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COMPARISON OF VPA RESULTS USING TWO METHODS FOR CONVERSION OF LENGTH TO AGE FOR *NEPHROPS* STOCKS IN PORTUGUESE WATERS (ICES, DIV. IXa)

by

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ABSTRACT

The main objective of this study is to compare the estimates of total stock abundance, fishing mortality and recruitment provided by VPA models, with three sets of catch at age data derived from different methods of conversion length to age composition, during 1984-1994. Length composition of the catch of *Nephrops norvegicus* from Algarve and Alentejo stocks in Portuguese waters, were converted into age groups using slicing, and Iterated Age Length Key techniques with t_o=0 year and t_o=-0.6 year. A fixed effects model ANOVA was used to test the differences in the means of fishing mortality (F_{bar2-6}), of total stock biomass (B_{tot}) and in the means of recruitment at age one (R_1), estimated by the three methods to convert length frequencies into age distributions. The null hypothesis, $F'_{bar\ 2+6} = F''_{bar\ 2+6} = F'''_{bar\ 2+6}$; $B'_{tot} = B''_{tot} = B'''_{tot}$ and $R'_1 = R''_1 = R'''_1$, was not rejected with a significance level of 5%.

INTRODUCTION

The Portuguese *Nephrops norvegicus* stocks (Fig. 1) are assessed within the ICES Working Group of *Nephrops*. Male growth differs markedly from that of females. A pronounced discontinuity of growth seems to occur in females around the size of maturity after which their growth is slower. Females were observed spend long periods in their burrows unavailable to fishing gear, etc., and that is used as justification for treating the sexes separately for assessment purposes (Anon, 1989).

The landings from Alentejo and Algarve, Functional Units 28 and 29 respectively, have been recorded since the 70's, however it is known that this fishery started at the beginning of this century. In 1969 the Spanish trawl fleet was officially allowed to catch in Portuguese waters and concentrated a great amount of its effort on the Alentejo and Algarve Functional Units. Since 1983 the Spanish trawlers were not been allowed to have a direct fishery of *Nephrops* in Portugal.

The objective of this study is to compare the estimates of total stock abundance, fishing mortality and recruitment provided by VPA, with three differents sets of catch at age derived from length at age conversions, during 1984-1994. This analysis was performed only for males, due to some difficulties with the VPA for females.

Length composition of the catches of *Nephrops norvegicus* from Algarve and Alentejo stocks in Portuguese waters, were converted into age groups using slicing, and Iterated Age Length Key (IALK) techniques, with two different values of t_0.

The usual procedure for deriving the age compositions of catches required for VPA-based assessments, involves application of age-length keys (ALK's) to the length composition of the catches. The ALKs are usually derived from direct age readings, but *Nephrops* cannot yet be aged. There are a number of graphical or numeric techniques that can be used to transform a length composition into age components. For *Nephrops* males from Portuguese stocks, length compositions were deconvoluted into age groups, using the "slicing" and Kimura & Chikuni methods (1987) and the conversion was performed by year.

The ICES Stock Assessment Methods Working Group (Anon.,1995) considered several methods, included the methods discussed here, using different data set.

MATERIALS AND METHODS

Slicing

This method uses the catch and abundance at length classes slicing them at points defined by the von Bertalanffy (1938) growth model. Each slice represents an age. The "aged" data are then analyzed by traditional VPA techniques.

Kimura & Chikuni

The Kimura and Chikuni method (1987), uses an Iterated Age Length Key (IALK) and it is closer to the usual Age Length Key (ALK) procedure. It uses an algorithm to solve the matrix equation, $L = PA$ where L is the known vector of length frequency distribution of the catch in a given year, P is a matrix of transition probabilities in which the elements p_{ij} represent the proportion of animals of age i which fall into length class j and A is the unknown vector of proportions of each age group in the catch.

