

## STANDARDIZATION OF ARTISANAL AND RECREATIONAL CPUE FOR SAILFISH (*ISTIOPHORUS PLATYPTERUS*) IN THE EASTERN ATLANTIC OCEAN 1975-1996

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### SUMMARY

Catch and effort statistics for sailfish (*Istiophorus platypterus*) from the eastern Atlantic are used to generate estimates of standardized indices of abundance using general linear model (GLM) analysis. Standardized, adjusted annual fishing effort time series were generated for fisheries from three countries: the Ghanaian artisanal drift gillnet fishery from 1975 to 1994 was standardized by month, area, and a month by area interaction; the Senegalese artisanal and recreational fishery from 1982 to 1996 was standardized by gear and approximate bi-weekly (half month) period; and the artisanal drift gillnet fishery of Côte d'Ivoire from 1987 to 1996 was standardized by month. In addition, a single series was computed for the period from 1975 to 1996, incorporating all data, standardized by gear, area, month, and weighted by catch (kg) represented by each fishery. Historical standardized CPUE trajectories by year are presented for each fishery as well as combined fisheries. There is high variability in early years, and more recent stability for Ghana, Côte d'Ivoire and combined models. The Senegalese fishery has higher variability in the most recent years, and exhibits a more positive trend in standardized CPUE across the time series.

### RÉSUMÉ

Les statistiques de prise et d'effort pour le voilier (*Istiophorus platypterus*) de l'Atlantique Est sont utilisées pour obtenir des estimations d'indices d'abondance standardisés au moyen de l'analyse du Modèle Linéaire Généralisé (GLM). On a obtenu des séries temporelles d'effort de pêche annuel, standardisées et ajustées, de trois pays : la pêche artisanale au filet maillant dérivant ghanéenne de 1975 à 1994 a été standardisée par mois, zone et interaction mois/zone ; la pêche artisanale et sportive sénégalaise de 1982 à 1996 a été standardisée par engin et par période de deux semaines approximativement (la moitié d'un mois). La pêche artisanale au filet maillant dérivant de la Côte d'Ivoire de 1987 à 1996 a été standardisée par mois. Par ailleurs, une série unique a été calculée pour la période 1975-1996, incorporant toutes les données, standardisées par engin, zone, mois et pondérés par la prise (kg) de chaque pêche. Les trajectoires standardisées de CPUE historiques par année sont présentées pour chaque pêche ainsi que pour les pêcheries combinées. Il y a une grande variabilité pour les premières années, et récemment plus de stabilité en ce qui concerne le Ghana, la Côte d'Ivoire et des modèles combinés. La pêche sénégalaise a une variabilité plus élevée au cours des dernières années, et présente une tendance plus positive de la CPUE standardisée au cours de la série temporelle.

### RESUMEN

Las estadísticas de captura y esfuerzo para el pez vela (*Istiophorus platypterus*) del Atlántico este, se aplican para obtener estimaciones de índices de abundancia estandarizados por medio del análisis del Modelo Lineal Generalizado (GLM). Se obtuvieron series temporales de esfuerzo de pesca anual, estandarizada y ajustada para las pesquerías de 3 países: se estandarizó la pesquería artesanal de Ghana de redes de enmalle a la deriva de 1975 a 1994, por mes, zona e interacción mes/zona; la pesquería artesanal y de recreo de Senegal de 1982 a 1996 se estandarizó por zona y por período aproximado de dos semanas (medio mes). La pesquería artesanal de red de enmalle a la deriva de Côte d'Ivoire de 1987 a 1996 se estandarizó por mes. Además se calculó una serie única para el período 1975-1996, incorporando todos los datos, estandarizados por arte, zona, mes y ponderados por la captura (kg) de cada pesquería. Se presentan trayectorias estandarizadas de CPUE histórica por año, para cada pesquería y para pesquerías combinadas. Hay una gran variabilidad en los primeros años y recientemente más estabilidad en lo que respecta a Ghana, Côte d'Ivoire y modelos combinados. La pesquería senegalesa tiene mayor variabilidad en años recientes y presenta una tendencia más positiva en la CPUE estandarizada a lo largo de la serie temporal.

