Standardized Taiwanese CPUE for bigeye tuna in the Indian Ocean

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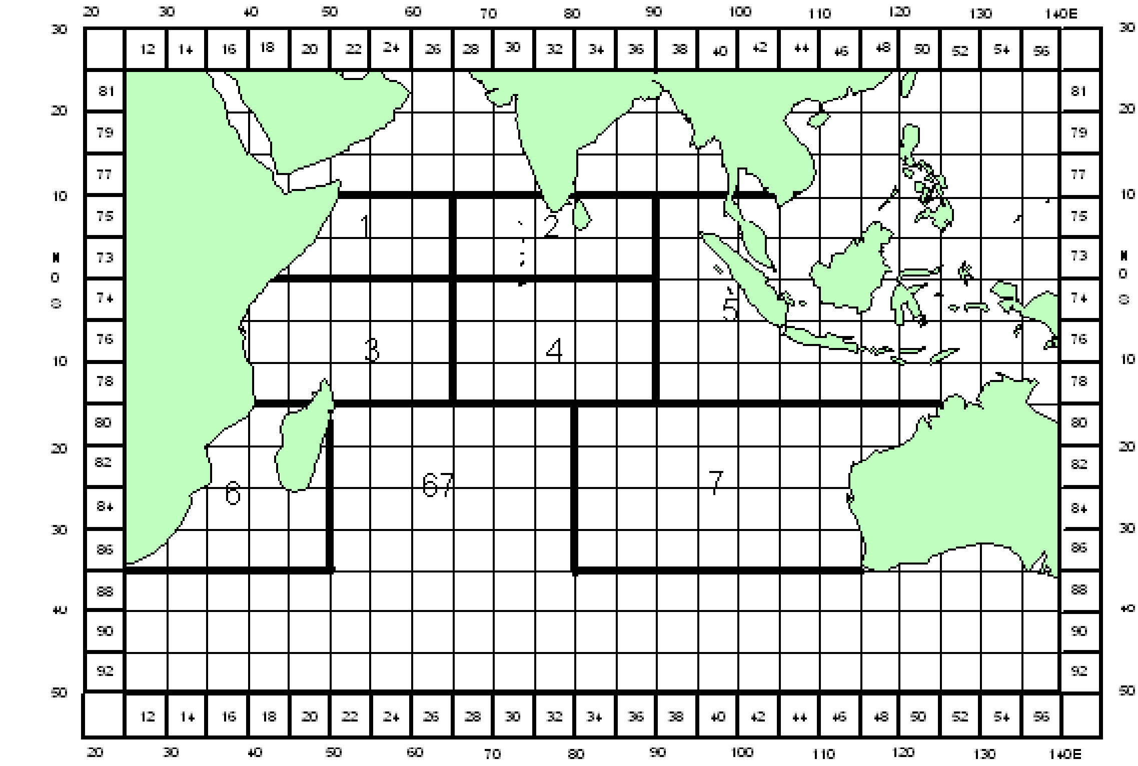
All Indian region



Base case:

the logbook data from 1979-2008 was used to standardize Taiwanese CPUE for bigeye tuna in all Indian Ocean by GLM method, and the catch ratios of ALB and YFT were used as targeting factor, due to the absent NHBF from 1995 onwards in the logbooks of Taiwanese longline fishery. The main effects considered in this analysis are year, quarter, region, targeting. The selected model was

$$\log(CPUE + c) = \mu + Y + Q + R + G + T205 + IOI + TD + \varepsilon$$

where *CPUE* is the nominal CPUE of bigeye tune (catch in number/1000 hooks),

c is the constant value (i.e. 10% of the average nominal CPUE),

μ is the intercept,

Y is the effect of year,

Q is the effect of quarter,

R is the effect of fishing area,

ALB is the effect of targeting as the catch ratios of ALB,

YFT is the effect of targeting as the catch ratios of YFT, The results of standardized CPUE for bigeye tuna were shown in the diagram below Table1, **Figure 1** and **Figure 2** is trend of relative CPUE:

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Table1. ANOVA Tables resulted for Base Case.

