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STANDARDIZED CPUE FROM THE ROD AND REEL AND SMALL SCALE GILLNET FISHERIES OF LA GUAIRA, VENEZUELA

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SUMMARY

*Catches of sailfish (*Istiophorus albicans*), white marlin (*Tetrapturus albidus*) and blue marlin (*Makaira nigricans*) and effort data were available from the recreational rod and reel fishery based at the Playa Grande Yacht Club, Central Venezuela, from 1961 to 2001. Data were also available from a small-scale gillnet fishery in the same area from 1991 to 2012. Each dataset was standardized independently using a generalized linear mixed model (GLMM). The two datasets were also combined in a GLMM analysis that included the year, season, fishery and some two-way interactions as potential explanatory variables. The combined analysis produced a CPUE index of abundance that runs from 1961 to 2012. The index shows a decline followed by a period of stability for both sailfish and white marlin. The blue marlin index shows no trend.*

RÉSUMÉ

Les prises de voiliers (Istiophorus albicans)*, de makaire blanc* (Tetrapturus albidus) *et de makaire bleu* (Makaira nigricans) *et les données d'effort étaient disponibles de la pêcherie récréative de canne et moulinet, basée à Playa Grande Yacht Club, au centre du Venezuela, de 1961 à 2001. Les données étaient également disponibles de la pêcherie de petits métiers opérant aux filets maillants dans la même zone de 1991 à 2012. Chaque jeu de données a été standardisé indépendamment à l'aide d'un modèle linéaire mixte généralisé (GLMM). Les deux jeux de données ont également été combinés dans une analyse de GLMM qui comprenait l'année, la saison, la pêcherie et une interaction à double sens, comme variables explicatives possibles. L'analyse combinée produit un indice d'abondance de la CPUE qui s'étend de 1961 à 2012. L'indice montre une diminution suivie d'une période de stabilité pour les voiliers et le makaire blanc. L'indice du makaire bleu ne dégage aucune tendance.*

RESUMEN

*Se disponía de datos de captura y esfuerzo de pez vela (*Istiophorus albicans*), aguja blanca (*Tetrapturus albidus*) y aguja azul (*Makaira nigricans*) de la pesquería de recreo de caña y carrete con base en el Playa Grande Yacht Club, Venezuela central, desde 1961 hasta 2001. Se disponía también de datos de una pesquería de redes de enmalle de pequeña escala en la misma zona para 1991-2012. Cada conjunto de datos se estandarizó de forma independiente utilizando un modelo lineal mixto generalizado (GLMM). Los dos conjuntos de datos se combinaron también en un análisis GLMM que incluía el año, la temporada, la pesquería y algunas interacciones de dos direcciones como posibles variables explicativas. El análisis combinado produjo un índice de abundancia de CPUE que va desde 1961 a 2012. El índice muestra un descenso seguido de un periodo de estabilidad tanto para el pez vela como para la aguja blanca. El índice para la aguja azul no muestra ninguna tendencia.*

KEYWORDS

Catch/effort, Mathematical models

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1. Introduction

The fishing site known as Placer de la Guaira, off Venezuela, has been a known hot-spot for billfishes since the 1960s. Data are available from 1961 to 2001 on the number of rod and rod and reel fishing trips taken each month from the Playa Grande Yacht Club, and the number of sailfish, white marlin and blue marlin caught in each month. Gaertner and Alio (1997) evaluated trends in this dataset from 1961 to 1995 for all three billfish species and found apparent declines in all three species. Beginning in 1991, this fishery was required to release all billfish caught, so the records are less complete in the 1990s, and there are no records after 2001. A dataset is also available from the small-scale gillnet fishery that operates in the same area, from 1991 to 2012. This dataset includes the number of sets and the monthly total catch in kg of all three billfish species. Arocha *et al.* (2008) standardized the gillnet fishery data to calculate an index of abundance for sailfish, and found no trend over time.

The objective off this paper is to provide updated series for both the rod and reel and the gillnet fishery. In addition, we produce a combined index that includes the data from both fisheries. Because the two fisheries operate in the same area, they should give similar abundance trends. Considering that the rod and reel fishery data are not available since 2001, it would be useful to combine the two series to get a longer time trend in abundance.

2. Methods

For both the rod and reel fishery and the gillnet fishery, and for the two datasets combined, the data were standardized using a generalized linear mixed model (GLMM). The response variable was log(CPUE+0.01) for either sailfish, white marlin or blue marlin. The constant was added because there were some zero observations. However, because the available data were monthly summaries, there were not enough few zero observations to require a delta model to be used. For the rod and reel fishery, CPUE was in numbers caught per trip. For the gillnet fishery, CPUE was in kilograms caught per set. For the combined analysis, both CPUE data sets were divided by their mean in 1991 to 2001 in order to make the units approximately comparable. The explanatory variables were year, season (Winter: December-February, Spring: March-May, Summer: June-August, Autumn: September-November), and the interaction between year and season. For the analysis that included both fisheries, fishery was an explanatory variable, along with a fishery × season interaction. It was not possible to include an interaction between fishery and year because most years only had data from one fishery. Season and any interactions were treated as random effects, while year and fishery were fixed effects. Explanatory variables were included in the model if they were supported by the Akaike information criterion (AIC) and the Bayesian information criterion (BIC), and if they explained more than 5% of the model deviance (Ortiz and Arocha 2004). All analyses were conducted in R version 3.01 (R Core Team 2013).

3. Results

The rod and reel fishery has complete records between 1961 and 1989 (**Table 1**). From 1991 to 2001, there are records for some months in each year, but many months have no recorded catches. The gillnet fishery data are incomplete in 1991, but contain records for all months in every year from 1992 to 2012. Despite the fact that many months are missing, the total effort in the rod and reel fishery, in number of trips, is as high in the 1990s as it has ever been (**Figure 1**).

For both the rod and reel and the gillnet fishery, there were consistent seasonal trends in CPUE for all three species (**Figure 2**). In both fisheries, white marlin were more commonly caught in the second half of the year, and blue marlin in the first half of the year. The trend in sailfish catch rates was not as consistent between the two fisheries. The monthly catch rates appeared to be lognormally distributed in both fisheries for all three species, with the exception of blue marlin, which had a large number of zero observations in the rod and reel fishery (**Figure 3**).

For all three species in the rod and reel fishery the BIC and AIC both preferred a model with both year and season effects, and in some cases an interaction between year and season (**Table 2a**). Nevertheless, the year effect explained the majority of the deviance (**Table 2b**). Using the AIC best model, which included an interaction term for sailfish and white marlin, but not blue marlin, the residuals seem to be fairly normally distributed (**Figure 4**). The predictions from the best fit models (**Figure 5**) are very similar to the raw CPUE if the raw CPUE is calculated using a lognormal estimator (i.e. the mean of the log(CPUE) converted back to normal). The trend in the GLMM-standardized CPUE is rather flat compared to the raw arithmetic means, because the arithmetic mean is more influenced by the few large CPUE values in the late 1960s and early 1970s. The previous analyses of the rod and reel fishery (Gaertner and Alio 1994, 1998) adjusted the effort in each trip by the number of fish caught, on the assumption that anglers on a boat would have to stop fishing when someone was fighting a fish. However, the average CPUE is quite similar with or without the adjustment (**Figure 5**).