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## 1. INTRODUCTION

Nominal catch per unit effort (CPUE) estimates must be standardized to generate consistent indices across gear-based, spatial, and temporal boundaries. A standardized eastern Atlantic artisanal and recreational CPUE for sailfish (*Istiophous platypterus*) has historically been difficult to estimate, due to difficulties in obtaining catch-effort datasets and the possible inclusion of spearfish in the catch statistics. The most recent assessment attempt of sailfish in the eastern Atlantic (Farber et al., 1996) used two approaches to index abundance for the stock: a single index approach, with Japanese longline standardized CPUE as an index for all fisheries; and a two index approach, with Japanese standardized CPUE as an index for the longline fisheries and the Ghanaian drift gillnet nominal CPUE data as an index for all artisanal fisheries. Farber et al. (1996) emphasized the need to standardize artisanal CPUEs from Ghana, and addressed other problems with the catch-effort series for East Atlantic sailfish.

There has been significant development and revision of West African sailfish fishery databases. Much of the work was initiated at the Second ICCAT Billfish Workshop held in Miami in 1992 (ICCAT, 1994), and supplemented by Farber et al. (1995), as well as recent collaborative unpublished work between researchers in Senegal (T. Diouf, *pers. comm.*), Côte d'Ivoire, and Ghana. The Côte d'Ivoire database was previously standardized using sea surface temperature as an explaining variable (Joanny et al. 1994), and has been updated here.

In this study, we standardize the updated East Atlantic artisanal and recreational databases from Senegal, the updated (A. Herve, *pers. comm.*) artisanal database for Côte d'Ivoire, the artisanal database for Ghana, and compute a composite standardized CPUE for all countries combined. The analysis examines individual regions, time periods, and gears using a generalized linear model (GLM) approach.

## 2. DATA and METHODS

### 2.1 Senegalese Artisanal and Recreational Fishery

All catch and effort statistics for the Senegalese database were gathered and compiled through the government of Senegal (CRODT Dakar, Senegal, T. Diouf, *Pers. Comm.*) The artisanal database consists of nominal CPUE in kg/trip for three gear types: handline; trolling; and net. These data were collected in approximate bi-weekly (half month) periods from June to October, 1982 to 1996. The recreational database consists of nominal CPUE in kg/trip for rod and reel gear, collected in the same time strata as the artisanal fishery. The geographic region for these fisheries is located in Atlantic waters off Senegal. The GLM used period and gear as effects to

standardize nominal log CPUE. The computed standardized estimates were bias-corrected and adjusted, with 1982 as the standard year.

### 2.2 Côte d'Ivoire Drift Gillnet Fishery

All catch and effort statistics for the Côte d'Ivoire database were gathered and compiled through the government of Côte d'Ivoire (CRO Abidjan. Côte, d'Ivoire, S.N.Qatey, *Pers. Comm.*) The Côte d'Ivoire drift gillnet database consists of nominal CPUE in kg/trip. These data were collected monthly from 1987 to 1996. The fishery operates in a limited area offshore of the port of Abidjan, Côte d'Ivoire (Joanny et al. 1995). We had no sea surface/seasonal temperature data at the time of this analysis and hence employed a different methodology than Joanny et al (1995), using only month to standardize the nominal log CPUE. The computed standardized estimates were bias-corrected and adjusted, with 1987 as the standard year.

### 2.3 Ghanaian Drift Gillnet Fishery

All catch and effort statistics for the Ghana database were gathered and compiled through the government of Ghana (FRU, Tema, Ghana, A. Herve, *Pers. Comm.*) The Ghanaian artisanal drift gillnet fishery database consists of nominal CPUE in kg/trip collected monthly from 1975 to 1994. The data were collected from four major fishing regions off Ghana: western, central, greater-Accra, and Volta (Mensah and Doyi, 1994). The GLM used area, month, and an area/month interaction term as effects to standardize nominal log CPUE. The computed standardized estimates were bias-corrected and adjusted, with 1975 as the standard year.