Base Case

Source	DF	Sum of Squares	Mean Square	F-value	P-value
Model	353	152396.2408	431.7174	866.43	<.0001
Error	482113	240223.3698	0.4983		
Corrected Total	482466	392619.6106			

	R-Square	Coeff Var	Root MSE	lnbetcpue Mean
	0.388152	50.50767	0.705884	1.397577

Source	DF	Type III SS	Mean Square	F-value	P-value
Y	29	3486.82888	120.23548	241.3	<.0001
Q	3	422.25786	140.75262	282.48	<.0001
R	7	14440.00932	2062.85847	4140.03	<.0001
ALB	1	3643.71802	3643.71802	7312.71	<.0001
YFT	3	31330.27306	10443.42435	20959.3	<.0001
Y*R	202	7075.12444	35.02537	70.29	<.0001
Y*YFT	87	1629.58681	18.73088	37.59	<.0001
Q*R	21	2088.6876	99.46131	199.61	<.0001

Base Case from 1979-2008 | Base Case from 1979-2008

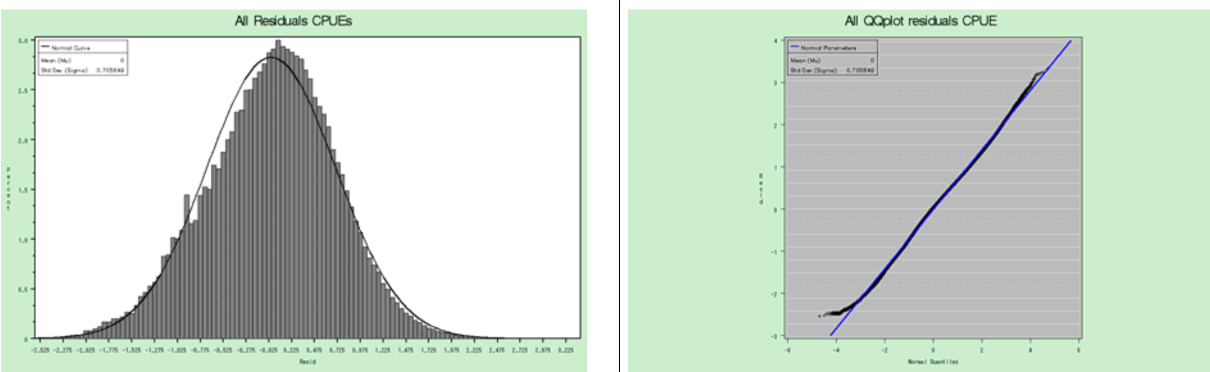

Fig. 1. Distributions of the standardized residuals for the standardization models(left) and the normal probability plots for the standardization models(right) fitted to the catch and effort data.

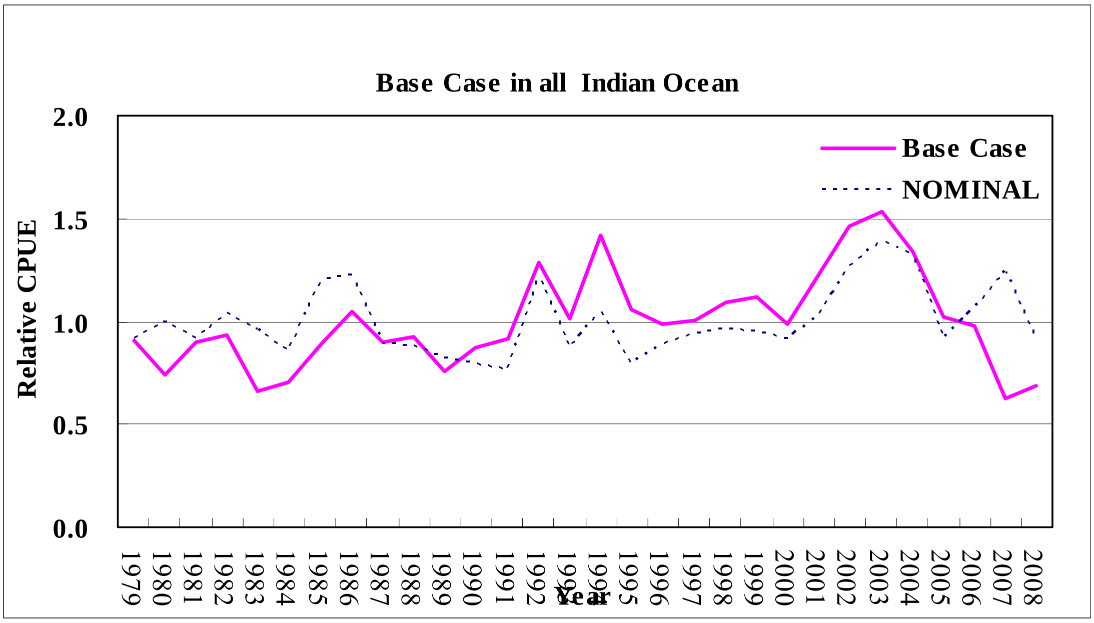

Figure 2.

