TRIALS OF A FOX MODEL-BASED MANAGEMENT PROCEDURE WITH TAC ADJUSTMENT BY RECRUITMENT INFORMATION

加入量情報による TAC 調整機能の付いた Fox モデルベース管理方式のテストトライアル

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Abstract We tested a Fox model-based management procedure with TAC adjustment by directly using recruitment information. CPUE of age 4 fish was used as an indicator of recruitment status. To examine effects of such adjustment on MP performances, results from testing the MP with TAC adjustment were compared with that from a MP without adjustment. Compared to the MP with no TAC adjustment, the MP with adjustment set TAC distinguishably corresponding to 3 cases of recruitment condition, reference , no autocorrelation, and reduced recruitment, i.e., catch more when recruitment is better or catch less when recruitment is lower. In all the cases, ranges between 10th and 90th quantiles of TAC were much wider for the MP with adjustment than for the MP with no adjustment . Our results indicate that adding a mechanism of TAC adjustment by discriminating between good and bad recruitments to the Fox model-based MP merits considering. It should be also noted that there is a trade-off between adding the adjustment mechanism and increase in TAC variance.

要旨 **加入量情報を直接使用することによる** TAC **調整機能のついた** Fox **モデルベース管理方式をテストした。**4 **歳魚の** CPUE **を加入状態の指標として使った。調整機能の管理方式のパフォーマンスへの効果を調べるために、調整機能がある場合とない場合とでの結果を比較した。加入量情報による** TAC **調整機能がない管理方式に比べて、機能がある管理方式は、**3 **つの加入量のケース(リファレンス、自己相関なし、加入量減少)に応じ区別して** TAC **を設定することができた。すなわち、加入が良い場合は漁獲を増やし、悪い場合は減らす。全てのケースで、**10th **と** 90th **分位点の幅は調整機能がついた管理方式の方が機能なしのものより広くなった。加入の良し悪しを見分けて** TAC **を調整する機能の** Fox **モデルベース管理方式への追加は考慮する価値がある。調整機能を追加することと** TAC **のばらつきが増大することの間にはトレードオフ関係があることは留意すべきである。**

INTRODUCTION

A Fox model-based management procedure (MP) is one of candidate MP's for southern bluefin tuna, and its performances of this type of MP has been examined since the MPWS2 (e.g., Butterworth and Mori 2003, Polacheck et al. 2003). Although detailed TAC specifications are different among Fox model-based MP's tested in past, all the MP's specify TAC using MSY and B_{MSY} estimated from the Fox model, and never directly utilize recruitment information (e.g., CPUE for age 4 fish). It is possible to develop a MP in which TAC specified by information from the Fox model is further adjusted corresponding to recruitment condition. There was a concern noted in the last meeting that several indicators (2000 acoustic survey, 2002 Australian surface fishery CPUE, Japanese longline CPUE of age 4 fish in 2003) were consistent with a marked decline in recruitment in 1999 and 2000 (Anonymous 2003, p. 4). In contrast with this, there might be also a situation in which actual recruitment is better than being assumed in MP evaluations. It is, therefore, worthwhile to explore a possibility of developing a Fox model-based MP with TAC adjustment by recruitment information. In this short paper, we report results from such exploration.

STRUCTURE AND TAC SPECIFICATION OF TESTED MP

Fox Model

The structure of Fox model is exactly same as that used by Butterworth and Mori (2004). Descriptions of the model and data used are summarized in their paper.

