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An Assessment of the *D. gigas* fishery in South-east Pacific Ocean using a State-space Surplus Production model

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An Assessment of Jumbo Squid (*Dosidicus gigas*) in Southeast Pacific Using a State-space Surplus Production Model

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Introduction:

Dosidicus gigas is widely distributed in the eastern Pacific Ocean. It supports two major fisheries in Peru and central Chile in the South-East Pacific Ocean (Nevárez-Martínez *et al*., 2000; Morales-Bojórquez *et al*., 2001; Taipe *et al*., 2001; Rocha and Vega, 2003). Chinese squid jigging fleet began to explore this squid in 2001. There are 6 fishing entities targeting *Dosidicus gigas* in South-east Pacific Ocean (Fig.1). The whole fishing ground of the 6 fishing entities was approximately located in the area of 0°~30°S, 70°~90°W (In central Chile southern than 30°S , Jumbo squid is prat of the bycatch of commercial bottom trawl fleet. i.e., Alarcón *et al*., 2008). Chinese fishing vessels were operating in high seas and boats and vessels of Peru and Chile were fishing in Economic Exclusive Zone (EEZ; Fig.2). The stock of the squid both in and out of EEZ was considered to be a unit stock. There has been limited effort for a formal assessment of this stock so far. In this study, we used standardized CPUE data of Chinese vessels as biomass abundance index in a state-space surplus production model developed to describe the dynamics of this stock.

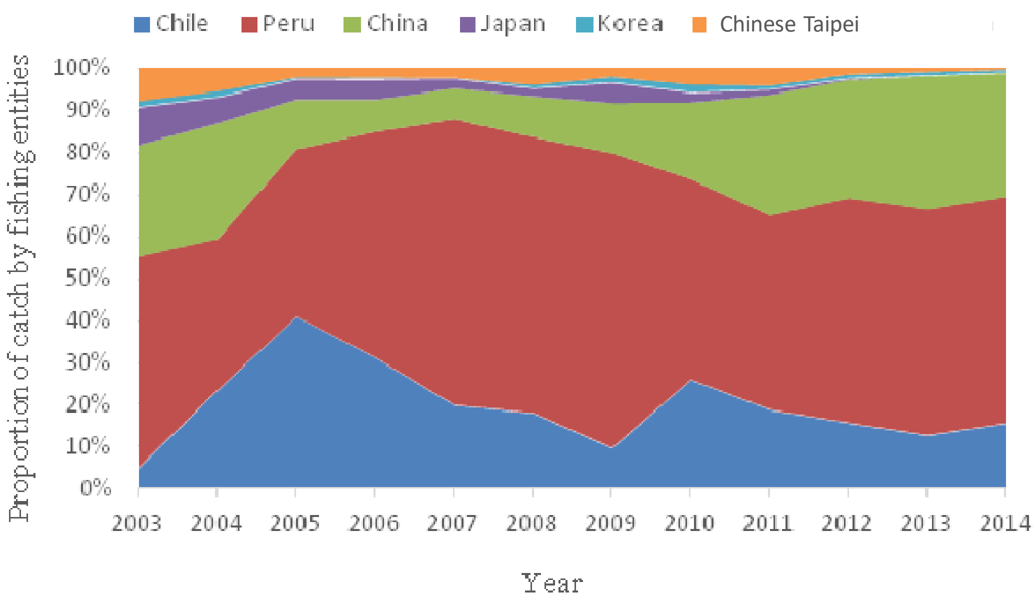

Fig.1 Proportion of catch of *D. gigas* in South-east Pacific by fishing entities