### 2.4 Composite CPUE Series

To accommodate a single standardized CPUE series to represent all artisanal and recreational sailfish effort, we combined all nominal series into one dataset. The bi-weekly Senegalese fishery catch and effort statistics were combined into monthly statistics. Côte d'Ivoire and Senegal were each assigned an area, along with the four areas of the Ghanaian database. The model used month, area, and gear (no interactions) weighted by catch, to standardize the nominal data into one single standardized CPUE series. The computed standardized estimates were bias-corrected and adjusted, with 1996 as the standard year.

## 3. RESULTS and DISCUSSION

### 3.1 Senegal Artisanal and Recreational Fishery

The model results from the GLM fit for the Senegalese gear and period effects model indicated statistical significance of effects (Appendix 1). The computed standardized CPUE estimates for 1982 to 1996, along with upper and lower 95% confidence intervals (Table 1, Figure 1) demonstrates a variable trend that appears to exhibit a general increase across the time series. There is increasing variability toward the last 4-5 years in the series. The highest historical CPUE occurred in 1993.

### 3.2 Côte d'Ivoire Drift Gillnet Fishery

The results from the GLM fit for the Côte d'Ivoire model indicated statistical significance of the month and year effects (Appendix 2). Peak CPUE estimates are from the months of November to June. The computed standardized CPUE estimates for 1987 to 1996, along with upper and lower 95% confidence intervals (Table 2, Figure 2) demonstrate a decreasing trend across the time series. The highest variability is in the earlier years (1987-1988). There appears to be a slight upward turn in CPUE in the most recent two years of the series. The resulting annual CPUE trajectory of the month effect model is consistent with the seasonal model of Joanny et al. (1995), which examined catch effort data for the years 1987-1994 and included sea surface temperature data. However, the month effect approach exhibited a higher percentage of the variability explained by the model ( $r^2 = 0.66$ , Appendix 2) than that of the Joanny et al. analysis ( $r^2 = 0.50$ ).

### 3.3 Ghana Drift Gillnet Fishery

The model results from the GLM fit for the Ghana area, year, month, area-month effects model indicated statistical significance of effects and interaction (Appendix 3). The computed standardized CPUE estimates for 1975 to 1994, along with upper and lower 95% confidence intervals (Table 3, Figure 3) demonstrates an annual pattern that is variable, with a general increase in the later 1970's, a decrease in the early 1980's, and a stable trend in the 1990's. There is much higher variability in the 1970's and early 1980's, most likely due to the fact that there was only data recorded for the western region for the years 1975-1983.

### 3.4 Composite CPUE Series

The model results from the GLM fit for the combined area, year, month, gear model indicated statistical significance of effects (Appendix 4). The computed standardized CPUE estimates for 1975 to 1996, along with upper and lower 95% confidence intervals (Table 4, Figure 4) demonstrates a highly variable pattern in the 1970's, a general rise in CPUE in the early 1980's, and a decreasing pattern in the late 1980's into the 1990's. Because this composite CPUE has been weighted by catch, the pattern most closely resembles that of the Ghana data series for most years, as the Ghana driftnet catches are the highest of the fisheries considered. As with Ghana, there is much higher variability in the 1970's and early 1980's than in the latter part of the time series.

## 4. CONCLUSION

In this paper, we combined all of the available artisanal and recreational sailfish CPUE data sets from Senegal, Côte d'Ivoire, and Ghana in order to generate standardized abundance indices. A plot of all models (Senegal, Côte d'Ivoire, Ghana, and combined) overlaid (Figure 5) from 1975 to 1996 provides a comparison of results across years. These resulting adjusted standardized CPUEs will be used in conjunction with longline standardized CPUEs from the eastern Atlantic for stock assessment (Farber et al. 1997).