For the gillnet fishery, both AIC and BIC preferred models with both the year and season effects, for all three species. For blue marlin, both criteria preferred models that included the interaction term as well (**Table 3**). Year explained more than 90% of the deviance for both sailfish and blue marlin, but only 45% of the deviance for white marlin. The diagnostics (**Figure 6**) show generally normal residuals, except for some outliers at low predicted values. The standardized CPUE index looked very similar to the raw arithmetic mean, or the raw lognormal mean, and was also very similar to the values calculated by Arocha *et al.* (2008) for sailfish (**Figure 7**).

When both datasets were combined, the AIC preferred the model with effects of year, fishery, season and the interaction between fishery and season for sailfish and white marlin (**Table 4a**). That fishery was included in the AIC best model was surprising, because fishery explained less than 2% of the deviance for either species (**Table 4b**). For blue marlin, the AIC preferred the model with only year and season. For all three species, much of the deviance was explained by the interaction between year and season, perhaps because of changes over time in the seasonal trend in abundance. The diagnostics of the AIC preferred models looked fairly normal (**Figure 8**), except for some outliers at low predicted values. The predicted values of the index look very low and flat over the recent time period for all three species (**Figure 9**). Combining the data from the two sources gives very similar trends to what would be obtained by fitting the two series separately and dividing them by their mean in the time period when they overlap (**Figure 10**). However, the standard errors are somewhat higher in recent years for the artisanal fishery than for the two datasets combined (**Table 5**).

4. Discussion

Because La Guaira is a billfish hotspot, catch rates from the area may provide a useful index of abundance. Given that the rod and reel dataset has not been continued since 2001, it would be useful to be able to combine the two datasets to estimate a long term index of abundance. Combining the two indices requires several assumptions. First, the average weight must be assumed to be constant in each fishery over time, so that CPUE in numbers in the rod and reel fishery are directly proportional to CPUE in weight in the gillnet fishery. This is a reasonable assumption because the rod and reel fishery did not select for a specific size of fish, and the average size of fish in the gillnet fishery has not changed over time.

Second, although the two fisheries may have different catchabilities, both catchabilities must be constant over time. Because information is not available on vessel characteristics such boat size, gear used, time spent fishing, or targeting in either fishery, these variables could not be added to the standardization. Any change in fishing methods over time in either fishery would bias the index. It is known that fishing methodology in the gillnet fishery has not changed over time (Arocha *et al.* 2008). Whether rod and reel fishermen have become more efficient over time is not known.

Third, the combined GLMM makes the assumption that the error structure in the two fisheries is comparable. This may not be a good assumption, because catch rates are more variable in the rod and reel fishery than the artisanal gillnet fishery. For this reason, it may be preferable to model the fisheries separately if they are to be used in a stock assessment model that uses the variances of the indices as an input (**Table 5**).

Finally, whether modeling the two fisheries separately or together, the scaling of the two fisheries depends on the CPUE in the years when both data sets overlap. In the combined model presented here, the CPUE data were rescaled by dividing each dataset by its mean in the 1990s. The model was also given the opportunity to estimate the scaling factor between the two datasets, in the main effect of “fishery” in the GLMM. If the two series were standardized independently and input into a stock assessment model, the model would be able to estimate the scaling factor by estimating a different catchability for fishery. In either a combined GLMM or a stock assessment using both series, the relative scaling depends on the assumption that the CPUE in the rod and reel fishery in the 1990s is comparable to the CPUE in the rod and reel fishery before 1990. Thus, the results are highly dependent on what assumptions are made about the missing data in the 1990s in the rod and reel fishery (**Table 1**). Considering that in 1991 there was a ban on retention of billfishes in the rod and reel fishery, it is quite possible that total catch in the 1990s is under-reported because billfishes are more likely to be released at sea. The analyses presented here left out months with no recorded catches. Thus, if some of the months with no reported catches actually had a catch of zero for a billfish species, the rod and reel CPUE in the 1990s could be overestimated. Conversely, if the reported catches in months with data are an underestimate of the true catch, then the CPUE in the 1990s could be underestimated. Future analyses of these datasets may consider using some kind of imputation model to deal with the missing data in this period. Considering that the effort in the rod and reel fishery did not decline after the ban on retaining billfishes, it seems likely that large numbers of billfish continue to be caught and released.

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Table 1. Number of months with effort data and catch data for each speces available for each dataset in each year.

RR						***Gillnet***			***RR***						***Gillnet***		
Yr	Eff	SAI	WHM	BUM	Eff	SAI	WHM	BUM	Yr	Eff	SAI	WHM	BUM	Eff	SAI	WHM	BUM
61	12	12	12	12	0	0	0	0	87	12	12	12	12	0	0	0	0
62	12	12	12	12	0	0	0	0	88	12	12	12	12	0	0	0	0
63	12	12	12	12	0	0	0	0	89	12	12	12	12	0	0	0	0
64	12	12	12	12	0	0	0	0	90	0	0	0	0	0	0	0	0
65	12	12	12	12	0	0	0	0	91	12	8	9	10	12	7	10	10
66	12	12	12	12	0	0	0	0	92	9	11	10	11	12	12	12	12
67	12	12	12	12	0	0	0	0	93	12	0	3	5	12	12	12	12
68	12	12	12	12	0	0	0	0	94	12	5	9	7	12	12	12	12
69	12	12	12	12	0	0	0	0	95	12	4	7	8	12	12	12	12
70	12	12	12	12	0	0	0	0	96	12	4	1	12	12	12	12	12
71	12	12	12	12	0	0	0	0	97	12	4	8	9	12	12	12	12
72	12	12	12	12	0	0	0	0	98	12	2	1	6	12	12	12	12
73	12	12	12	12	0	0	0	0	99	12	3	3	4	12	12	12	12
74	12	12	12	12	0	0	0	0	00	12	1	3	4	12	12	12	12
75	12	12	12	12	0	0	0	0	01	11	3	4	8	12	12	12	12
76	12	12	12	12	0	0	0	0	02	0	0	0	0	12	12	12	12
77	12	12	12	12	0	0	0	0	03	0	0	0	0	12	12	12	12
78	12	12	12	12	0	0	0	0	04	0	0	0	0	12	12	12	12
79	12	12	12	12	0	0	0	0	05	0	0	0	0	12	12	12	12
80	12	12	12	12	0	0	0	0	06	0	0	0	0	12	12	12	12
81	12	12	12	12	0	0	0	0	07	0	0	0	0	12	12	12	12
82	12	12	12	12	0	0	0	0	08	0	0	0	0	12	12	12	12
83	12	12	12	12	0	0	0	0	09	0	0	0	0	12	12	12	12
84	12	12	12	12	0	0	0	0	10	0	0	0	0	12	12	12	12
85	12	12	12	12	0	0	0	0	11	0	0	0	0	12	12	12	12
86	12	12	12	12	0	0	0	0	12	0	0	0	0	12	12	12	12

Table 2. Rod and reel GLMM results. Δ refers to the difference between the best model (lowest DIC or AIC) and the model shown. Random effects are in italics.