Case1:

the logbook data from 1995-2008 was used to standardize Taiwanese CPUE for bigeye tuna in all Indian Ocean by GLM method, due to available NHBF. The main effects considered in this analysis are year, quarter, region, targeting, temperature at 205m depth, and IOI. Especially, NHBF was used as target effect and according Nishida and Wang (2006) to have four categories of NHBF (1: <=9; 2: 10-12; 3: 13-14; 4: >14). The interactions for the main effects are also included into the model, except the interaction TD*IOI which were not statistically significant.

$$\log(CPUE+c) = \mu + Y + Q + R + G + T205 + IOI + TD + Y*A + Q*A + Q*G + T205*Q + TD*Q + IOI*Q + A*G + T205*A + TD*A + IOI*A + T205*G + TD*G + IOI*G + T205*TD + T205*IOI + \varepsilon$$

where *CPUE* is the nominal CPUE of bigeye tune(catch in number/1000 hooks),

c is the constant value (i.e. 10% of the average nominal CPUE),

μ is the intercept,

Y is the effect of year,

Q is the effect of quarter,

R is the effect of fishing area,

G is the effect of targeting,

T205 is the effect of temperature at 205m depth,

IOI is the effect of Indian Oscillation Index,
TD is hermocline depth

The results of standardized CPUE for bigeye tuna were shown in the diagram below Table2, **Figure 3** and **Figure 4** is trend of relative CPUE: Case1

Table2. ANOVA Tables resulted for Case1.

Source	DF	Sum of Squares	Mean Square	F-value	P-value
Model	212	35628.6432	168.0596	281.77	<.0001
Error	266873	159173.7502	0.5964		
Corrected Total	267085	194802.3935			

R-Square	Coeff Var	Root MSE	lnbetcpue Mean
0.182896	52.18791	0.772295	1.479836

Source	DF	Type III SS	Mean Square	F-value	P-value
Y	13	1956.162888	150.474068	252.29	<.0001
Q	3	12.008545	4.002848	6.71	0.0002
R	7	375.325467	53.617924	89.90	<.0001
G	3	244.725575	81.575192	136.77	<.0001
T205	1	62.125495	62.125495	104.16	<.0001
IOI	1	10.341568	10.341568	17.34	<.0001
TD	1	21.751745	21.751745	36.47	<.0001
Y*R	91	2130.392975	23.410912	39.25	<.0001
Q*R	21	523.003018	24.904906	41.76	<.0001
Q*G	9	76.409157	8.489906	14.23	<.0001
T205*Q	3	7.273809	2.424603	4.07	0.0067
TD*Q	3	113.494140	37.831380	63.43	<.0001
IOI*Q	3	33.351100	11.117033	18.64	<.0001
R*G	21	552.302710	26.300129	44.10	<.0001
T205*R	7	170.416106	24.345158	40.82	<.0001
TD*R	7	81.819637	11.688520	19.60	<.0001
IOI*R	7	96.387048	13.769578	23.09	<.0001
T205*G	3	255.072277	85.024092	142.55	<.0001
TD*G	3	26.812580	8.937527	14.98	<.0001
IOI*G	3	222.467295	74.155765	124.33	<.0001
T205*TD	1	20.172888	20.172888	33.82	<.0001
T205*IOI	1	28.064745	28.064745	47.05	<.0001

