CPUE standardization of swordfish (*Xiphias gladius*) caught by Taiwanese longline fishery in the Indian Ocean

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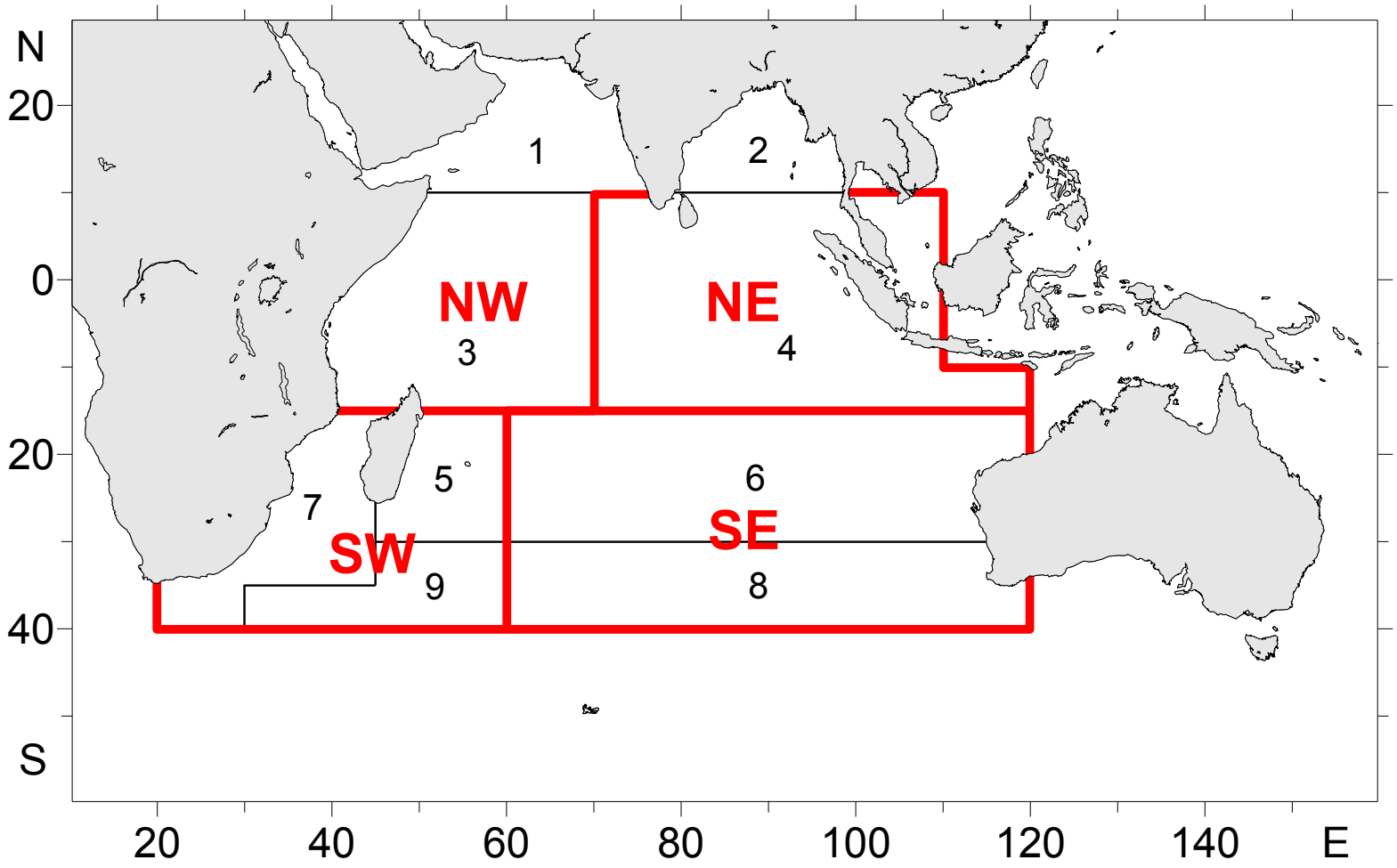
Data series