(a) DIC and AIC

Model	***SAI***		***WHM***		***BUM***	
	Δ-AIC	***Δ-BIC***	***Δ-AIC***	***Δ-BIC***	***Δ-AIC***	***Δ-BIC***
year	75.6	67.7	113.5	108.3	50	45.9
year+*season*	13.0	9.0	1.3	0	0	0
year+*season*+*year:season*	0	0	0	2.7	0.2	4.3

(b) Analysis of deviance

Species	***Factor***	***Df***	***Deviance***	***Resid. Df***	***Resid. Dev***	***F***	***Pr(>F)***	***% deviance***
SAI	NULL			390	2051.6			
	year	39	1682.9	351	368.7	64.9	0.0000	82
	season	3	84.8	348	284.0	42.5	0.0000	4
	year:season	99	118.4	249	165.6	1.8	0.0001	6
WHM	NULL			404	1664.4			
	year	40	1101.8	364	562.6	27.3	0.0000	66
	season	3	166.3	361	396.4	54.9	0.0000	10
	year:season	103	136.1	258	260.2	1.3	0.0454	8
BUM	NULL			429	4242.4			
	year	40	3896.1	389	346.3	144.7	0.0000	92
	season	3	73.0	386	273.2	36.2	0.0000	2
	year:season	112	88.7	274	184.5	1.2	0.1450	2

Table 3. Gillnet GLMM results.

(a) DIC and AIC

Model	SAI		WHM		BUM	
	Δ-AIC	Δ-BIC	Δ-AIC	Δ-BIC	Δ-AIC	Δ-BIC
year	158.8	155.2	58.4	54.8	36.1	28.9
year+season	0	0	0	0	13.3	9.7
year+*season*+*year:season*	2.0	5.6	0.5	4.0	0	0

(b) Analysis of deviance

Species	Factor	Df	Deviance	Resid. Df	Resid. Dev	F	Pr(>F)	% deviance
SAI	NULL			259	2911.0			
	Year	22	2647.2	237	263.8	232.3	0.0000	91
	Season	3	145.4	234	118.4	93.5	0.0000	5
	year:season	63	29.8	171	88.6	0.9	0.6526	1
WHM	NULL			262	623.8			
	year	22	281.7	240	342.1	13.4	0.0000	45
	season	3	98.0	237	244.2	34.1	0.0000	16
	year:season	63	77.5	174	166.7	1.3	0.1046	12
BUM	NULL			262	2607.8			
	year	22	2369.0	240	238.8	173.1	0.0000	91
	season	3	46.4	237	192.4	24.8	0.0000	2
	year:season	63	84.2	174	108.2	2.1	0.0001	3

Table 4. Both datasets combined.

(a) AIC and BIC

Model	SAI		WHM		BUM	
	Δ-AIC	Δ-BIC	Δ-AIC	Δ-BIC	Δ-AIC	Δ-BIC
year	142.6	129.2	164.3	153.6	67.4	62.8
year+fishery	144.4	135.4	160.0	153.7	69.1	69.1
year+fishery+season	69.5	65.0	1.7	0	3.5	8.0
year+fishery+season+fishery:season	0	0	0	2.8	0.4	9.4
year+season+year:season	45.1	45.1	3.7	6.4	4.4	13.5
year+season	68.6	59.6	10.2	3.9	0	0
year+season+year:seaon	44.3	39.9	12.0	10.3	1.0	5.5

(b) Analysis of Deviance

Species	Model	Df	Deviance	Resid. Df	Resid. Dev	F	Pr(>F)	% deviance
SAI	NULL			648	1393.4			
	year	50	408.5	598	984.9	7.4	0.0000	29
	fishery	1	0.4	597	984.5	0.4	0.5536	0
	season	3	157.6	594	826.8	47.8	0.0000	11
	year:season	150	330.3	444	496.6	2.0	0.0000	24
	fishery:season	3	12.0	441	484.5	3.7	0.0127	1
WHM	NULL			665	1478.3			
	year	50	356.8	615	1121.5	5.4	0.0000	24
	fishery	1	10.6	614	1110.9	8.0	0.0048	1
	season	3	290.0	611	820.9	73.1	0.0000	20
	year:season	150	210.6	461	610.3	1.1	0.3163	14
	fishery:season	3	4.9	458	605.4	1.2	0.3009	0
BUM	NULL			690	1741.6			
	year	50	462.6	640	1279.0	5.5	0.0000	27
	fishery	1	0.4	639	1278.6	0.3	0.6159	0
	season	3	162.9	636	1115.7	32.6	0.0000	9
	year:season	150	306.2	486	809.4	1.2	0.0569	18
	fishery:season	3	4.2	483	805.2	0.8	0.4721	0

Table 5. Means and standard errors of the indices.

(a) Rod and Reel

Year	SAI	SE	WHM	SE	BUM	SE	Year	SAI	SE	WHM	SE	BUM	SE
1961	0.33	0.15	0.33	0.18	0.09	0.04	1981	0.08	0.04	0.63	0.34	0.06	0.02
1962	0.27	0.12	0.46	0.25	0.14	0.05	1982	0.04	0.02	0.67	0.36	0.02	0.01
1963	0.12	0.06	0.26	0.14	0.08	0.03	1983	0.12	0.06	0.34	0.18	0.06	0.02
1964	0.16	0.08	0.36	0.19	0.06	0.02	1984	0.21	0.1	0.29	0.16	0.1	0.04
1965	0.18	0.08	0.23	0.13	0.05	0.02	1985	0.17	0.08	0.32	0.17	0.05	0.02
1966	0.38	0.17	0.28	0.15	0.12	0.05	1986	0.1	0.05	0.14	0.08	0.04	0.02
1967	0.22	0.1	0.23	0.13	0.08	0.03	1987	0.17	0.08	0.16	0.09	0.05	0.02
1968	0.3	0.14	0.23	0.13	0.09	0.03	1988	0.09	0.04	0.16	0.09	0.03	0.01
1969	0.3	0.14	0.18	0.1	0.1	0.04	1989	0.12	0.06	0.12	0.07	0.05	0.02
1970	0.25	0.12	0.11	0.06	0.09	0.04	1991	0.04	0.02	0.05	0.04	0.04	0.02
1971	0.37	0.17	1.04	0.56	0.03	0.02	1992	0.07	0.04	0.2	0.12	0.05	0.02
1972	0.31	0.14	0.52	0.28	0.02	0.01	1993	NA	NA	0.06	0.05	0.05	0.03
1973	0.26	0.12	0.9	0.48	0.02	0.01	1994	0.08	0.05	0.08	0.05	0.15	0.07
1974	0.25	0.11	0.23	0.13	0.03	0.01	1995	0.05	0.04	0.16	0.11	0.18	0.08
1975	0.15	0.07	0.34	0.19	0.01	0.01	1996	0.02	0.02	0.02	0.04	0.03	0.01
1976	0.2	0.09	0.54	0.29	0.01	0.01	1997	0.01	0.01	0.02	0.02	0.04	0.02
1977	0.09	0.04	0.3	0.16	0.01	0.01	1998	0.02	0.03	0.03	0.06	0.02	0.02
1978	0.06	0.03	0.16	0.09	0.01	0.01	1999	0.01	0.02	0.04	0.04	0.02	0.02
1979	0.06	0.03	0.27	0.15	0.02	0.01	2000	0.06	0.09	0.01	0.02	0.05	0.03
1980	0.09	0.04	0.52	0.28	0.03	0.01	2001	0.06	0.06	0.2	0.16	0.08	0.04