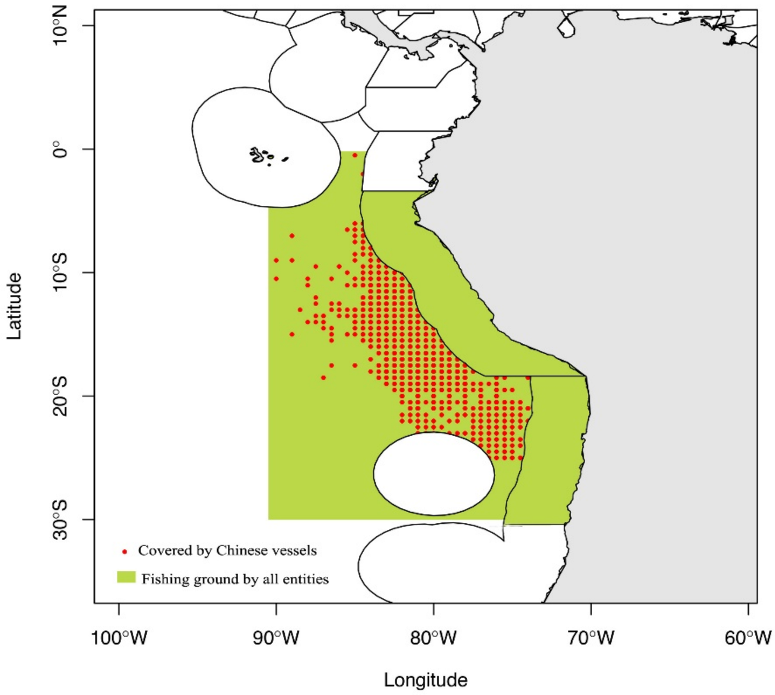

Fig.2 Chinese vessels' coverage and global fishing ground in South-east Pacific

Data Source:

Catch data are derived from FAO website www.fao.org/fishery/statistics/global-capture-production/query/en. The data are the total catch yielded in South-east Pacific. CPUE data are from China Overseas Fisheries Association. The time duration of data is from 2003-2014.

Methods:

A Bayesian state-space surplus production model was used to assess the stock. The dynamic model was re-parameterized using the proportion of capacity (*P=B/K*) in order to improve the efficiency of Markov Chain Monte Carlo (MCMC) algorithm used in estimating parameters (Meyer and Millar, 1999). Both the process and observation errors were assumed to follow lognormal distributions. The state-space model are described as follows:

$$P_T = e^{U_t} \quad ; \quad T = 1 \qquad (1)$$

$$P_T = (P_{T-1} + r \cdot P_{T-1}(1 - P_{T-1}^{s}) - \frac{C_{T-1}}{K}) \cdot e^{U_t} \quad ; \quad T > 1 \qquad (2)$$

$$I_T = KP_T Q e^{V_t} \qquad (3)$$

where K is the capacity, P_T is the ratio of biomass and capacity in year T, Q is catchability coefficient, r is intrinsic growth rate, C_T is the catch in year T. U_t are normal distributed variables with mean 0 and variance ε^2 and V_t are normal distributed variables with mean 0 and variance δ^2.

We used MCMC to estimate the parameters. Three Markov Chains were created and 100,000 replications were run in each chain with the first 50,000 times results being eliminated and results being saved for every 4 runs in the last 50,000 runs, resulting in 12,500 sets of estimates.

The prior distributions of parameters were assumed to follow uniform distributions since we did not have strong evidence supporting any specific informative distributions.

Results:

We tried different scales of prior distributions and found that the posterior distributions of parameters tended to be sensitive to the upper boundary of prior distribution of *K*. So we tried several upper limit values of prior distribution for *K* (scenarios 1~6) and compared the results. In each scenario, the posterior distribution of *K* was rightly skewed. The values of F/F_{MSY} and B/B_{MSY} were relatively robust and there was no evidence showing the fishery was subject to overfishing or stock was overfished. We did the retrospective analysis and did not find obvious retrospective patterns.