The IALK, uses a constructed age length matrix and an initial estimate of the proportions of catches at age, to set up a starting age-length key. Modal lengths for each age were set by accepting the modes derived from the growth parameters.

VPA Analysis

Following the age composition of the catch obtained from the methods presented here, the Lowestoft package was used to carry out a VPA assessment (Darby and Flatman, 1994).

Statistical model

The three different methods, to convert the length composition into age composition of the catch are compared (main effect), using an analysis of variance designed with fixed effects and a significance level of 5%.

The mean fishing mortality from age two to age six (F_{2-6}), the total stock biomass (B_{tot}), and the mean recruits at age 1 (R_1), estimated by the VPA analysis, during the period 1984-1994 are the dependent variables. The normality of errors and homogeneity of variances were controlled using the Kolmogorov-Smirnov and Levene tests respectively. In practice this implies the transformation of the F_{2-6} vectors, into logarithms of these variable. Normality assumption remains violated for the fishing mortalities estimates for the year 1985. Nevertheless, it was decided to proceed with the analysis of variance because it operates well even with considerable heterogeneity of variances, as long as all the sample size are equal or nearly equal (Zar, 1984).

The null hypothesis, $F'_{bar\ 2+6}=F''_{bar\ 2+6}=F'''_{bar\ 2+6}$; $B'_{tot}=B''_{tot}=B'''_{tot}$; $R'_1=R''_1=R'''_1$ were tested, considering the different methods as the main effect, with a magnitude of Type I error set at $\alpha=0.05$.

Input Data

Length distributions of the *Nephrops* landings from the Portuguese crustacean trawl fleet were obtained once or twice by month from the main ports in the Portuguese South coast.

Length frequency distributions from bottom trawl research cruises carried out to estimate abundance indices of deep-sea crustacean and associated demersal fish species of commercial interest, in the period 1990 to 1994 (Anon, 1994), were used for tuning purposes.

The length frequency data for 1984-1994 were grouped into classes of 1 mm in a half year basis. The range of the length compositions were restricted to 23-60 mm for *Nephrops* males. Numbers at age were estimated by splitting length frequency distributions by the methods described above, with $L_\infty=70$ mm and $k = 0.2$ year^{-1} (Anon, 1995). Two values of t_o were used in slicing method, $t_o=0$ (Anon.,1995) and $t_o=-0.6$. For Kimura & Chikuni t_o was set as -0.6 year. This value was chosen to provide a length of 24 mm carapace length at age 1.5 years that fits the existing growth data. A maximum of 9 age groups were adopted.

Fig. 2 shows the catch at age used as input in VPA. The weight/length relationship used was $W = 0.00028\ L^{3.22}$ where W is the weight in grams and L is the carapace length in mm. The mean weights at age in the stock and in the catch were assumed to be equal. The natural mortality was set at 0.3 year^{-1} for all ages. The proportion of annual natural mortality M occurring before spawning was taken to be 0.25 year on all ages and in all years and the proportion of F before spawning was set at 0.25 year. VPA tuning was carried out using estimated effort data from the log-books information and shipowner association, and using the biomass indices from Portuguese cruises in the period 1990-1994 (Anon., 1995).

RESULTS

A VPA Laurec-Shepherd tuning (Pope and Shepherd, 1985) was carried out, using the 3 different catch at age compositions, using the commercial fishing effort data for 1984-1994, and the *Nephrops* cruises data for 1990-1994, to confirm the stability of catchability coefficient with respect to time. For the crustacean fleet effort, the diagnostics gave a year effects from 1984 to 1987.

An Extended Survivors Analysis (XSA) tuning (Shepherd,1992) was also performed, assuming catchability dependent of stock size for age less than 4 years, with estimates shrunk to the population mean. By inspecting the mean q from commercial fleets age 6 was selected as the age at which log catchability stabilizes. The tuning was performed using 1988 to 1994. The diagnostics gave quite low standard errors of the log catchability for each age in the commercial fleet. The cruises data show higher variances in mean log catchabilities for ages for the period 1990 to 1994. The XSA tuning converged after 15 to 18 iterations.