- The number of hooks between float (NHBF) were only available since 1994 (many missing data in 1994).
- Daily set-by-set catch and effort data (logbook) with 1x1 degree longitude and latitude data of Taiwanese longline fishery during 1995-2009 were used in this study.
- Fishing areas used in this study were redefined by four areas based on the IOTC statistics areas for swordfish in the Indian Ocean

Fishing Areas



GLM analysis

Model 1: $\log(CPUE+c) = \mu + Y + Q + A + Y \times A + \varepsilon$

Model 2: $\log(CPUE+c) = \mu + Y + Q + A + Y \times A + V + \varepsilon$

Model 3: $\log(CPUE+c) = \mu + Y + Q + A + Y \times A + NHBF + \varepsilon$

Model 4: $\log(CPUE+c) = \mu + Y + Q + A + Y \times A + NHBF2 + \varepsilon$

Model 5: $\log(CPUE+c) = \mu + Y + Q + A + Y \times A + V + NHBF2 + ENV1 + \varepsilon$

Model 6: $\log(CPUE+c) = \mu + Y + Q + A + Y \times A + V + NHBF2 + ENV1 + ENV2 + \varepsilon$

Model 7: $\log(CPUE+c) = \mu + Y + Q + A + Y \times A + V + NHBF2 + ENV1 + ENV2\_A + \varepsilon$

Model 8: $\log(CPUE+c) = \mu + Y + Q + A + Y \times A + V + NHBF2 + ENV1 + ENV2 + Q \times A + Q \times NHBF2 + A \times NHBF2 + \varepsilon$

Model 9: $\log(CPUE+c) = \mu + Y + Q + A + Y \times A + V + NHBF2 + ENV1 + ENV2 + \text{interactions} + \varepsilon$

NHBF	is the effect of NHBF treated as continuous variable,
NHBF2	is the effect of three categories of NHBF,
ENV1	are the environmental effects of IOI, DMI and MP,
ENV2	are the environmental effects of SC, AM, TD and TG,
ENV2_A	are the environmental effects of anomalies of SC, AM, TD, TG