TAC Specification

First the TAC is calculated from the following equation using results from the Fox model:

$$TAC_{tmp} = wTAC_y + \alpha(1-w)\cdot MSYR_y \cdot \hat{B}_{MSY} \cdot \left(\frac{\hat{B}}{\hat{B}_{MSY}} \right)^{\gamma} \cdot g(\hat{r}_y) \qquad (1)$$

where $\hat{B}_{MSY}$ is the estimated maximum sustainable yield level (*MSYL*),

γ is a control parameter (here fixed to be 0.6),

w, α are control parameters,

$M\hat{S}YR_y$ is the estimated maximum sustainable yield rate, calculated as $M\hat{S}Y_y / MSYL$ ($\hat{r}_y / \ln \hat{K}_y$ for the Fox model – note that these estimated values change with year *y* as more data become available),

$\hat{B}_y$ is the estimated biomass for year *y*, which (together with $\hat{r}_y$ and $\hat{K}_y$) is re-estimated for each projection year, and

$g(\hat{r}_y)$ is a function which reduces the TAC further if $\hat{r}_y$ is low,

The TAC reduction factor $g(\hat{r}_y)$ is set to:

$$g(\hat{r}_y) = \begin{cases} 0 & \text{for } 0 \le \hat{r}_y \le r_1 \\ \dfrac{1}{r_2 - r_1}(\hat{r}_y - r_1) & \text{for } r_1 < \hat{r}_y < r_2 \\ 1 & \text{for } r_2 \le \hat{r}_y \end{cases} . \qquad (2)$$

We set r_1=1.0, r_2=1.5 as is in Butterworth and Mori (2003, 2004).

Then the TAC calculated as above is further adjusted by the following equation directly using recruitment information to specify TAC for each future year (here utilized CPUE of age 4 fish as an indicator of recruitment status):

$$TAC_{y+1} = TAC_{tmp} \times (1 + \Delta) \qquad (3)$$

where *Δ* is the rate of TAC adjustment determined from the relationship between the average of age 4 CPUE over the past 3 years and the adjustment rate. The function form of this relationship is illustrated in Fig. 1.

Nominal CPUE of age 4 fish of Japanese longline fleet was used as past recruitment information (Fig. 2). Future CPUE of age 4 fish was calculated from CPUE of age 4+ and age composition of LL1 provided in the file “sbtOMdata” of the projection program by the equation below:

$$CPUE_{age4} = \frac{Catch_{age4}}{Catch_{age4+}} \cdot CPUE_{age4+} \qquad (4)$$

To examine effects of TAC adjustment by recruitment information, results from testing the MP with TAC adjustment were compared with that from a MP without adjustment. Due to time constraint, only the case in which the stability option is b (every 3 years) and the tuning level is 1.1 was examined. In tuning processes, the control parameters, *w* and α were varied, and were respectively set to 0.7 and 0.58 (for the MP with no TAC adjustment), and to 0.557 and 0.3 (for the MP with TAC adjustment) as final values.

RESULTS AND DISCUSSION

Compared to the MP with no TAC adjustment (appeared as “no adjust” in figures), the MP with adjustment (named DMN_25_2b but appeared as “adjust” in figures) sets TAC distinguishably corresponding to 3 cases of recruitment condition, reference (“Ref”), no autocorrelation (“No_AC”), and reduced recruitment (“Red_rec”), i.e., catch more when recruitment is better or catch less when recruitment is lower (Fig. 3). Trends in median TAC trajectory for the MP with no adjustment show continuous reduction of TAC over 30 years whereas trends for the MP with adjustment stop declining and somewhat keep constant. Timing and amount of changes in TAC vary depending upon recruitment condition.

In the reference case, TAC reduction of the MP with adjustment in the first few years was greater than that of the MP with no adjustment (Fig. 3a). This may be because recruitment in the reference case is still so low as to allow the MP with adjustment to discriminate the situation as low recruitment. Thus, this is a correct response of the MP with adjustment to the reference case.

In all the cases, ranges between 10^{th} and 90^{th} quantiles of TAC are much wider for the MP with adjustment than for the MP with no adjustment (Fig. 3). These results were expected because the MP further adjusts TAC calculated from the Fox model corresponding to recruitment status. In contrast, ranges between 10^{th} and 90^{th} quantiles of spawning biomass are narrower for the MP with adjustment than for that with no adjustment. This suggests that sacrificing TAC stability favors decreases in variance of spawning biomass.