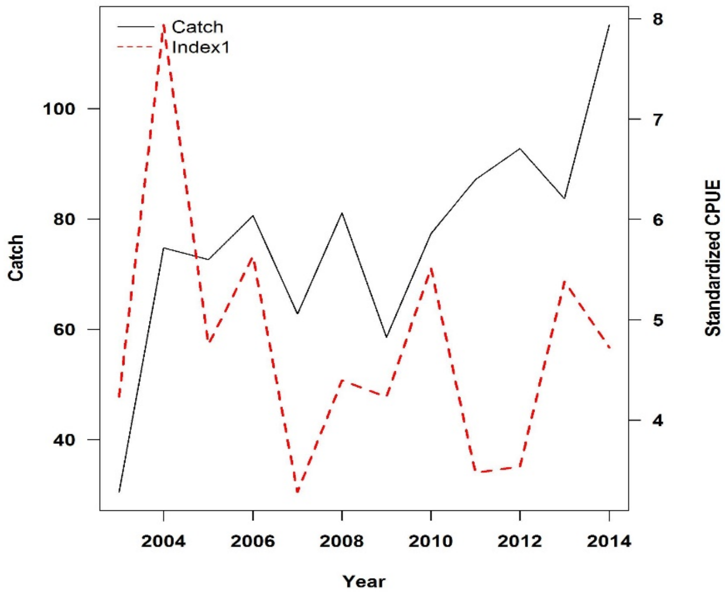

Fig.3 Catch and index

Tab1 Prior distribution of parameters

Parameter	Prior Distribution	Lowest Value	Highest Value
R	Normal	0.01	1.5
K(ten thousand ton)	Normal	120	Scenario1~6
pq1(1/*Q*)	Normal	1	10000
Sigma(ε^2)	Normal	0.01	20
tau1(δ^2)	Normal	0.01	20

S	Normal	0.01	2
Pm($P_{T=1}$)	Normal	0.01	1

*Scenario1-200; Scenario2-500; Scenario3-1000; Scenario4-1500; Scenario5-5000; Scenario6-10000;