## 5. LITERATURE CITED

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**Table 3. Standardized annual CPUE (1975-1994) for the Ghana artisanal drift gillnet sailfish fishery, with upper and lower 95% confidence limits.**

Year	Lower 95% Confidence Limit	Adjusted, standardized CPUE	Upper 95% Confidence Limit
1975	0.40996	1	2.11322
1976	1.18062	2.45399	4.85644
1977	0.61045	1.37828	2.82691
1978	1.67739	3.39125	6.62474
1979	0.95527	2.02883	4.05429
1980	0.77386	1.68658	3.40858
1981	0.67804	1.50578	3.06748
1982	0.74985	2.19557	5.72031
1983	1.17286	2.43936	4.82884
1984	0.44753	0.89658	1.63247
1985	0.41158	0.79184	1.38884
1986	0.41157	0.82528	1.49559
1987	0.63487	0.95219	1.38259
1988	0.78649	1.17593	1.71093
1989	0.15299	0.33799	0.60678
1990	0.32182	0.57873	0.94996
1991	0.6688	1.08011	1.67447
1992	0.56061	0.93757	1.48864
1993	0.56745	0.92688	1.44329
1994	0.72983	1.09725	1.60169

**Table 1. Standardized annual CPUE (1982-1996) for the Senegalese artisanal and recreational sailfish fishery, with upper and lower 95% confidence limits.**

Year	Lower 95% Confidence Limit	Adjusted, standardized CPUE	Upper 95% Confidence Limit
1982	0.66866	1	1.44992
1983	0.52268	0.88137	1.40501
1984	0.13236	0.27179	0.46111
1985	0.17276	0.32664	0.53559
1986	0.63563	0.93459	1.33365
1987	0.57018	0.81562	1.13387
1988	0.76949	1.07405	1.46896
1989	0.94354	1.29973	1.76158
1990	0.70793	0.99423	1.36545
1991	0.6	0.85429	1.18401
1992	1.01054	1.46161	2.07316
1993	0.95096	1.82067	3.31644
1994	0.7901	1.54402	2.84066
1995	0.43292	0.92974	1.78417
1996	0.61966	1.2509	2.33652

**Table 4. Standardized annual CPUE (1975-1996) for the combined Senegal, Côte d'Ivoire, and Ghana artisanal and recreational sailfish fishery, with upper and lower 95% confidence limits.**

Year	Lower 95% Confidence Limit	Adjusted, standardized CPUE	Lower 95% Confidence Limit
1975	0.521946	1.080477	2.23669037
1976	2.816696	5.840387	12.109974
1977	0.577242	1.289217	2.8793433
1978	1.876911	3.974271	8.41532908
1979	1.361617	2.863826	6.02335505
1980	0.622814	1.345304	2.90590869
1981	0.558243	1.1957	2.56106786
1982	1.093863	2.304607	4.85546469
1983	1.502652	3.130885	6.52342602
1984	1.007161	2.135521	4.52802804
1985	0.776814	1.645617	3.48610417
1986	0.921409	1.963274	4.18320503
1987	0.842856	1.758935	3.67067586
1988	0.954954	1.943476	3.95526788
1989	0.86212	1.764296	3.61056785
1990	0.83257	1.699561	3.46938875
1991	0.4889	1.006775	2.07321499
1992	0.599731	1.224808	2.50137605
1993	0.453911	0.934784	1.92509482
1994	0.404905	0.829603	1.69975929
1995	0.446288	0.916344	1.88149311
1996	0.513131	1	1.94882046

**Table 2. Standardized annual CPUE (1987-1996) for the Côte d'Ivoire artisanal drift gillnet sailfish fishery, with upper and lower 95% confidence limits.**

Year	Lower 95% Confidence Limit	Adjusted, standardized CPUE	Upper 95% Confidence Limit
1987	0.34107	1	2.03813
1988	0.68718	0.97686	1.32282
1989	0.77803	1.08536	1.45239
1990	0.54928	0.81217	1.12614
1991	0.17804	0.36881	0.59663
1992	0.32431	0.54349	0.80526
1993	0.17466	0.36478	0.59182
1994	0.1341	0.31634	0.53397
1995	0.17901	0.36997	0.59803
1996	0.25029	0.4551	0.69969