Trends in median, 10^{th} and 90^{th} quantiles of TAC and spawning biomass, and all performance statistics for the MP with adjustment for reference and all robustness tests are summarized in Fig.4 for readers’ reference.

Our results indicate that adding a mechanism of TAC adjustment by discriminating between good and bad recruitments to the Fox model-based MP merits considering. One of advantages in using the Fox model-based MP (with no TAC adjustment) may be that variance in TAC dynamics is not large, especially in the first few years (Fig. 3). This is preferable from the manager and industry points of view. However, the MP with no adjustment cannot respond promptly to recruitment condition and as a results it is possible that the average catch over years becomes lower than actually expected when recruitment is better, or stock is depleted by delayed TAC reduction when fairly low recruitment continues for several years. The MP with TAC adjustment by directly using recruitment information can promptly respond to such situations. So there is a trade-off between adding the adjustment mechanism and increase in TAC variance.

We somewhat struggled to determine the function form of the relationship between the average CPUE(age4) over 3 years and the TAC adjustment rate to discriminate between good and bad recruitments (Fig. 2). One reason for this is that differences in recruitment condition with respect to CPUE(age 4) are not so large as to clearly discriminate between good and bad recruitments for reference, no autocorrelation, and reduced recruitment cases (frequency distributions in Fig. 5 do not differ greatly). If the differences are much greater, then defining a function form of CPUE(age 4) – TAC adjustment relationship will be easier. However, the MP with adjustment discussed here can accordingly respond to uncertainties of recruitment status assumed in the current MP evaluation, and thus this is not really a problem here.

LITERATURE CITED

Anonymous. 2003. Report of the Eighth Meeting of the Scientific Committee. 1-4 September 2003, Christchurch, New Zealand. Commission for the Conservation of Southern Bluefin Tuna (CCSBT).

Butterworth, D. S. and M. Mori. 2003. Further investigations of a Fox model based management procedure for southern bluefin tuna. CCSBT-ESC/0309/37.

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Polacheck, T., D. Ricard, P. Eveson, M. Basson, D. Kolody, and J. Hartog. 2003. Results from further testing of candidate management procedures for southern bluefin tuna. CCSBT-ESC/0309/29.

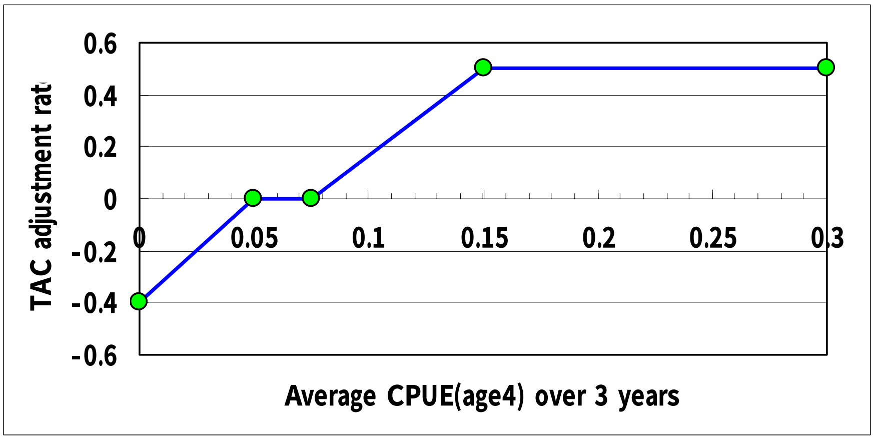


Fig. 1. The function form of the relationship between the average of CPUE(age4) over 3 years and the TAC adjustment rate.