Model selection

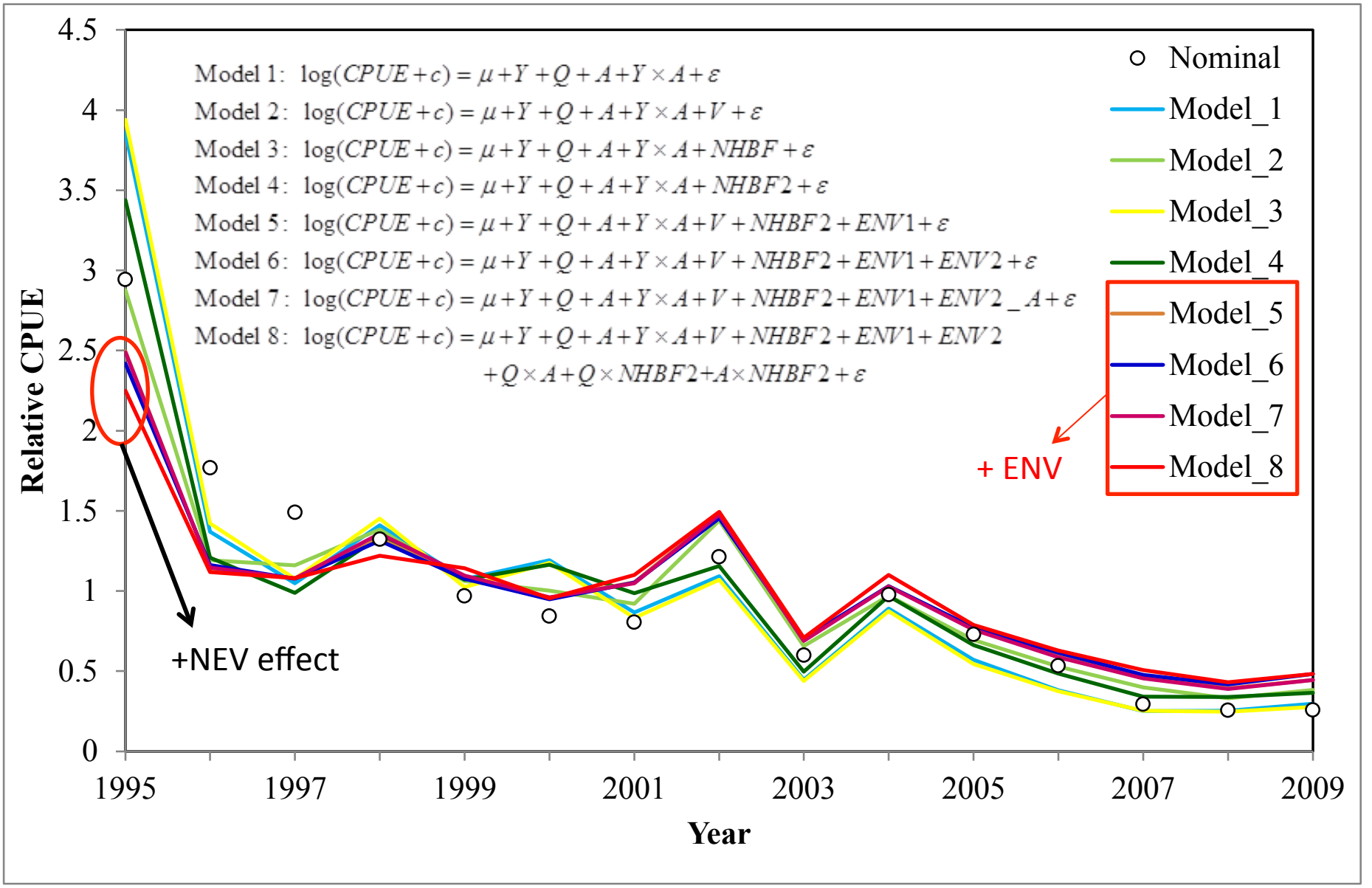
Table 1. The values of R2, AIC and BIC for nine models.

	Model	Model DF	AIC	BIC	R2(%)	ΔR2(%)	ΔAIC	ΔBIC
	1	62	265244	265925	7.3			
V	2	457	222304	227323	16.3	9	-42940	-38602
NHBF	3	63	263877	264569	7.6	0	-1367	-1356
NHBF2	4	64	262173	262876	8.0	1	-3071	-3049
	5	462	219909	224983	16.8	9	-45335	-40942
ENV2	6	466	217894	223012	17.1	10	-47350	-42913
ENV2_A	7	466	219681	224799	16.8	9	-45563	-41126
	8	487	211115	216463	18.4	11	-54129	-49462
	9	4744	161064	213158	29.4	22	-104180	-52767

ANOVA table for Model 8

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Y	14	4670.46	333.60	205.58	<.0001
Q	3	3167.61	1055.87	650.67	<.0001
A	3	2274.26	758.09	467.16	<.0001
Y*A	42	4799.40	114.27	70.42	<.0001
NHBF2	2	1882.31	941.15	579.98	<.0001
V	395	68392.42	173.15	106.70	<.0001
DMI	1	22.00	22.00	13.56	0.0002
IOI	1	184.40	184.40	113.63	<.0001
MP	1	242.62	242.62	149.52	<.0001
SC	1	2821.43	2821.43	1738.68	<.0001
AM	1	122.38	122.38	75.42	<.0001
TD	1	109.25	109.25	67.32	<.0001
TG	1	42.63	42.63	26.27	<.0001
Q*A	9	2921.54	324.62	200.04	<.0001
Q*NHBF2	6	2872.27	478.71	295.00	<.0001
A*NHBF2	6	3473.58	578.93	356.76	<.0001