Estimates of total stock biomasss (B_{tot}) mean fishing mortalities (F_{2-6}), total numbers in the stock (N_{1-9}) and recruits at age one (R_1), by year and by methods are presented in Fig. 3. The trends are similar and both total stock biomass and estimates shows a decreasing trend.

The ANOVA results for fishing mortality (F_{2-6}) are presented in Table 1 and total stock biomass (B_{tot}) are presented in Table 2. Table 3 presents the main results for number of recruits at age 1 (R_1) during the period 1984-1994.

These results indicate that there are no significative differences between the means of the fishing mortality, $F'_{bar\ 2+6} = F''_{bar\ 2+6} = F'''_{bar\ 2+6}$, total stock biomass $B'_{tot} = B''_{tot} = B'''_{tot}$ and recruitment at age one $R'_1 = R''_1 = R'''_1$ provided by the methods applied to the length composition of the catch for *Nephrops norvegicus* males during the period 1984-1994 (P>0.05).

Table 1
ANOVA table for mean fishing mortality per year, by each method

Source of variation Three Methods	α=0.05 Years	F_{2-6} year^{-1}	
		F_{obs}	P-level for $F_{2,12}$
	1984	0.906	0.429
	1985	0.469	0.636
	1986	0.589	0.570
	1987	2.961	0.090
	1988	1.188	0.338
	1989	0.087	0.916
	1990	0.309	0.739
	1991	0.763	0.487
	1992	0.800	0.471
	1993	3.616	0.058
	1994	0.675	0.527

Table 2
ANOVA table for mean stock biomass during 1984-1994, by each method

Source of variation	α=0.05	B_{tot}	
Three Methods		F_{obs}	P-level for $F_{2,30}$
		0.568	0.572

Table 3
ANOVA table for mean recruitment during 1984-1994, by each method

Source of variation	α=0.05	R_1	
Three Methods		F_{obs}	P-level for $F_{2,30}$
		0.658	0.525

DISCUSSION AND CONCLUSIONS

This study shows that the slicing or Kimura & Chikuni (1987) methods with t_o = 0 year (Anon,1995) or t_o = -0.6 year to convert length composition into age composition of the catch, of the *Nephrops* stocks from Alentejo and Algarve (ICES FU 28 and 29), present no main differences on the recruitment at age one R_1, total biomass B_{tot} and mean fishing mortality F_{2-6} estimates by VPA model.

The age composition obtained by slicing are generally quite biased, due to an ageing effect, and contamination by year class strengths of adjacent cohorts (Mesnil and Shepherd, 1990), but based on reliable data, the slicing technique can give acceptable results without requiring complex calculations.

The slicing and IALK methods are very important for the analysis of crustacean stocks, because they require only the length distributions of the catch and the knowledge of the growth parameters.

The Portuguese *Nephrops* fishery from ICES Division IXa, is a mixed fishery mainly with shrimps and prawns and it's difficult to split the fishing effort direct towards *Nephrops*. Also there are reasons to believe that the length distributions of the Portuguese landings do not represent the catches since some proportion of small and molting individuals are discarded, and large amounts of big individuals are landed at Spanish ports (Anon, 1995)

Since no differences occur in main estimates it will be wise to choose, for management purposes, the estimates that are more conservatives.