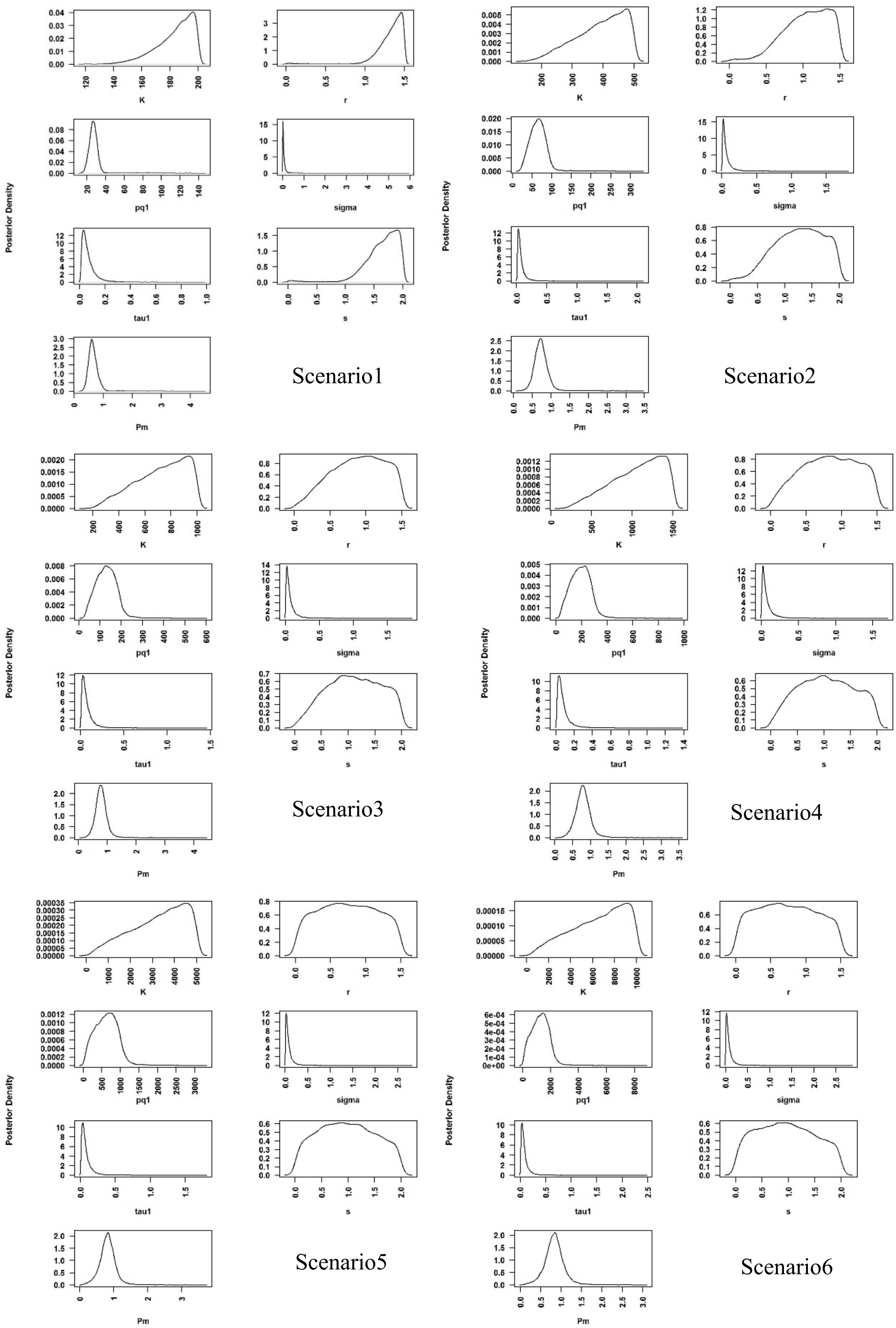

Fig.4 Posterior distribution of the parameters

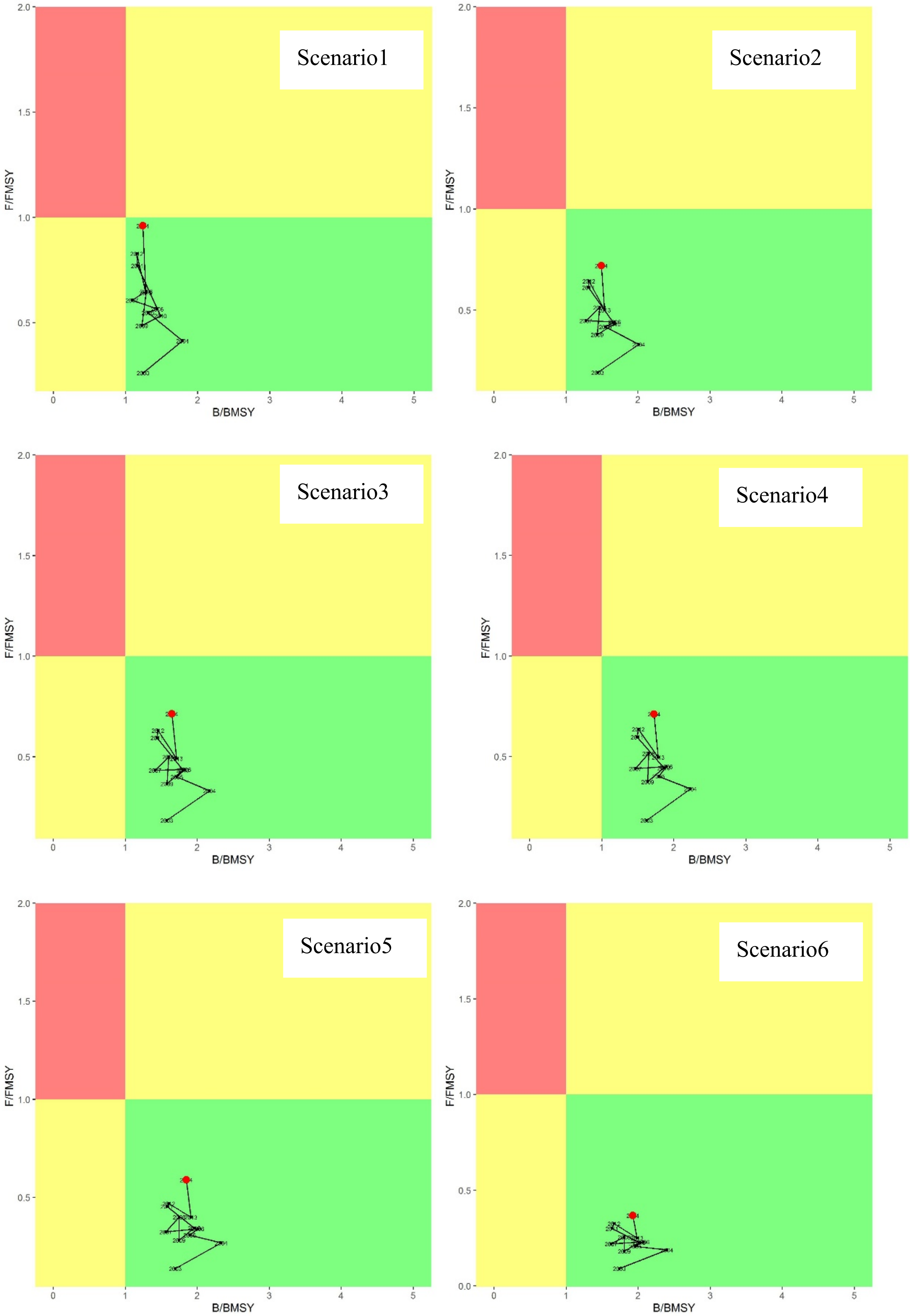