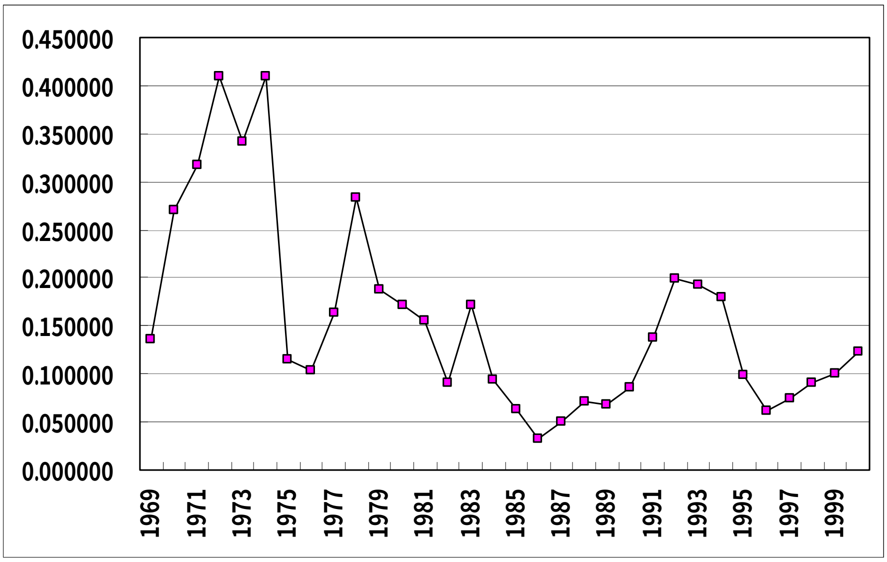
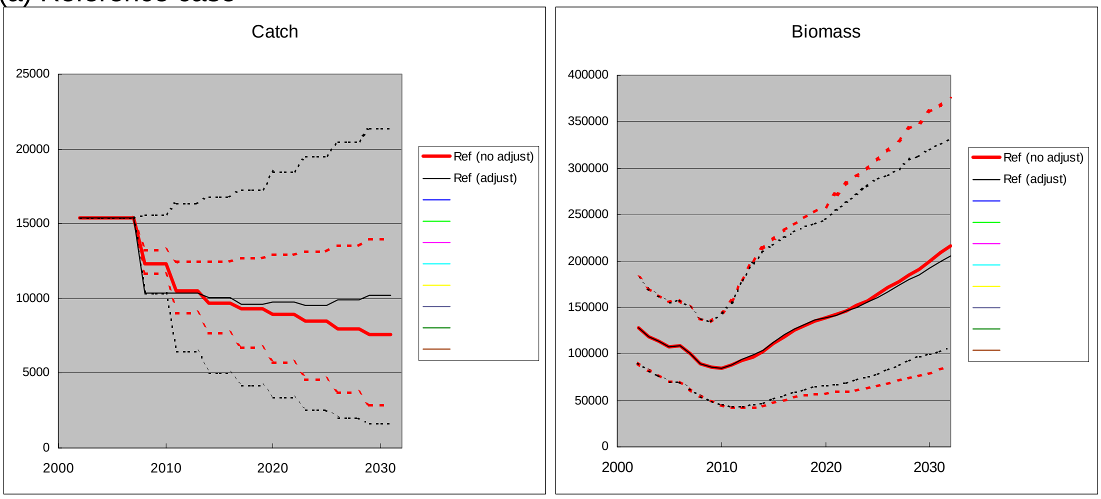
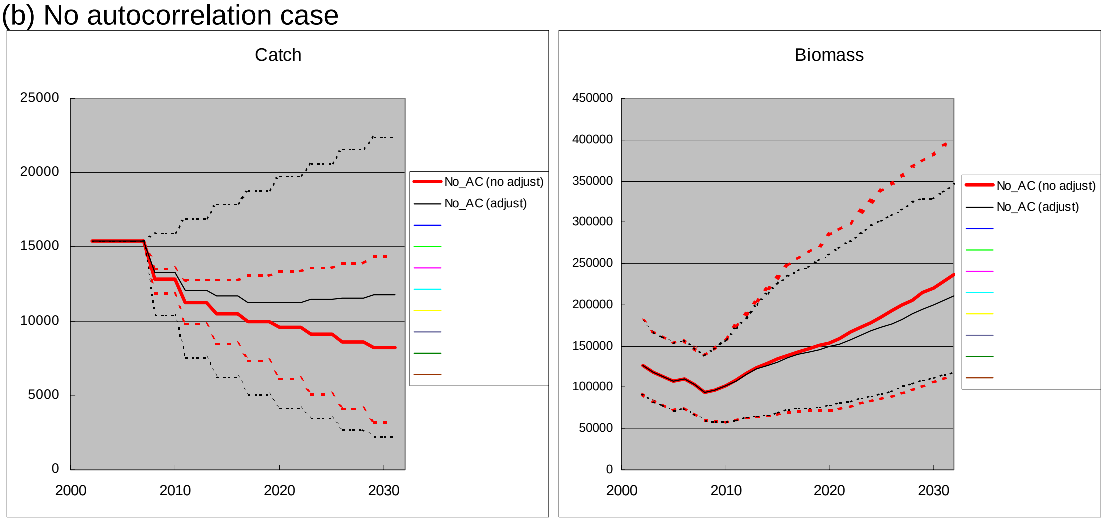