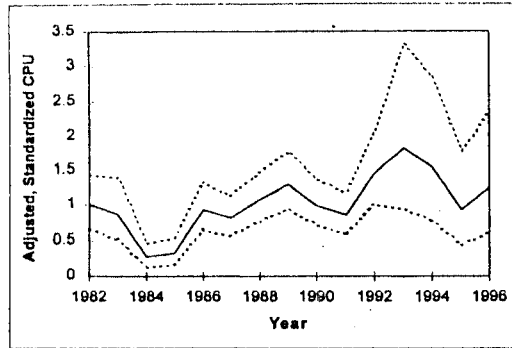


Figure 1. Sailfish standardized CPUE estimates for the Senegalese artisanal and recreational fishery with upper and lower 95% confidence limits, 1982 to 1996.

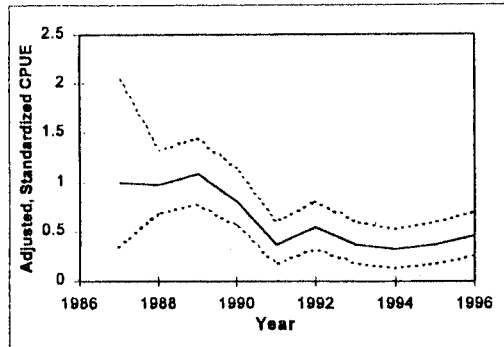


Figure 2. Sailfish standardized CPUE estimates for the Côte d'Ivoire artisanal drift gillnet fishery with upper and lower 95% confidence limits, 1987 to 1996.

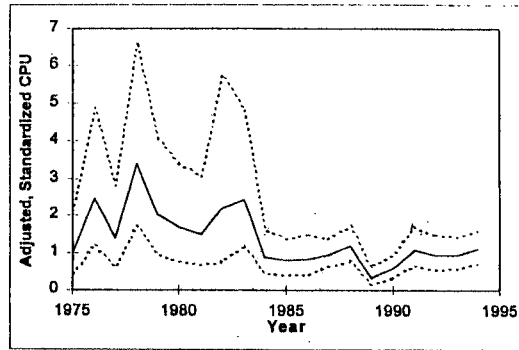


Figure 3. Sailfish standardized CPUE estimates for the Ghana artisanal drift gillnet fishery with upper and lower 95% confidence limits, 1975 to 1994.

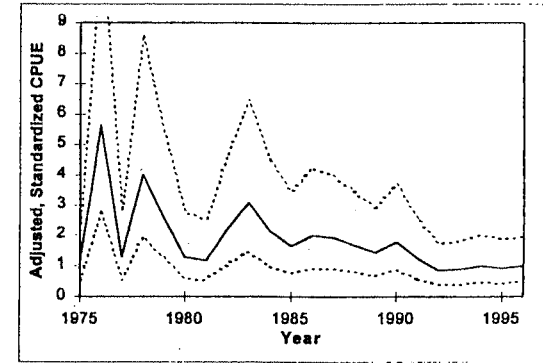


Figure 4. Sailfish standardized CPUE estimates for the combined Senegal, Côte d'Ivoire, and Ghana artisanal and recreational sailfish fishery, with upper and lower 95% confidence limits, 1975 to 1996.

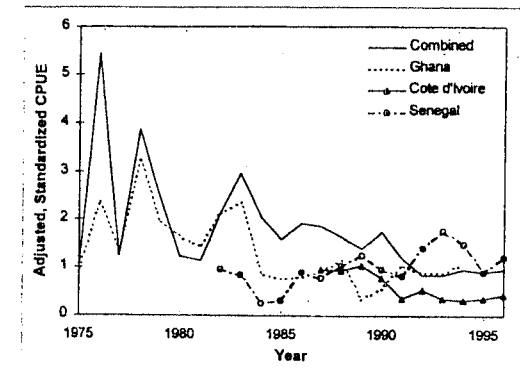


Figure 5. Overlaid sailfish standardized CPUE estimates for Senegal, Côte d'Ivoire, Ghana artisanal and recreational, and combined models, 1975 to 1996. All series have been scaled to the mean value of overlapping periods (1987-1994).