(b) Gillnet

Year	SAI	SE	WHM	SE	BUM	SE	Year	SAI	SE	WHM	SE	BUM	SE
1991	29.45	15.95	3.47	1.74	9.89	4.36	2002	15.98	8.06	2.6	1.25	15.37	6.52
1992	11.8	5.96	0.73	0.35	2.11	0.9	2003	28.46	14.36	3.12	1.5	18.4	7.81
1993	20.72	10.46	0.93	0.45	14.53	6.17	2004	41.23	20.8	4.42	2.12	22.2	9.42
1994	28.91	14.59	6.51	3.12	29.79	12.64	2005	35.1	17.71	3.98	1.91	20.99	8.91
1995	31.38	15.83	3.17	1.52	29.22	12.4	2006	28.23	14.24	3.52	1.69	26.97	11.44
1996	28.75	14.51	0.53	0.26	21.04	8.93	2007	38.09	19.22	5.23	2.51	30.97	13.14
1997	34.98	17.65	0.9	0.44	28.23	11.98	2008	22.78	11.5	3.77	1.81	24.19	10.27
1998	39.5	19.93	2.53	1.22	38.8	16.46	2009	19.85	10.02	2.89	1.39	16.95	7.19
1999	44.56	22.48	4.64	2.23	65.67	27.86	2010	22.07	11.13	1.98	0.95	28.43	12.06
2000	28.17	14.21	3.14	1.51	23.34	9.91	2011	18.36	9.26	1.39	0.67	15.41	6.54
2001	22.61	11.41	1.87	0.9	16.56	7.03	2012	32.8	16.55	3.64	1.75	22.05	9.36

(b) Combined

Year	SAI	SE	WHM	SE	BUM	SE	Year	SAI	SE	WHM	SE	BUM	SE
1961	8.18	4.69	3.44	2.01	0.72	0.37	1987	4.17	2.4	1.69	0.99	0.68	0.34
1962	6.7	3.84	5.56	3.24	1.29	0.65	1988	2.12	1.22	1.8	1.05	0.3	0.16
1963	3	1.73	3.06	1.79	0.72	0.36	1989	2.31	1.33	1.36	0.8	0.58	0.3
1964	3.22	1.85	3.69	2.15	0.64	0.33	1990	NA	NA	NA	NA	NA	NA
1965	3.56	2.05	1.81	1.06	0.46	0.24	1991	0.81	0.42	0.78	0.39	0.38	0.16
1966	7.46	4.28	2.85	1.67	1.6	0.8	1992	0.6	0.29	0.61	0.31	0.27	0.12
1967	4.24	2.43	2.68	1.57	0.71	0.36	1993	0.64	0.34	0.37	0.2	0.5	0.23
1968	7.42	4.25	2.36	1.38	1.17	0.59	1994	1.01	0.5	1.33	0.65	1.23	0.53
1969	5.79	3.32	2.12	1.24	1.34	0.68	1995	0.9	0.45	1.22	0.61	1.36	0.58
1970	6.13	3.52	0.99	0.58	1.19	0.6	1996	0.69	0.34	0.18	0.1	0.47	0.19
1971	9.3	5.34	12.73	7.42	0.21	0.11	1997	0.66	0.33	0.25	0.13	0.68	0.29
1972	7.6	4.36	6.31	3.68	0.21	0.11	1998	0.93	0.48	0.69	0.37	0.76	0.33
1973	6.6	3.79	10.98	6.4	0.11	0.06	1999	0.89	0.45	1.05	0.55	1.2	0.55
1974	6.01	3.45	2.43	1.42	0.2	0.11	2000	0.79	0.41	0.63	0.33	0.72	0.33
1975	3.02	1.74	3.92	2.29	0.04	0.03	2001	0.71	0.36	0.76	0.39	0.69	0.29
1976	3.87	2.22	6.53	3.81	0.05	0.03	2002	0.47	0.25	0.79	0.43	0.5	0.26
1977	1.8	1.04	3.66	2.13	0.06	0.03	2003	0.79	0.42	0.94	0.51	0.6	0.31
1978	1.24	0.72	1.97	1.15	0.09	0.05	2004	1.13	0.6	1.34	0.73	0.73	0.37
1979	1.01	0.58	3.23	1.88	0.17	0.09	2005	0.98	0.51	1.2	0.65	0.69	0.35
1980	1.67	0.96	6.28	3.66	0.18	0.1	2006	0.78	0.41	1.06	0.58	0.88	0.44
1981	1.81	1.04	7.69	4.48	0.73	0.37	2007	1.05	0.55	1.57	0.85	1.01	0.51
1982	0.5	0.29	8.24	4.8	0.12	0.06	2008	0.63	0.33	1.14	0.62	0.79	0.4
1983	2.99	1.72	4.05	2.36	0.82	0.41	2009	0.55	0.29	0.88	0.48	0.56	0.28
1984	5.16	2.96	3.49	2.04	1.29	0.65	2010	0.61	0.32	0.6	0.33	0.93	0.47
1985	4.2	2.41	3.37	1.97	0.62	0.32	2011	0.51	0.27	0.42	0.23	0.5	0.26
1986	2.55	1.46	1.61	0.94	0.36	0.18	2012	0.9	0.48	1.1	0.6	0.72	0.36

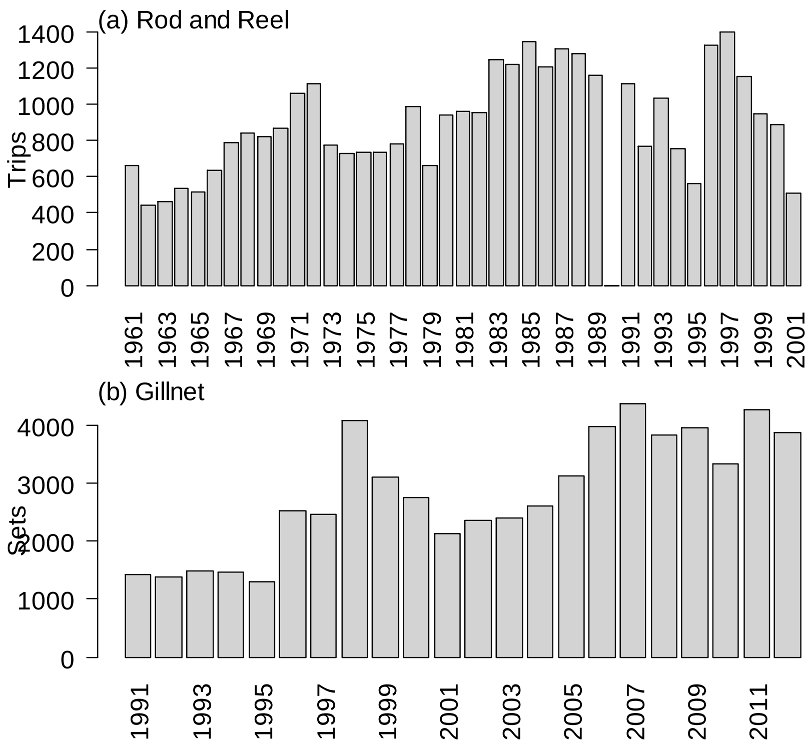

Figure 1. Effort in each fishery.