Fig. 2. Normalized nominal CPUE of age 4 fish of Japanese longline fleet used as past recruitment indicators.

(a) Reference case



(b) No autocorrelation case



(c) Reduced recruitment case

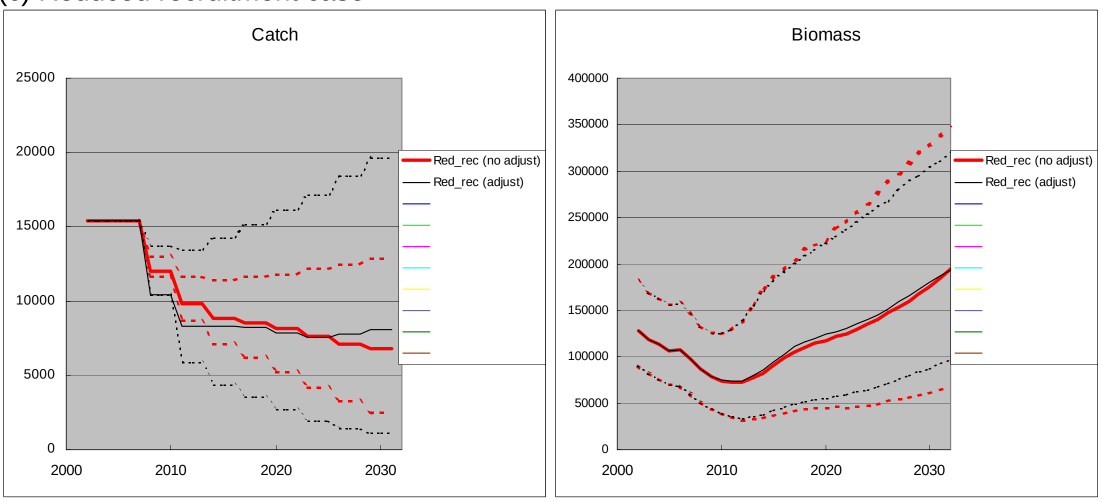


Fig. 3. Comparisons of results between Fox model-based MP's with and without TAC adjustment by recruitment information for 3 cases of reference, no autocorrelation, and reduced recruitment. The tuning level is 1.1, the TAC stability option is b, and trials are 2,000 times.