Fig.5 Kobe plot

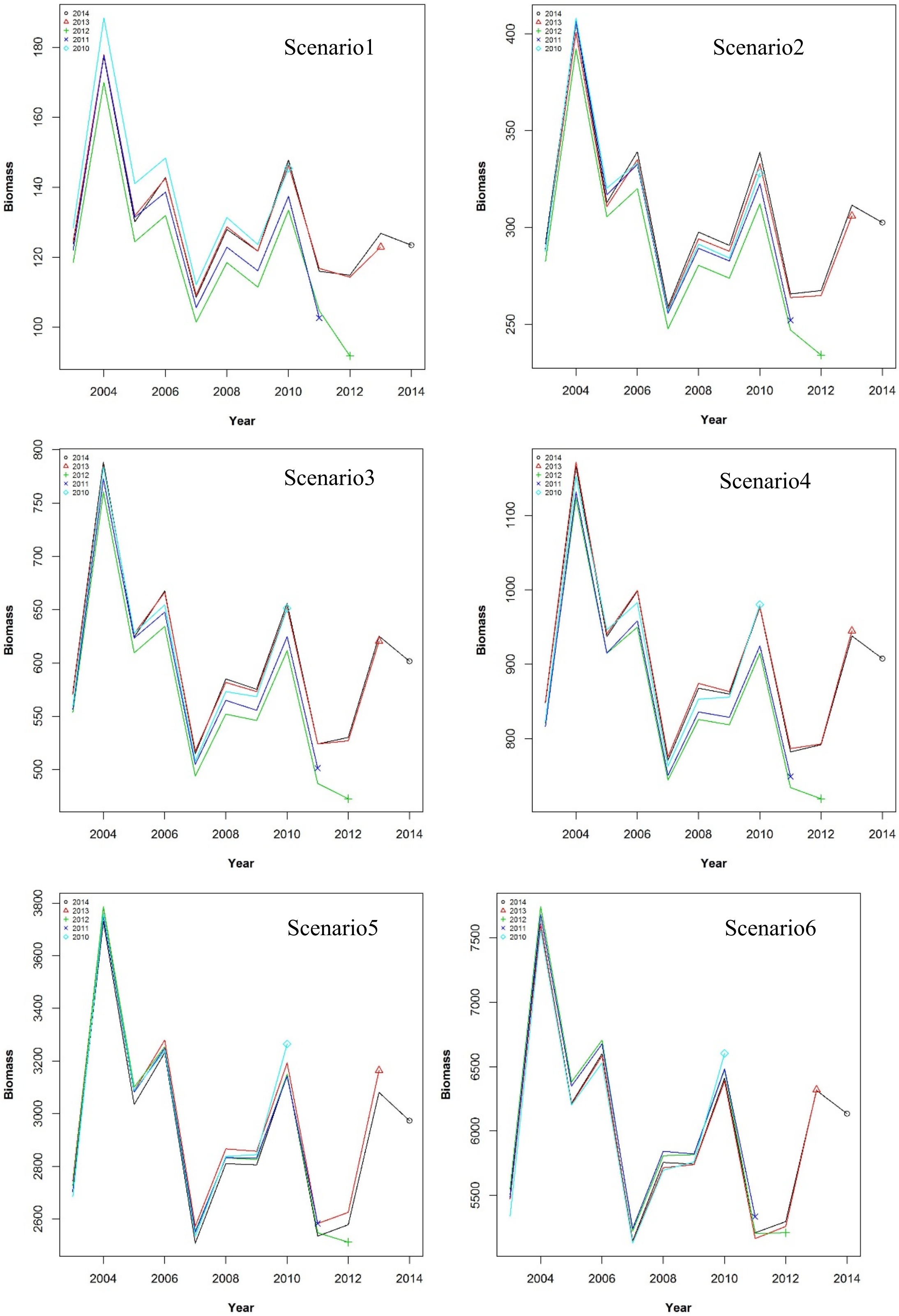

Fig.6 Retrospective analysis for biomass

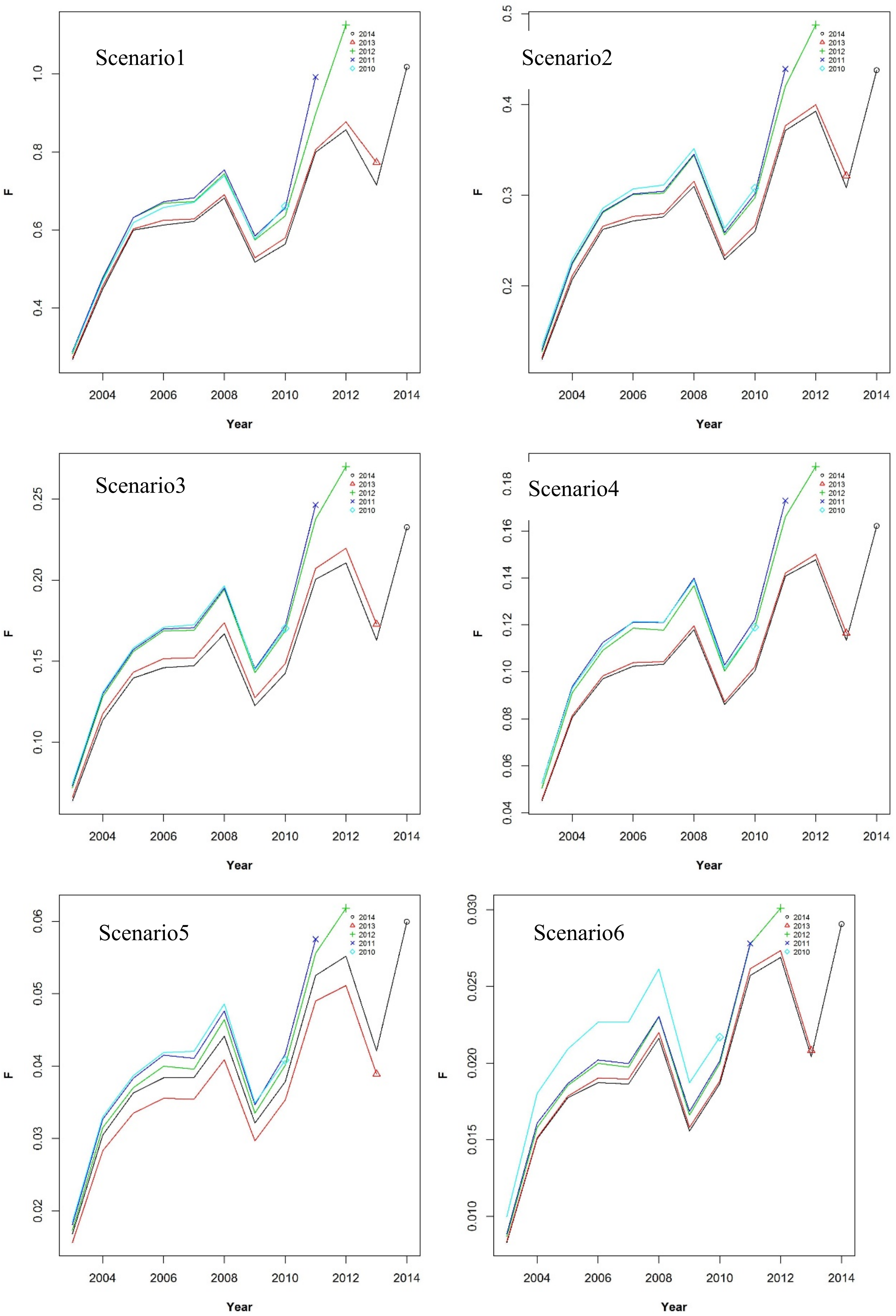

Fig.7 Retrospective analysis for fishing mortality

Reference:

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