Model selection



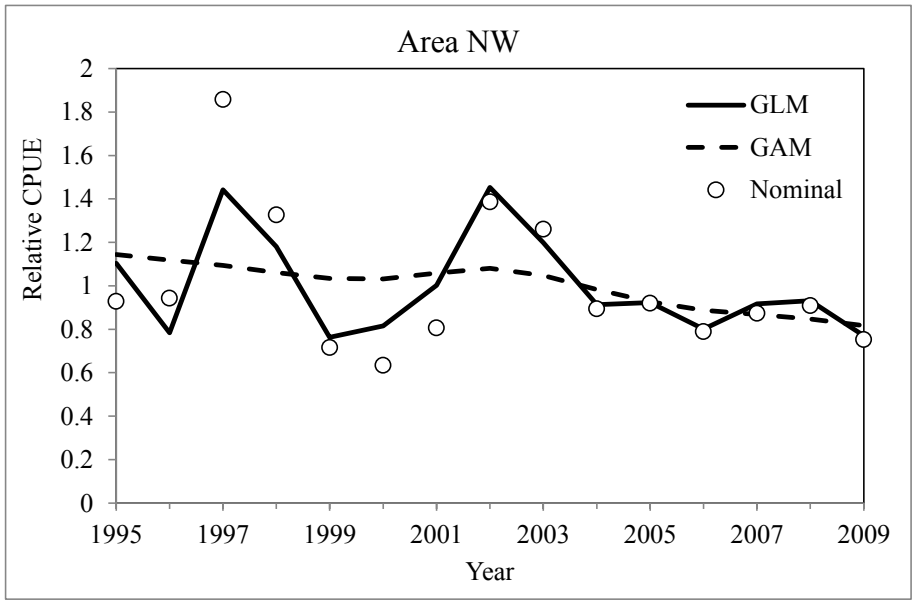
GAM analysis

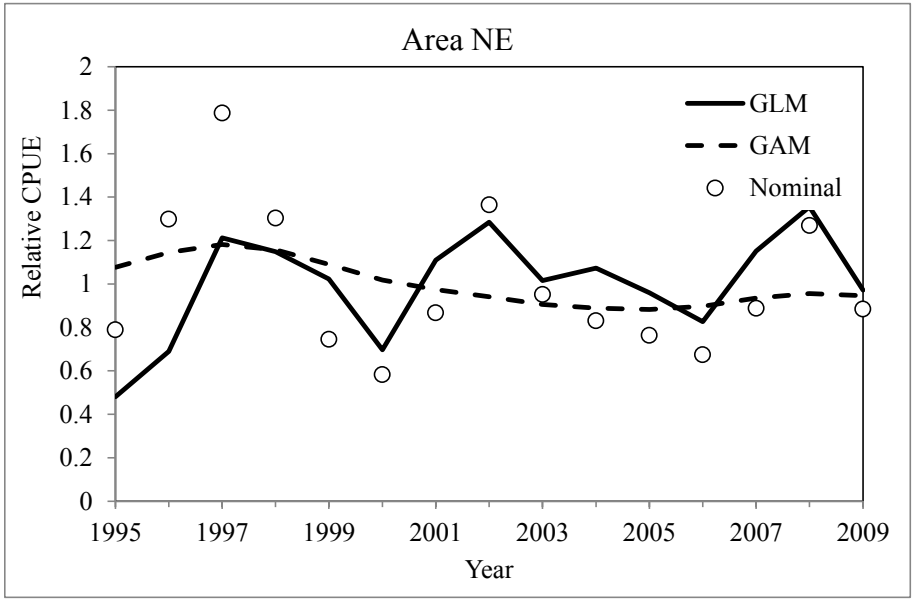
This study simply conducts the GAM based on the additive smoother function of the effects and do not consider the interactions between effects