(a)

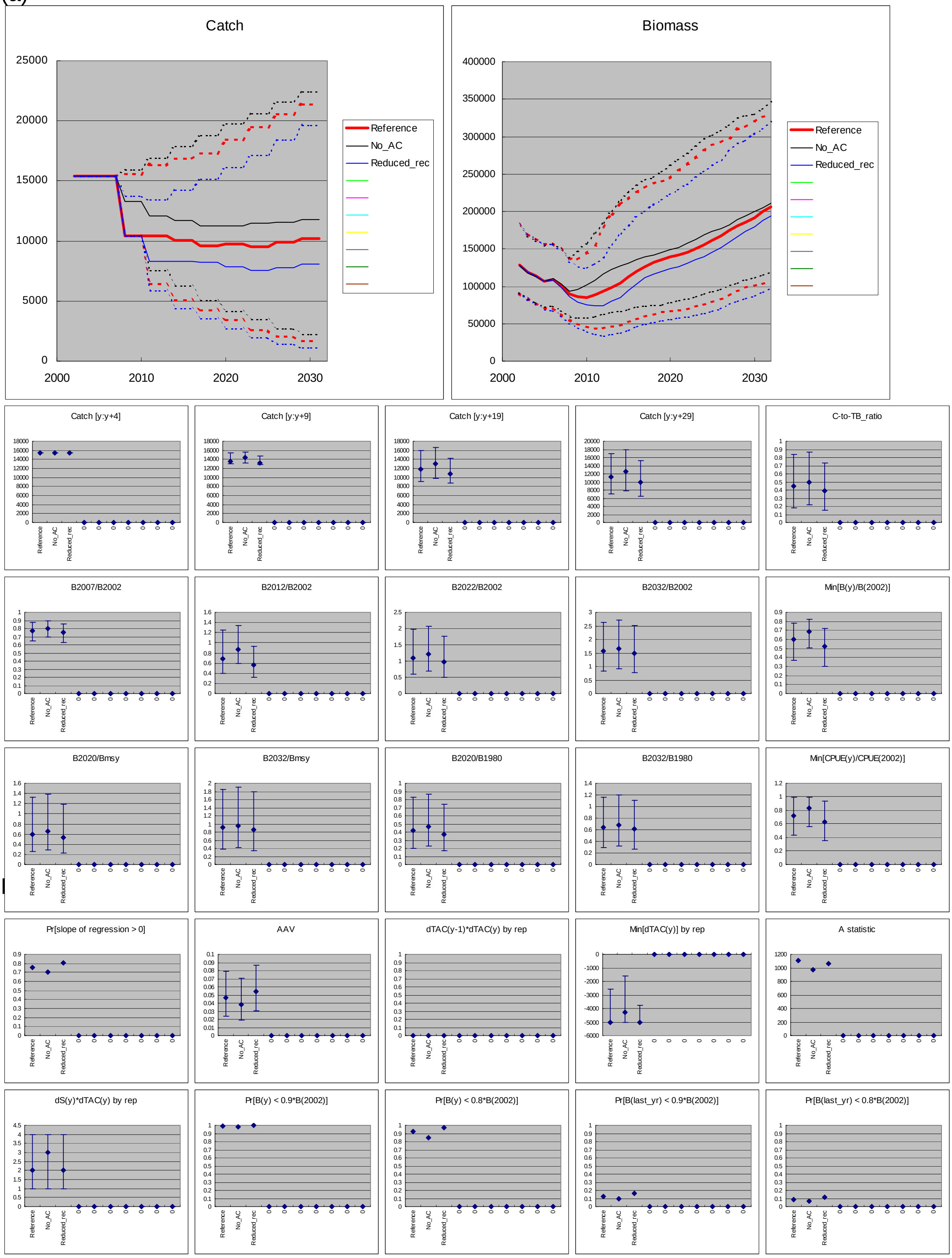


Fig. 4. Results from testing a Fox model-based MP with TAC adjustment by recruitment information (named DMN_25_2b). The tuning level is 1.1, the TAC stability option is b, and trials are 2,000 times for reference, no autocorrelation and reduced recruitment cases, and 200 times for other robustness tests.