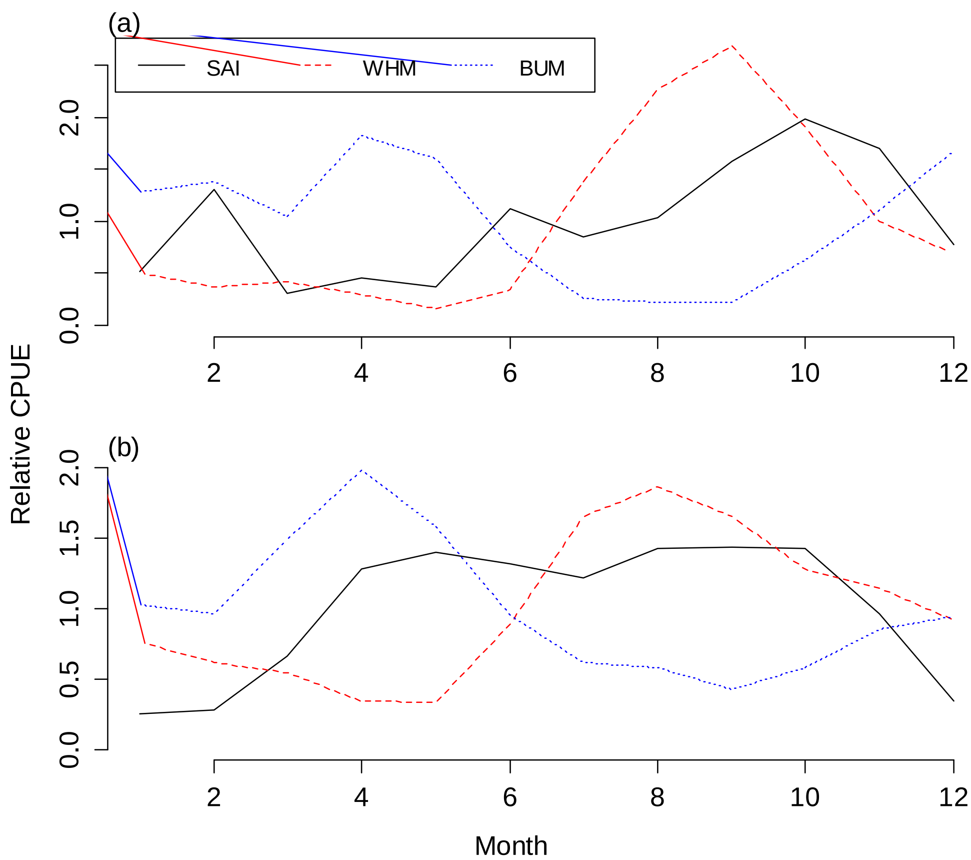

Figure 2. Average CPUE divided by its mean for each species in (a) the rod and reel fishery before 1990, and (b) the gillnet fishery.

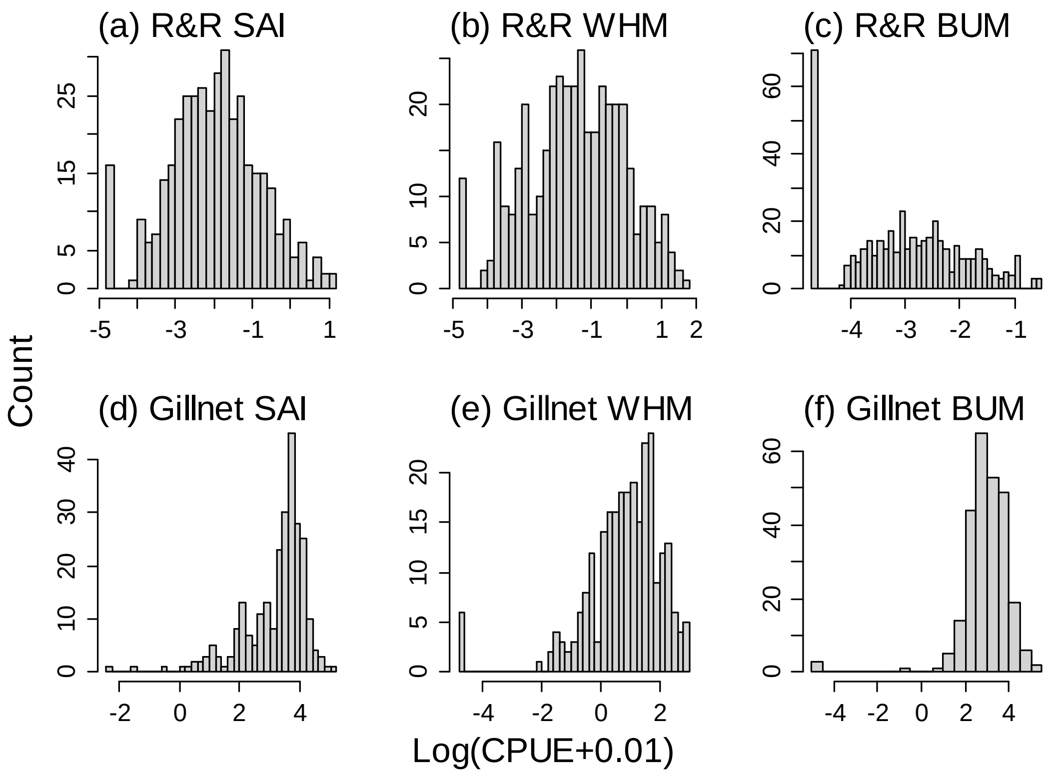

Figure 3. Histograms of log of CPUE for each species in each fishery.