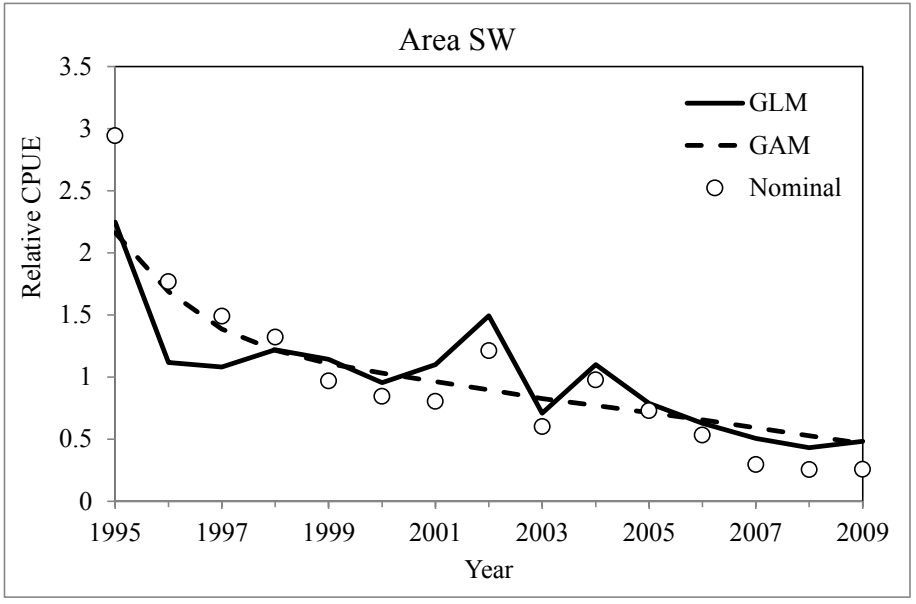
$$\log(CPUE + c) = s(Y) + s(Q) + s(A) + s(A) + s(V) + s(NHBF2) + s(ENV1) + s(ENV2) + \varepsilon$$

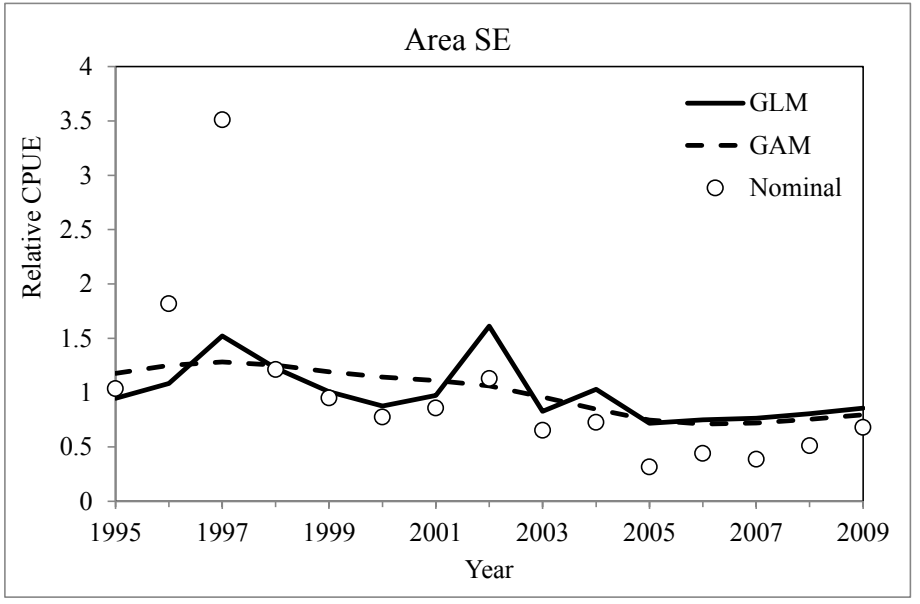
s(*x*) is the spline smoother function of the effects with model calculated degree or freedom

Standardized CPUE by area









Area-aggregated Standardized CPUE