(b)

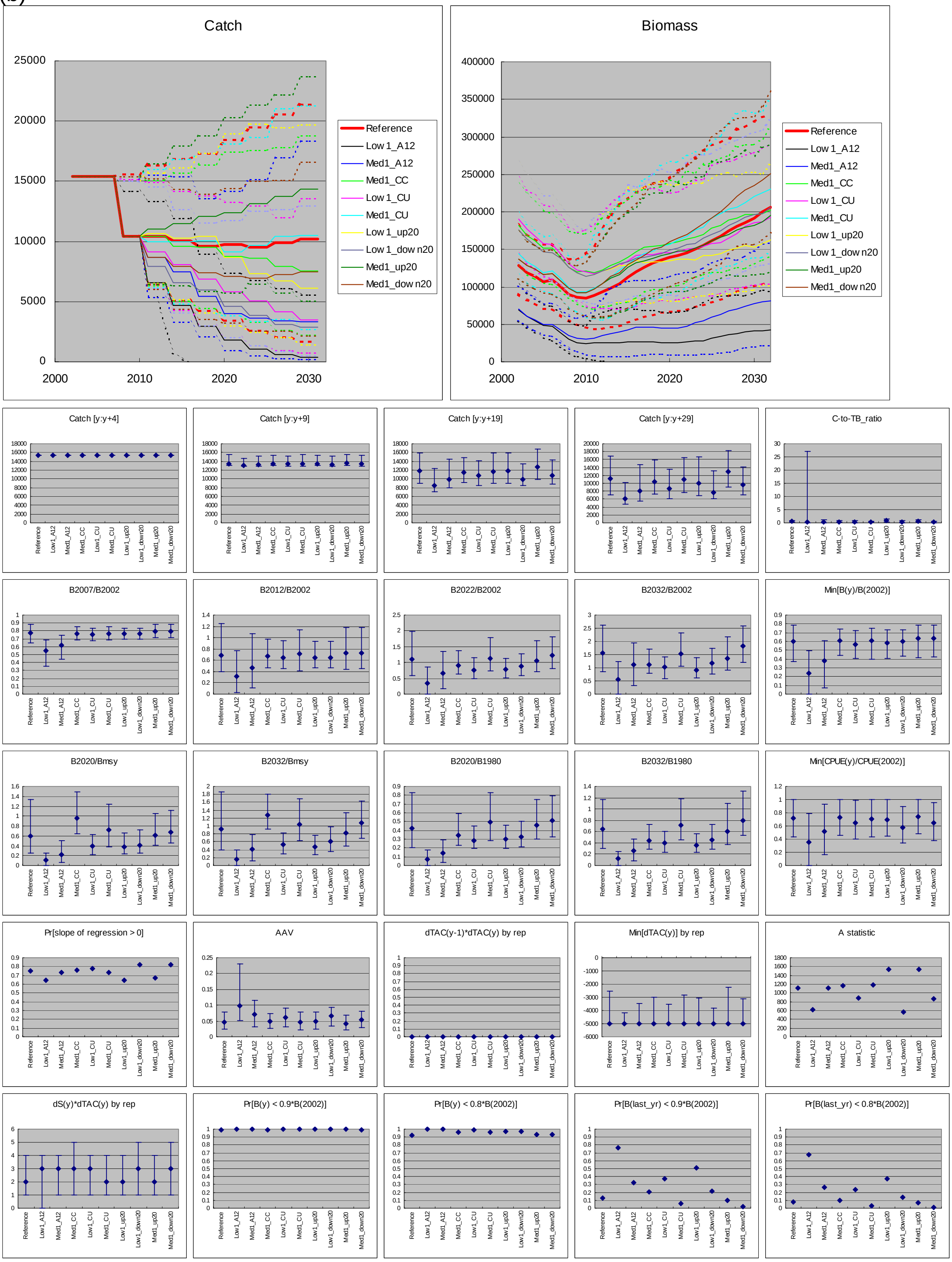

Catch
Biomass
Reference
Low 1_A12
Med1_A12
Med1_CC
Low 1_CU
Med1_CU
Low 1_up20
Low 1_dow n20
Med1_up20
Med1_dow n20
2000
2010
2020
2030
Catch [y:y+4]
Catch [y:y+9]
Catch [y:y+19]
Catch [y:y+29]
C-to-TB_ratio
B2007/B2002
B2012/B2002
B2022/B2002
B2032/B2002
Min[B(y)/B(2002)]
B2020/Bmsy
B2032/Bmsy
B2020/B1980
B2032/B1980
Min[CPUE(y)/CPUE(2002)]
Pr[slope of regression > 0]
AAV
dTAC(y-1)*dTAC(y) by rep