Appendix 1. General Linear Model (GLM) output for sailfish from Senegal artisanal and recreational data.

Class	Levels	Values
YEAR	15	1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996
GEAR	4	1 2 3 4
PERIOD	10	11 12 13 14 15 16 17 18 19 20

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	26	717.6227	27.60087	39.28	0.0001
Error	386	271.2139	0.702627		
Corrected Total	412	988.8366			

	R-Square	C.V.	Root MSE	LNCPUE MSE
	0.725724		51.83289	0.838228
			0.838228	1.617175

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
YEAR	14	46.04607	3.289005	4.68	0.0001
GEAR	3	441.0037	147.0012	209.22	0.0001
PERIOD	9	89.68113	9.96457	14.18	0.0001

Model Parameter Estimates

Parameter	Estimate	T for H0: Parameter=0	Pr >  T	Std Error of Estimate
INTERCEPT	3.056256570 B	10.46	0.0001	0.29215846
YEAR				
1982	-0.155867958 B	-0.50	0.6203	0.31437824
1983	-0.261435676 B	-0.76	0.4451	0.34202596
1984	-1.021496091 B	-3.25	0.0013	0.31437824
1985	-0.922844309 B	-2.94	0.0035	0.31437824
1986	-0.207971248 B	-0.67	0.5045	0.31132465
1987	-0.311058743 B	-1.01	0.3112	0.30675817
1988	-0.095239979 B	-0.31	0.7564	0.30675817
1989	0.061350565 B	0.20	0.8416	0.30675817
1990	-0.157072217 B	-0.51	0.6089	0.30675817
1991	-0.275650371 B	-0.90	0.3694	0.30675817
1992	0.156986492 B	0.48	0.6281	0.32378110
1993	0.320486420 B	0.85	0.3931	0.37486711
1994	0.177613255 B	0.47	0.6359	0.37486711
1995	-0.239465942 B	-0.64	0.5233	0.37486711
1996	0.000000000 B			
GEAR				
1	-1.547729538 B	-12.73	0.0001	0.12157920
2	-2.078730026 B	-14.38	0.0001	0.14458782
3	-3.006337654 B	-24.73	0.0001	0.12157920
4	0.000000000 B			
WAVE				
11	-0.622193709 B	-3.38	0.0008	0.18407850
12	0.043086690 B	0.23	0.8151	0.18407850
13	0.863518476 B	4.69	0.0001	0.18407850
14	0.809567914 B	4.40	0.0001	0.18407850
15	0.874197343 B	4.75	0.0001	0.18407850
16	0.756366090 B	4.11	0.0001	0.18407850
17	0.357360035 B	1.94	0.0529	0.18407850
18	0.165455244 B	0.90	0.3663	0.18291642
19	0.075436730 B	0.41	0.6803	0.18291642
20	0.000000000 B			

Appendix 2. General Linear Model (GLM) output for sailfish from Côte d'Ivoire artisanal gillnet data.

Class	Levels	Values
YEAR	10	1987 1988 1989 1990 1991 1992 1993 1994 1995 1996
MONTH	12	1 2 3 4 5 6 7 8 9 10 11 12

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	20	17.3161	0.865805	8.79	0.0001
Error	89	8.762605	0.098456		
Corrected Total	109	26.0787			

	R-Square	C.V.	Root MSE	LNCPUE MSE
	0.663994		58.22896	0.313777
			0.313777	0.538868

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
YEAR	9	3.962893	0.440321	4.47	0.0001
MONTH	11	12.55645	1.141496	11.59	0.0001