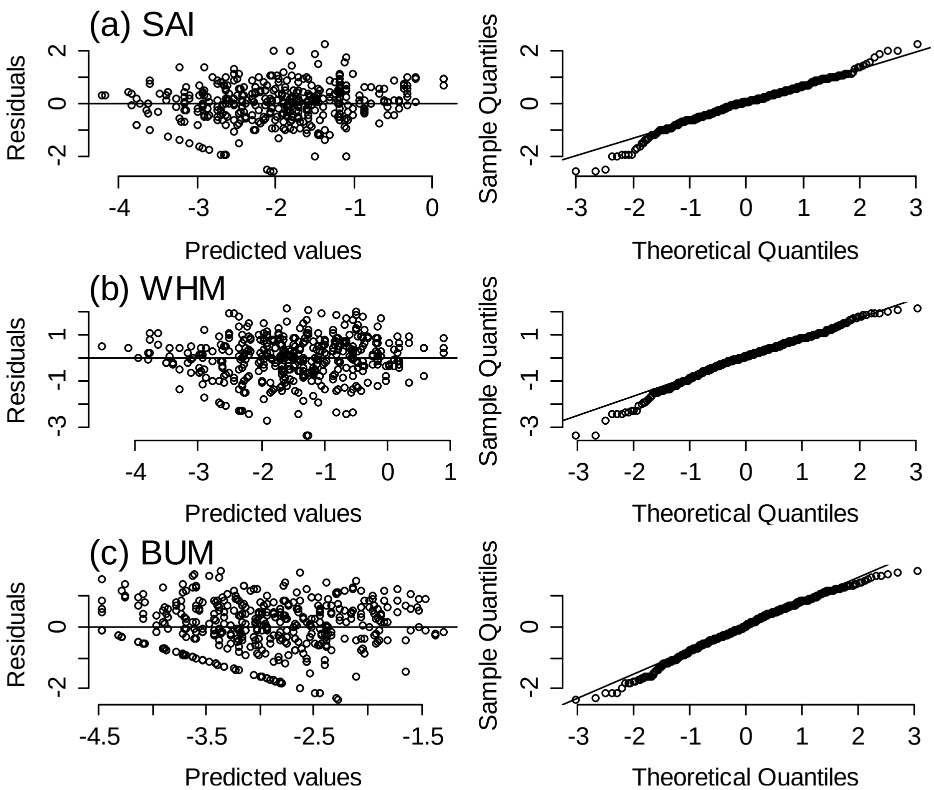

Figure 4. Rod and Reel model diagnostics.

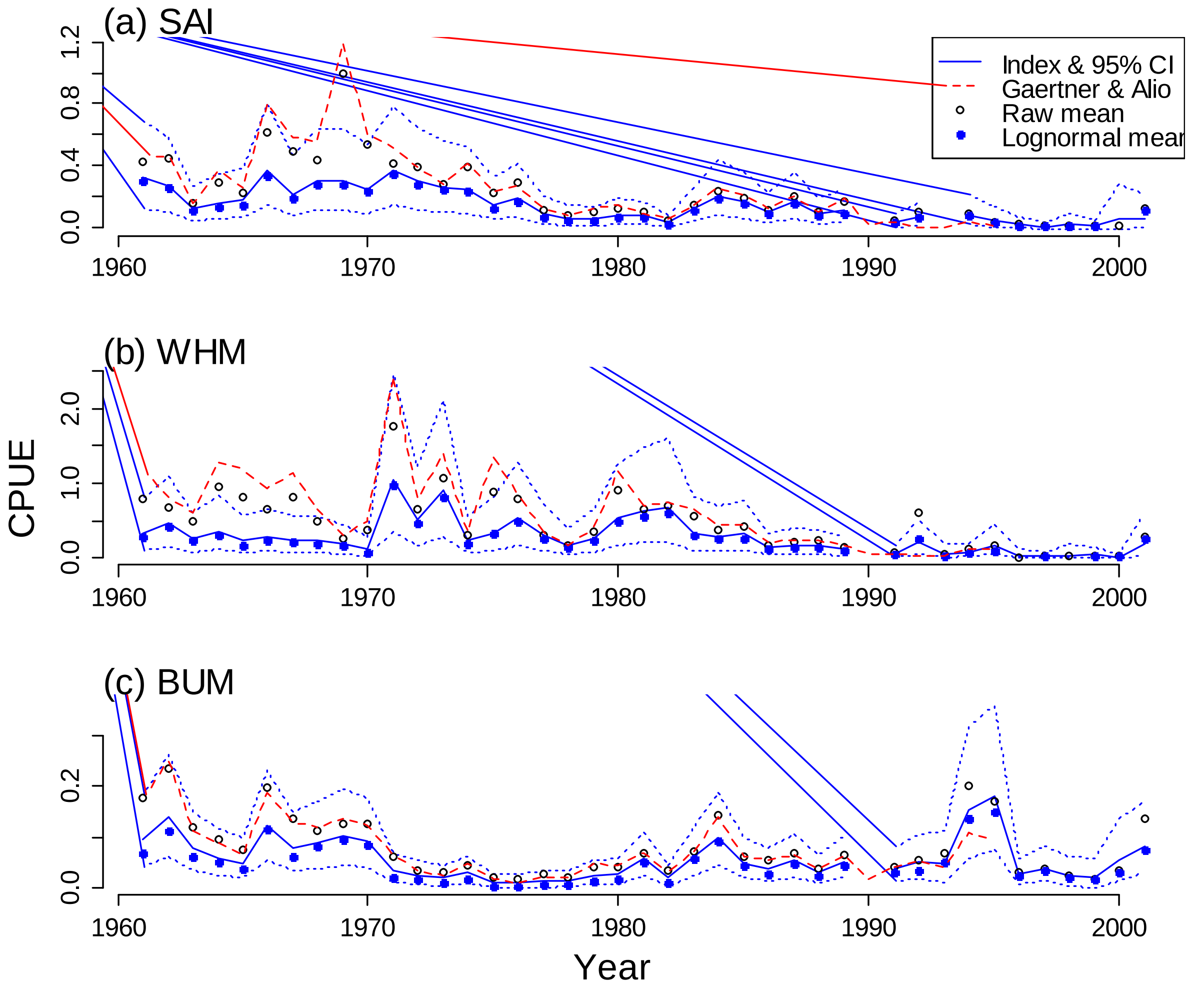

Figure 5. Rod and Reel fitted values.

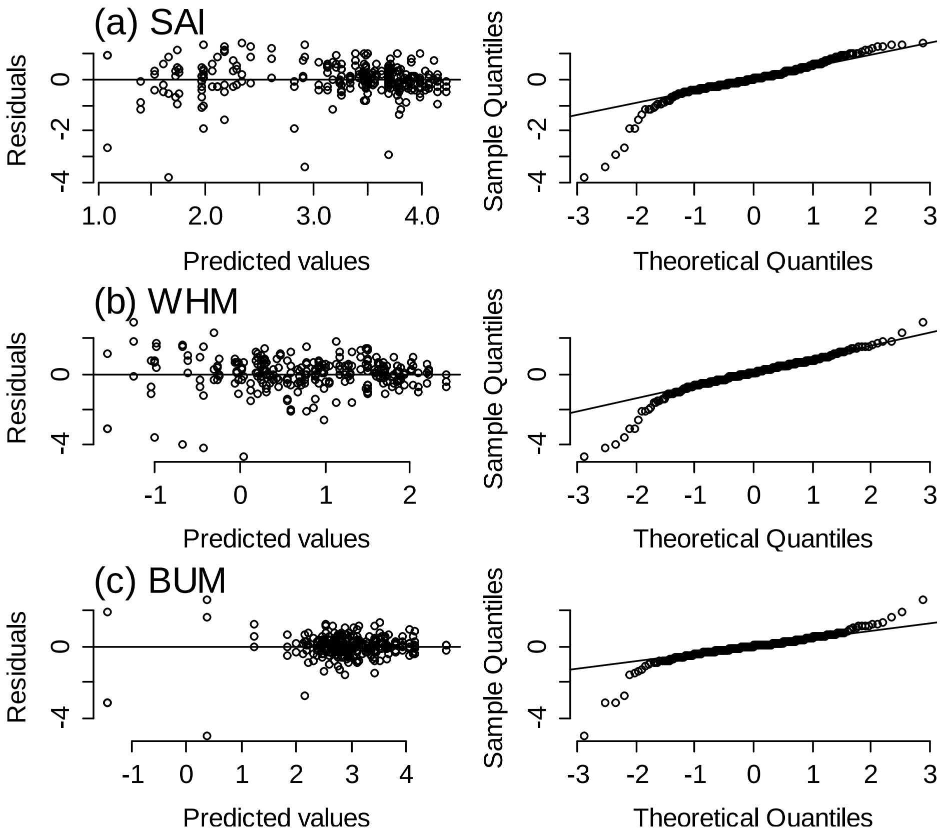

Figure 6. Gillnet diagnostics.