Min[dTAC(y)] by rep
A statistic
dS(y)*dTAC(y) by rep
Pr[B(y) < 0.9*B(2002)]
Pr[B(y) < 0.8*B(2002)]
Pr[B(last_yr) < 0.9*B(2002)]
Pr[B(last_yr) < 0.8*B(2002)]

Fig. 4. (cont'd)

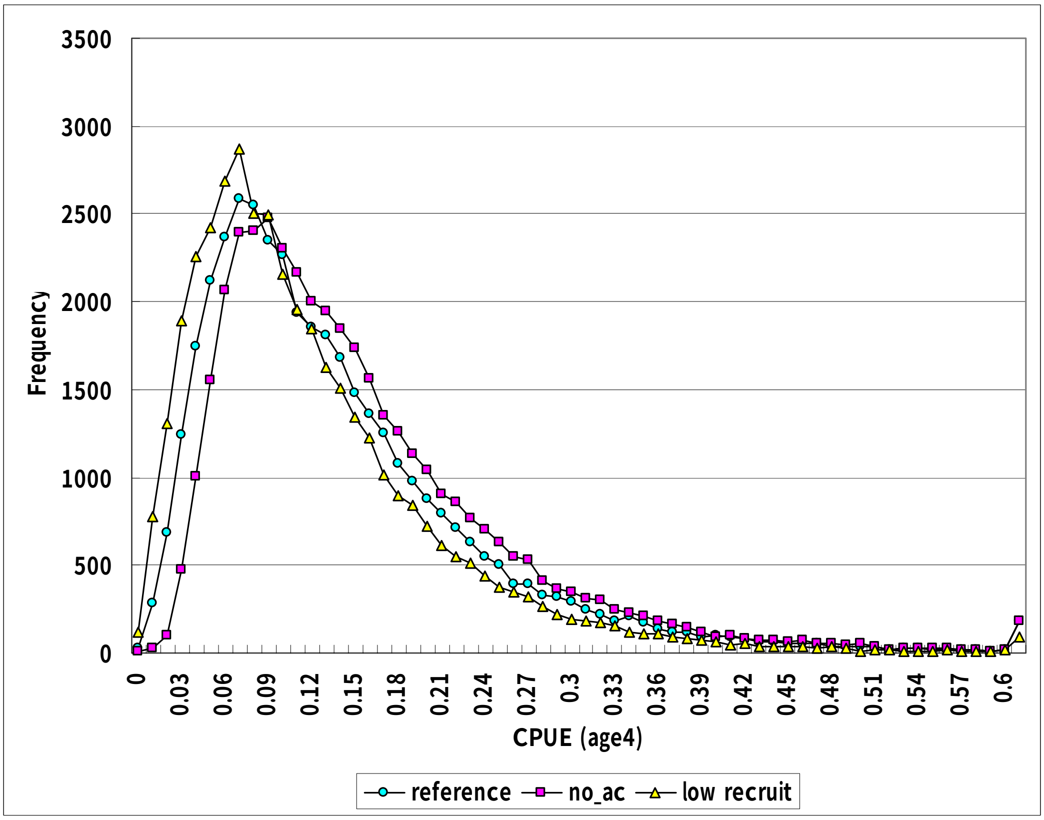


FIg. 5. Frequencies of different values of age 4 CPUE for reference, no autocorrelation, and reduced recruitment cases under constant 10,000 catch. The TAC stability option is b, the simulation period is 30 years, trials are 2,000 times.