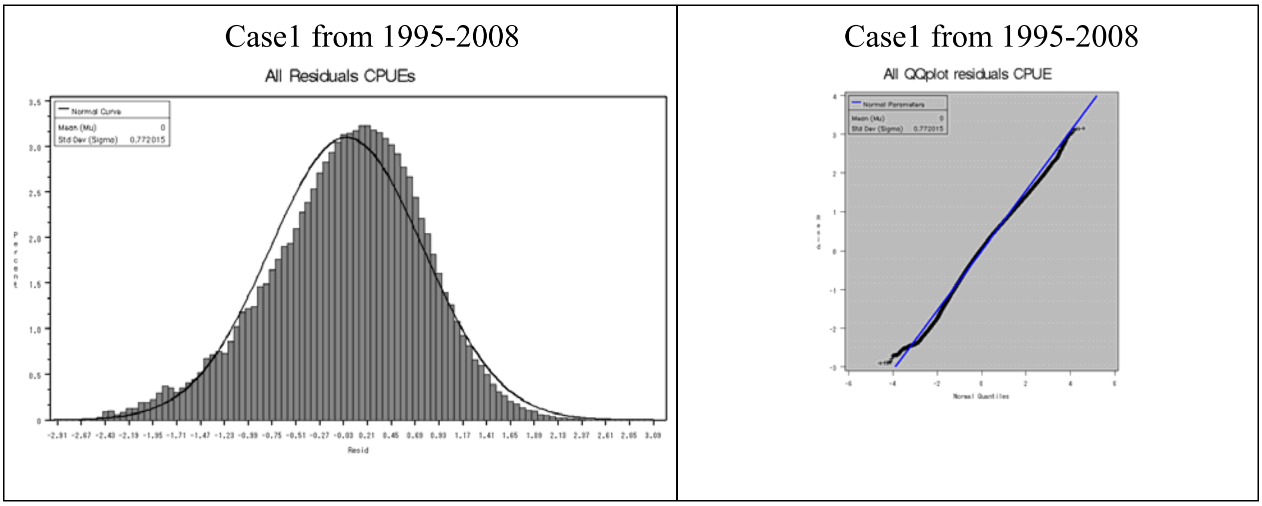

Fig. 3. Distributions of the standardized residuals for the standardization models(left) and the normal probability plots for the standardization models(right) fitted to the catch and effort data.

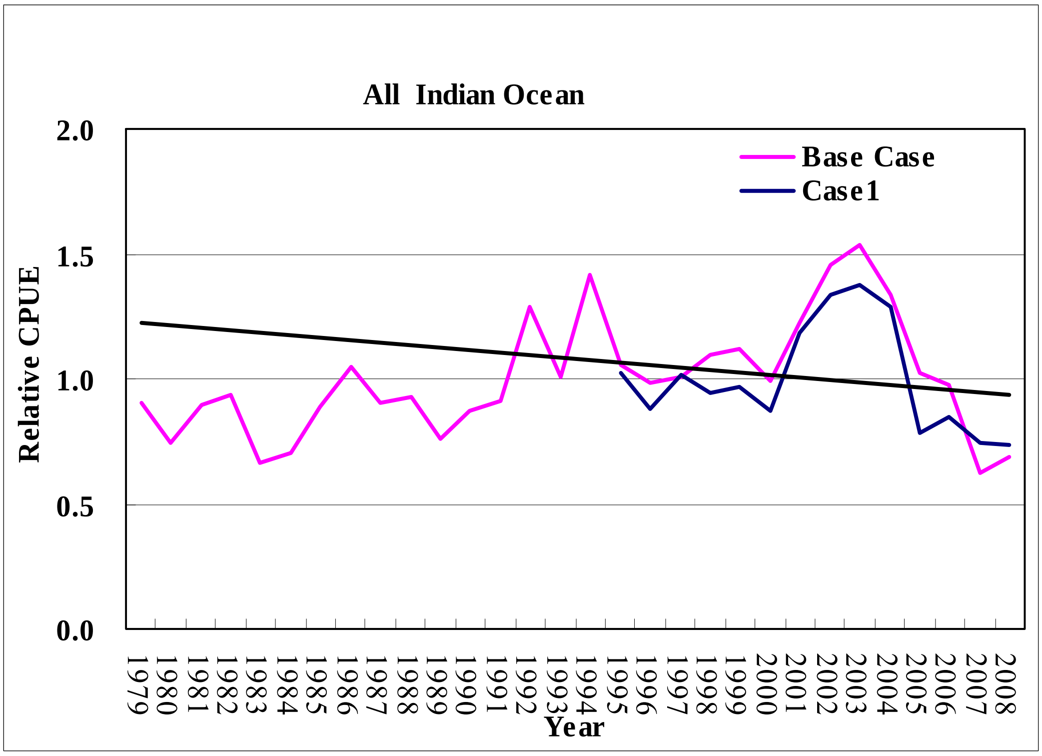

Figure 4

Case2:

the logbook data from 1995-2008 was used to standardize Taiwanese CPUE for bigeye tuna in all Indian Ocean by GLM method, due to available NHBF and additional environmental data , including amplitude of the Sear current , Gradient of Surface Salinity and the selected model was:

log(*CPUE +c)* =μ+*Y* +*Q*+ *R*+*G* + T205 +AM+SG +Y*R+Y*Q +Q*R+Y*Q*R +Q*G +T205*R+AM*Q+R*G+T205*R+AM*R+SG*R+T205*G+AM*G+SG*G+T205*AM+T205*SG+AM*SG+ε

where *CPUE* is the nominal CPUE of bigeye tune (catch in number/1000 hooks),
c is the constant value (i.e. 10% of the average nominal CPUE),
μ is the intercept,
Y is the effect of year,
Q is the effect of quarter,
R is the effect of fishing area,
G is the effect of targeting,
T205 is the effect of salinity at 205m depth,
AM is the effect of amplitude of the shear current,
SG is the effect of salinity gradient

The results of standardized CPUE for bigeye tuna were shown in the diagram below Table3, **Figure 5** and **Figure 6** is trend of relative CPUE: Case2:

Table3. ANOVA Tables resulted for Case2.

Source	DF	Sum of Squares	Mean Square	F-value	P-value
Model	487	41286.6591	84.7775	147.23	<.0001
Error	266598	153515.7344	0.5758		
Corrected Total	267085	194802.3935			

R-Square	Coeff Var	Root MSE	lnbetcpue Mean
0.211941	51.27840	0.758836	1.479836

Source	DF	Type III SS	Mean Square	F-value	P-value
Y	13	510.691712	39.283978	68.22	<.0001
Q	3	54.009595	18.003198	31.26	<.0001
R	7	450.242405	64.320344	11.70	<.0001
G	3	146.952207	48.984069	85.07	<.0001
T205	1	8.326861	8.326861	14.46	0.0001
AM	1	13.704932	13.704932	23.80	<.0001
SG	1	2.633123	2.633123	4.57	0.0325
Y*R	91	998.228969	10.969549	19.05	<.0001
Q*R	21	328.458001	15.640857	27.16	<.0001
Y*Q*R	277	6195.266677	22.365584	38.84	<.0001
Q*G	9	48.261589	5.362399	9.31	<.0001
T205*Q	3	73.056241	24.352080	42.29	<.0001
AM*Q	3	47.395005	15.798335	27.44	<.0001

R*G	21	442.726584	21.082218	36.61	<.0001
T205*R	7	282.473701	40.353386	70.08	<.0001
AM*R	7	147.037328	21.005333	36.48	<.0001
SG*R	7	13.863965	1.980566	3.44	0.0011
T205*G	3	255.177421	85.059140	147.72	<.0001
AM*G	3	39.025368	13.008456	22.59	<.0001
SG*G	3	14.412482	4.804161	8.34	<.0001
T205*AM	1	22.787383	22.787383	39.57	<.0001
T205*SG	1	4.298912	4.298912	7.47	0.0063
AM*SG	1	4.180031	4.180031	7.26	0.0071