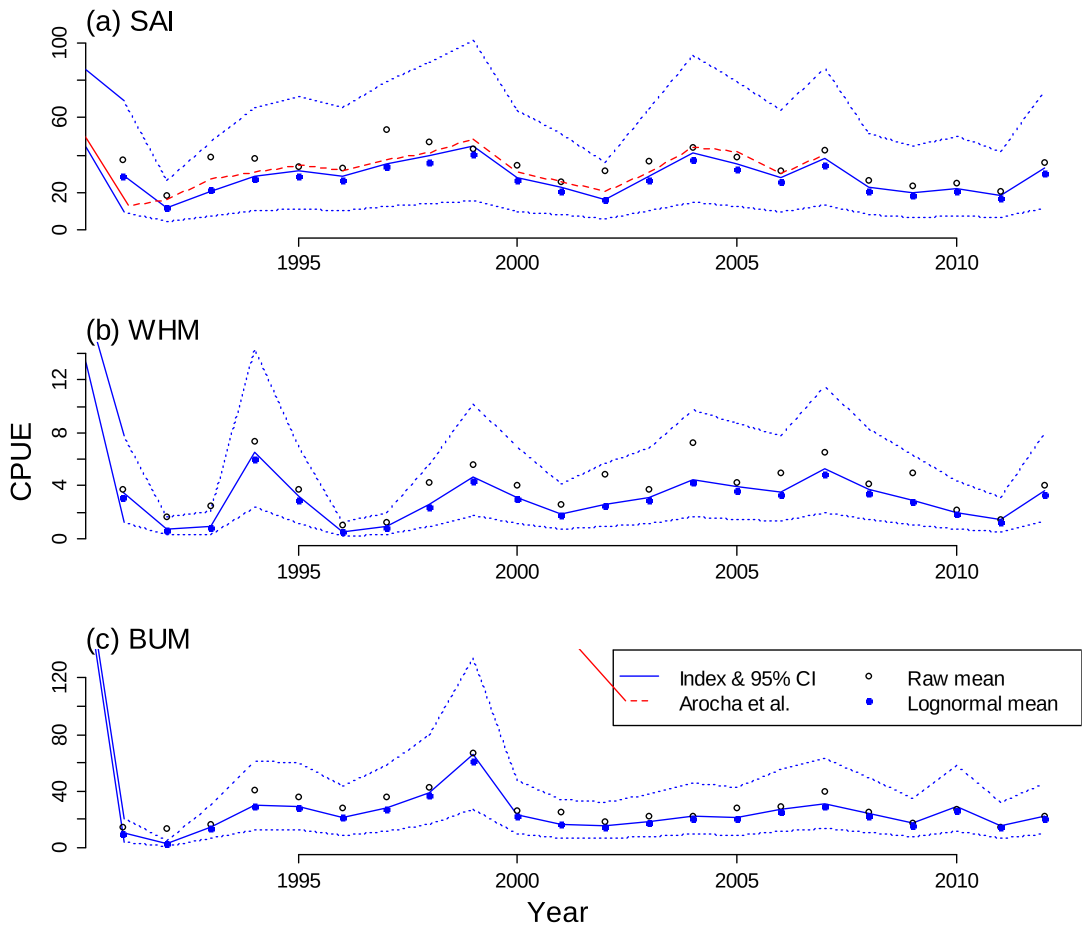

Figure 7. Gillnet fitted values.

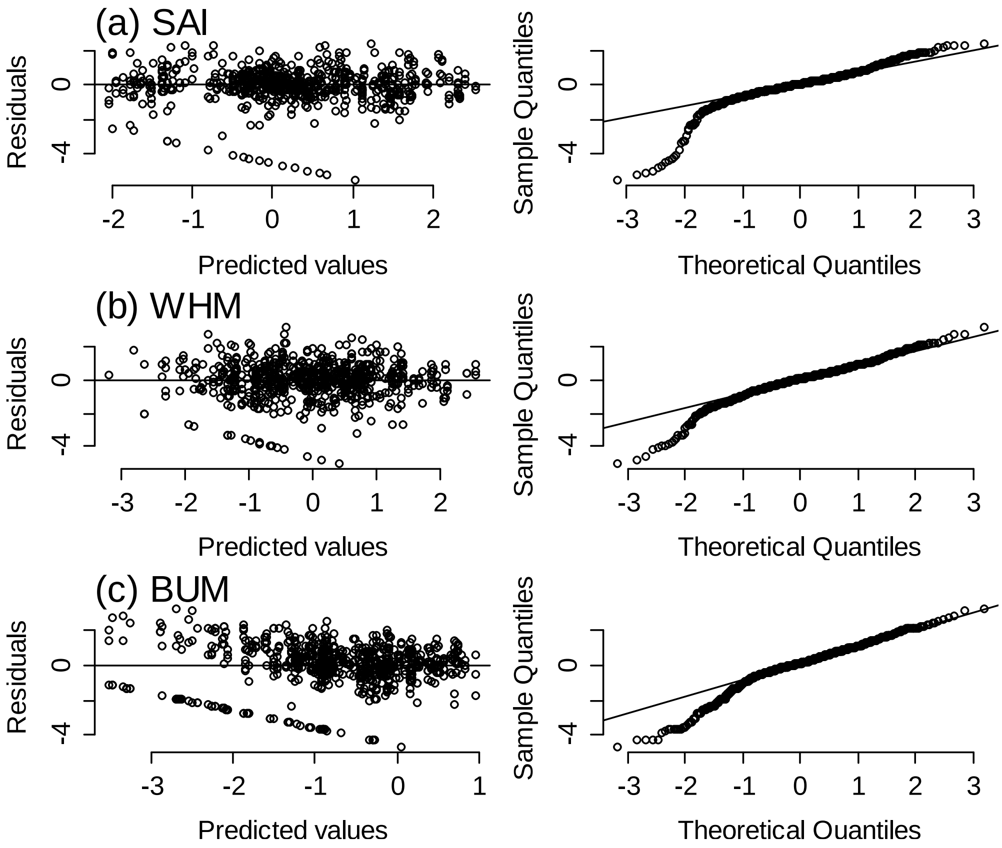

Figure 8. Diagnostics for the model with both datasets.