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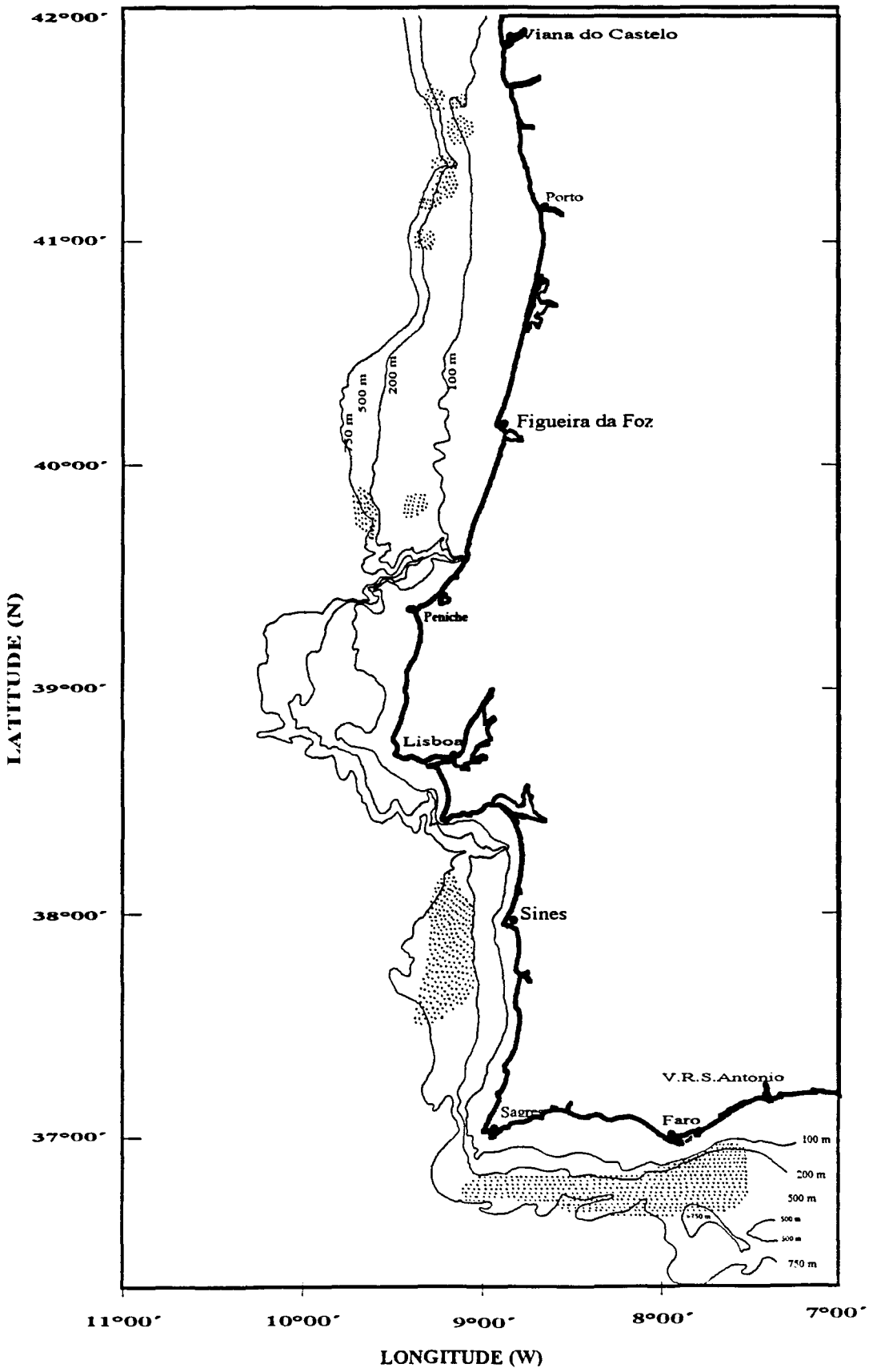

