardized bigeye CPUE from the Japanese longline fishery in the Atlantic. ICCAT SCRS/95/115.

Pella, J. J. and P. K. Tomlinson 1969. A generalized stock production model. Inter-Am. Trop. Tuna Comm. 13:419-496.


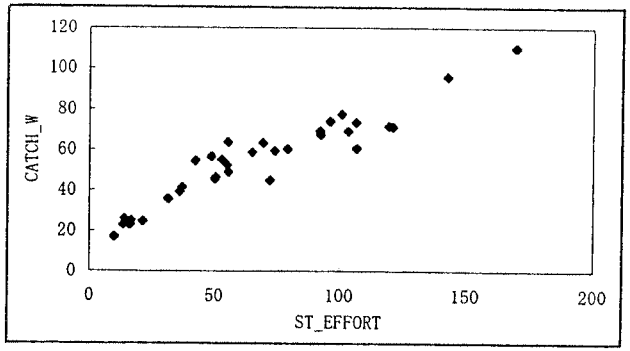


Fig.1. Plots of effort and catch (weight) relationship.
ST_effort were calculated from CPUE standardized by GLM.

Table 1 Parameters given for searching interval.

| | Fopt | q | r* | Umax |
|---|---|---|---|---|
| best guess | 150 | 0.00004 | 0.9 | 2.0 |
| lower limit | 50 | 0.00001 | 0.2 | 0.5 |
| upper limit | 300 | 0.10000 | 1.0 | 4.0 |

r : P(0)/Pmax

Table 2 Summary results of production model analysis on bigeye

| CPUE Model | Area of CPUE | CPUE series | Shape param. | MSY 1000MT | Umax | Fopt | Max popul. | q | -H (=r of ASPIC) | Sum of square |
|---|---|---|---|---|---|---|---|---|---|---|
| GM | Total | 61-94 | 1.1 | 48.5 (39)* | 1.100 | 114.37 | 1395.9 | 0.000788 | 0.48047 | 0.000330 |
| | Total | 61-92 | 1.2 | 47.2 | 1.216 | 96.64 | 1021.4 | 0.001190 | 0.17265 | 0.000276 |
| | Central | 61-94 | 1.3 | 50.5 (42) | 1.021 | 118.57 | 1417.6 | 0.000720 | 0.04196 | 0.000415 |
| | Central | 61-92 | 1.3 | 49.4 | 1.116 | 106.10 | 1046.5 | 0.001066 | 0.06089 | 0.000373 |
| GLM | Total | 61-94 | 1.4 | 55.0 (53) | 1.142 | 111.82 | 1529.1 | 0.000747 | 0.01556 | 0.000231 |
| | Total | 61-92 | 1.7 | 54.1 | 1.195 | 96.56 | 1080.5 | 0.001106 | 0.00195 | 0.000216 |
| | Central | 61-94 | 1.3 | 62.2 (54) | 1.032 | 144.50 | 1809.8 | 0.000570 | 0.03762 | 0.000348 |
| | Central | 61-92 | 1.4 | 58.1 | 1.083 | 124.39 | 1378.9 | 0.000785 | 0.01897 | 0.000334 |

* : MSY estimated by ASPIC model are written in the parenthesis.