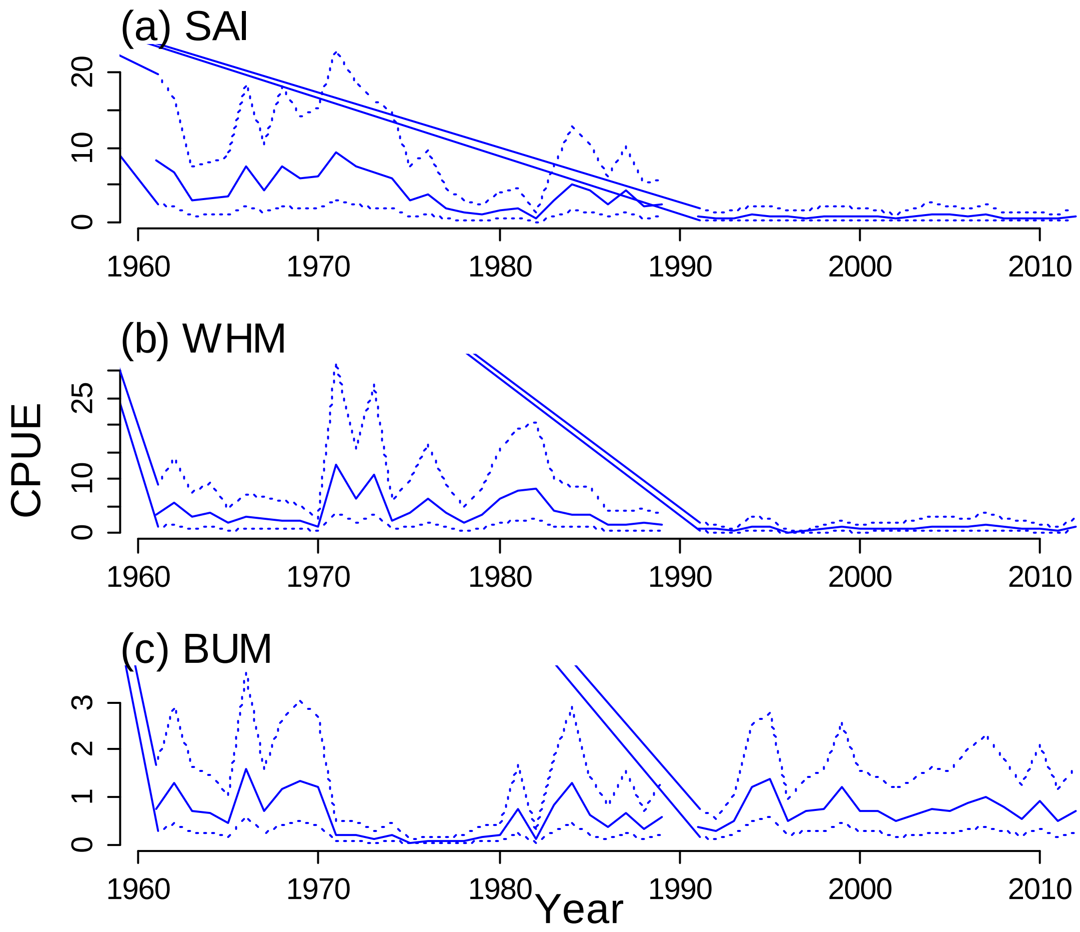

Figure 9. Fitted values for both datasets together.

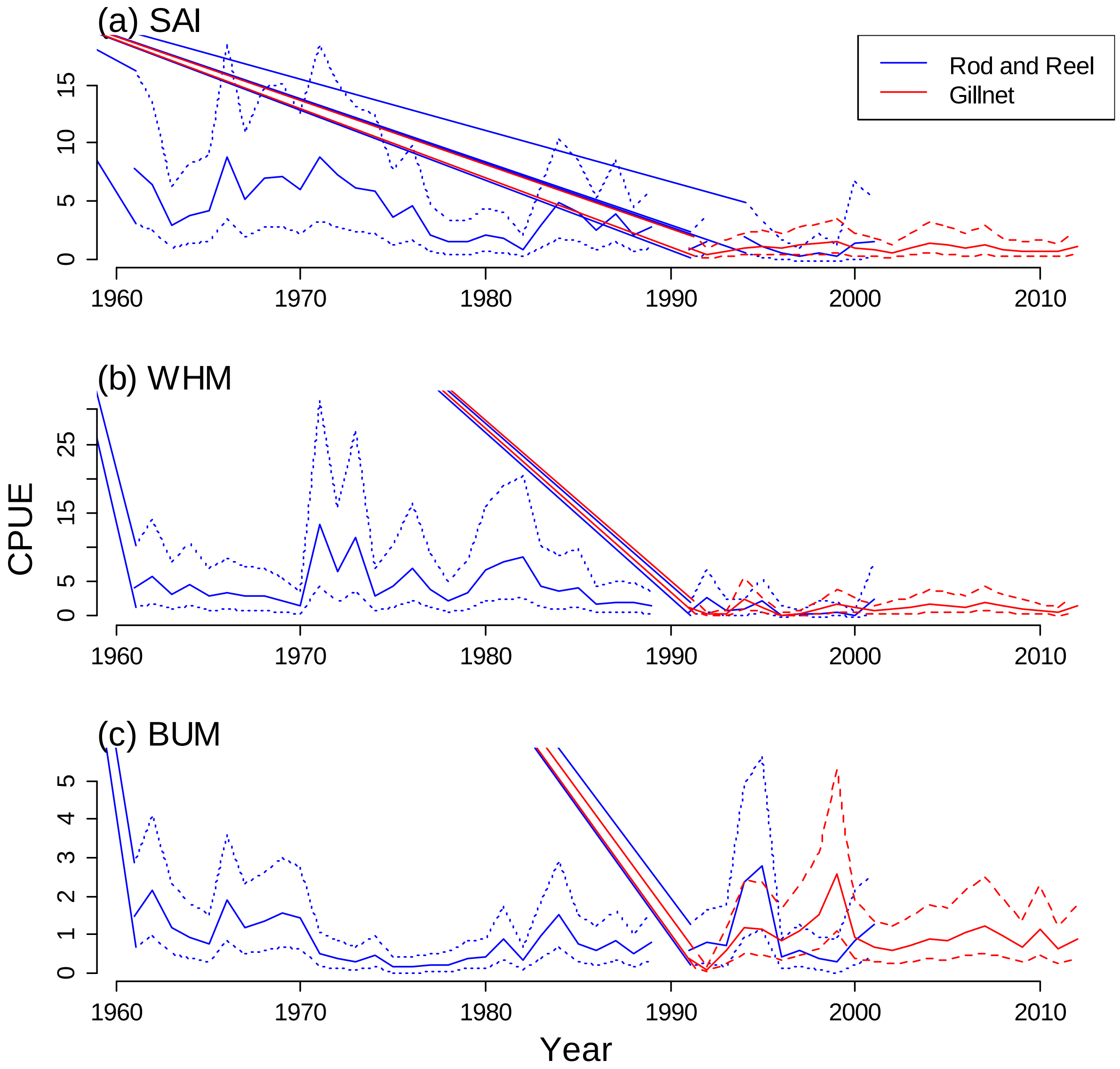

Figure 10. Fitted values for the two series separately.