Fig 1. Main distribution of portuguese Norway lobster stocks

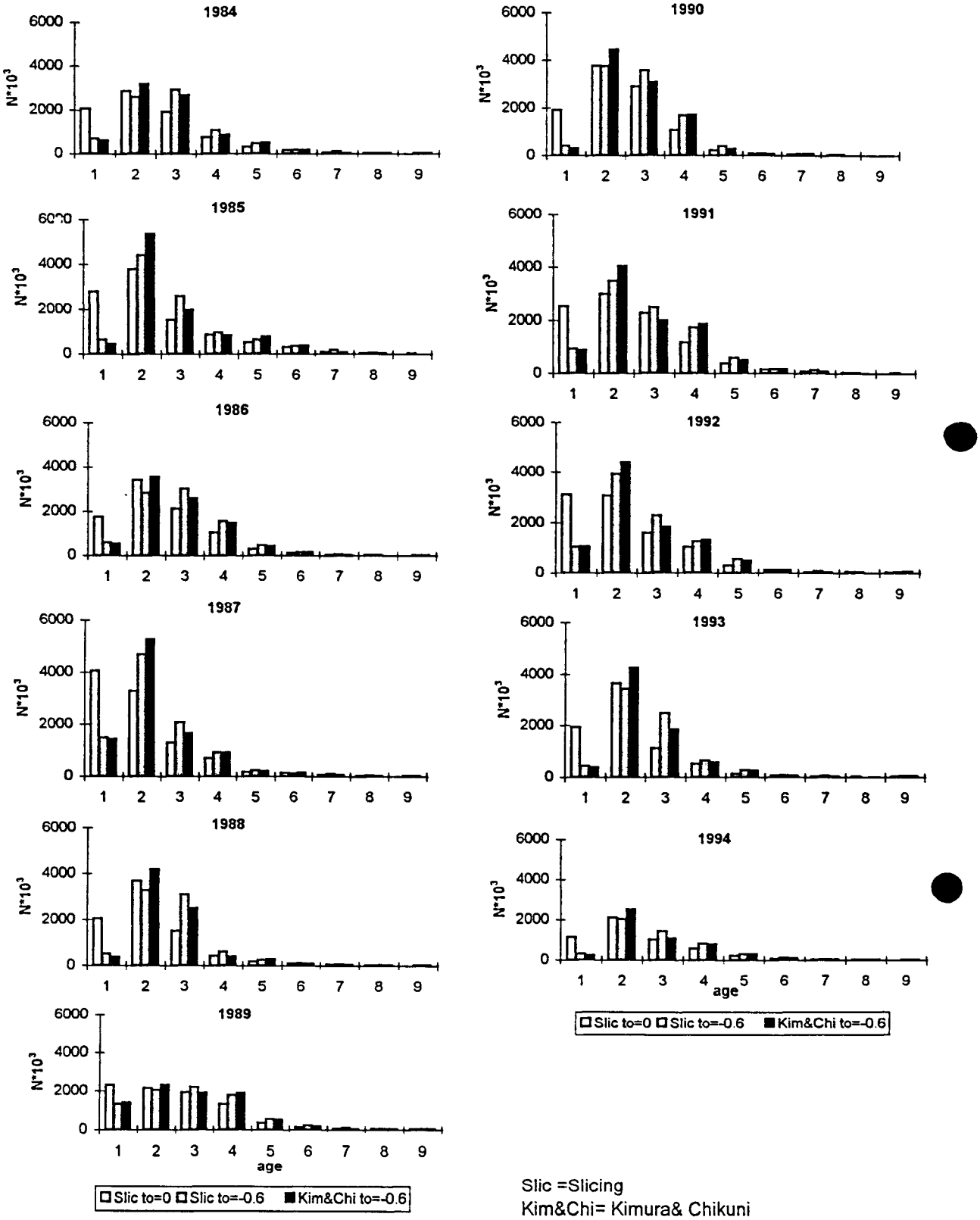

Fig.2. Age composition of the catch for Nephrops Males during 1984-1994

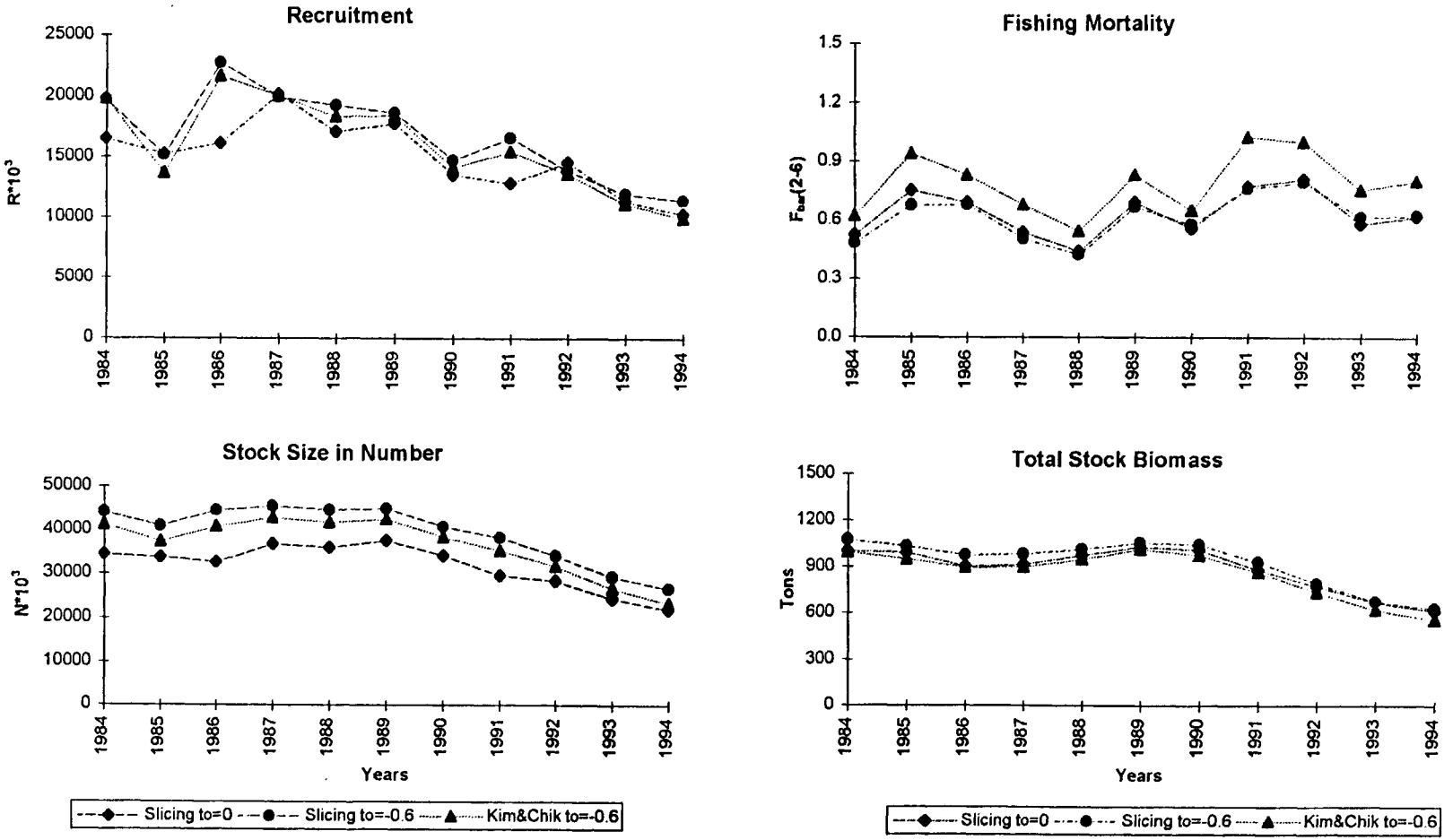

Fig 3. Comparison of the recruitment, total biomass, fishing mortality and numbers estimates using slicing with to=0, slicing with to=-0.6 and kimura&Chikuni with to=-0.6 methods