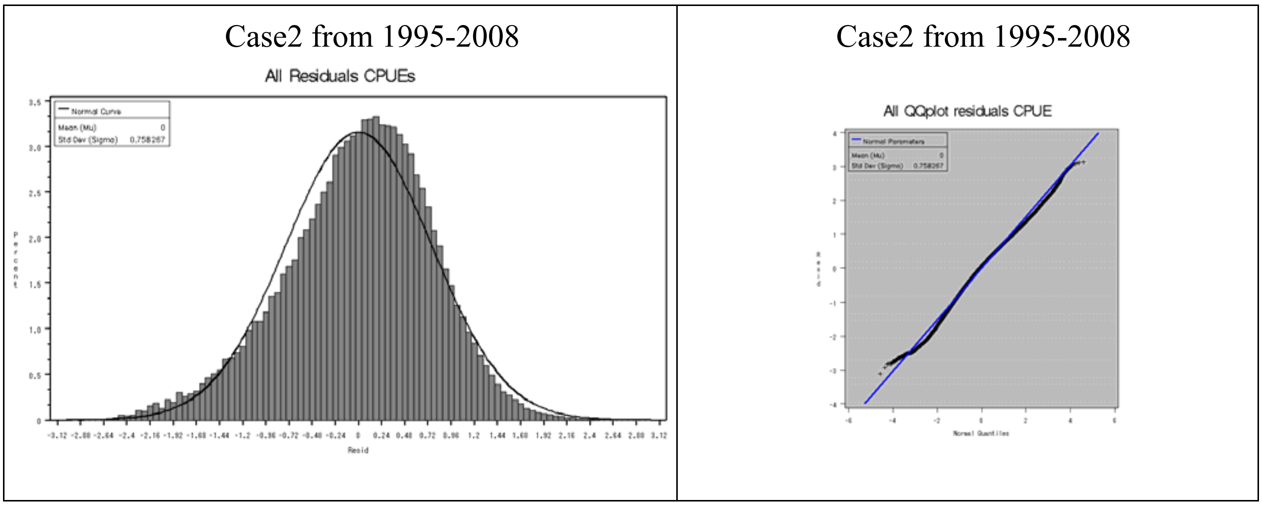

Fig. 5. Distributions of the standardized residuals for the standardization models(left) and the normal probability plots for the standardization models(right) fitted to the catch and effort data.

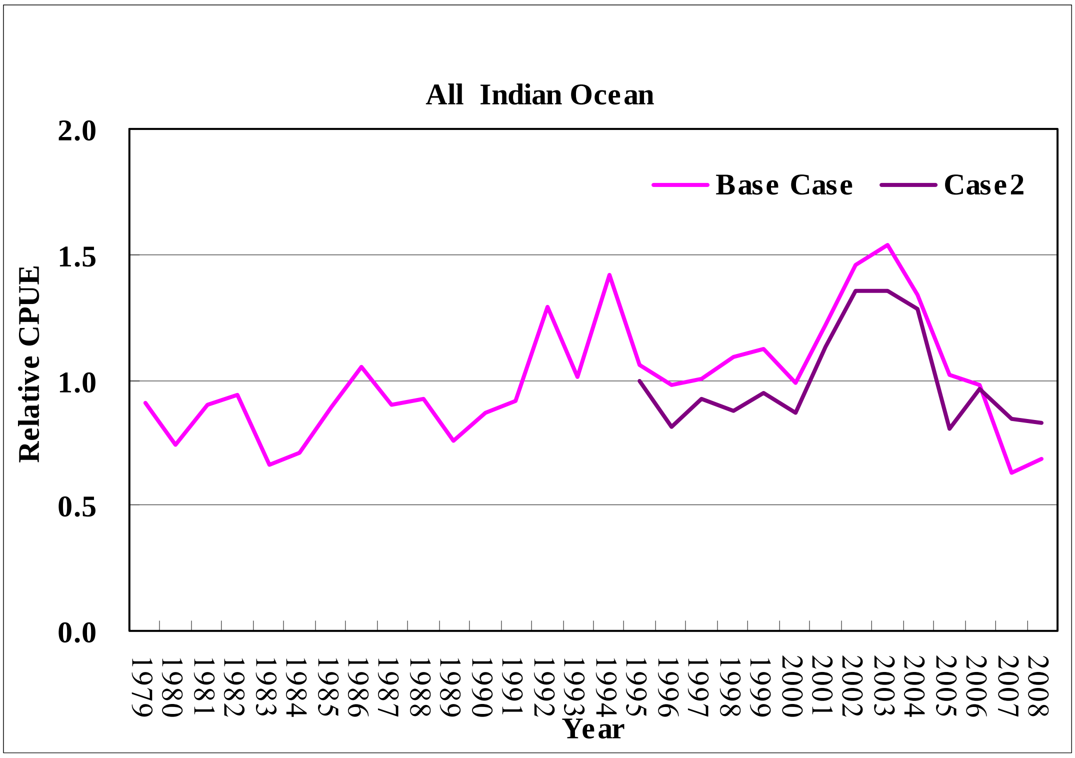
All Indian Ocean
Relative CPUE
2.0
1.5
1.0
0.5
0.0
Base Case
Case2
1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008
Year

Figure 6