Model Parameter Estimates

Parameter	Estimate	T for H0: Parameter=0	Pr >  T	Std Error of Estimate
INTERCEPT	1.059009107 B	7.96	0.0001	0.13298743
YEAR				
1987	0.336835891 B	1.35	0.1795	0.24897984
1988	0.346715898 B	2.71	0.0081	0.12809907
1989	0.405858139 B	3.17	0.0021	0.12809907
1990	0.249677532 B	1.95	0.0544	0.12809907
1991	-0.071001007 B	-0.55	0.5808	0.12809907
1992	0.067852704 B	0.53	0.5976	0.12809907
1993	-0.074442082 B	-0.58	0.5626	0.12809907
1994	-0.116774172 B	-0.91	0.3644	0.12809907
1995	-0.070005863 B	-0.55	0.5861	0.12809907
1996	0.000000000 B			
MONTH				
1	-0.432292251 B	-2.96	0.0039	0.14605542
2	-0.465397121 B	-3.19	0.0020	0.14605542
3	-0.567501329 B	-3.89	0.0002	0.14605542
4	-0.243412072 B	-1.67	0.0991	0.14605542
5	-0.412365027 B	-2.82	0.0059	0.14605542
6	-0.773450825 B	-5.30	0.0001	0.14605542
7	-1.036287250 B	-7.10	0.0001	0.14605542
8	-1.086259090 B	-7.44	0.0001	0.14605542
9	-1.046521362 B	-7.17	0.0001	0.14605542
10	-0.936356939 B	-6.41	0.0001	0.14605542
11	-0.374514927 B	-2.67	0.0090	0.14032550
12	0.000000000 B			

Appendix 3. General Linear Model (GLM) output for sailfish from the Ghana artisanal drift gillnet fishery.

Class	Levels	Values
YEAR	20	1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994
AREA	4	1 2 3 4
MONTH	12	1 2 3 4 5 6 7 8 9 10 11 12

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	67	1047.39	15.63269	12.99	0.0001
Error	422	507.8449	1.203424		
Corrected Total	489	1555.235			

R-Square C.V. Root MSE LNCPUE MSE  
0.673461 54.80873 1.097007 2.001519

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
YEAR	19	103.7771	5.461952	4.31	0.0001
AREA	3	414.9136	138.3045	114.93	0.0001
MONTH	11	87.18386	7.925806	6.59	0.0001
AREA*MONTH	33	168.6146	5.109533	4.25	0.0001

Model Parameter Estimates

Parameter	Estimate	T for H0: Parameter=0	Pr >  T	Std Error of Estimate
INTERCEPT	0.140252607 B	0.25	0.8060	0.57077161
YEAR	1975 -0.113985904 B	-0.31	0.7568	0.36785041
	1976 0.655242072 B	1.78	0.0756	0.36785041
	1977 0.149374604 B	0.41	0.6849	0.36785041
	1978 0.952317054 B	2.59	0.0100	0.36785041
	1979 0.484552276 B	1.32	0.1885	0.36785041
	1980 0.322239458 B	0.88	0.3815	0.36785041
	1981 0.224524333 B	0.61	0.5419	0.36785041
	1982 0.560509653 B	1.14	0.2538	0.49052372
	1983 0.649828025 B	1.77	0.0780	0.36785041
	1984 -0.179253253 B	-0.59	0.5571	0.30501676
	1985 -0.269304172 B	-0.94	0.3490	0.28726027
	1986 -0.241689385 B	-0.81	0.4209	0.30001485
	1987 -0.112453003 B	-0.49	0.6227	0.22841237
	1988 0.056485138 B	0.24	0.8087	0.23319894
	1989 -0.828971111 B	-3.27	0.0012	0.25349524
	1990 -0.487958370 B	-1.94	0.0529	0.25133402
	1991 -0.017314108 B	-0.07	0.9451	0.25133402
	1992 -0.131308810 B	-0.51	0.6083	0.25600364
	1993 -0.138635229 B	-0.56	0.5780	0.24903638
	1994 0.000000000 B			
AREA	1 3.909217795 B	6.41	0.0001	0.61025310
	2 4.087533962 B	5.21	0.0001	0.78444336
	3 0.622370485 B	0.91	0.3620	0.68194436
	4 0.000000000 B			

Appendix 3. (cont.)

MONTH	1	0.741949700 B	1.00	0.3173	0.74109363
	2	-0.013000215 B	-0.02	0.9877	0.84065654
	3	0.116964252 B	0.16	0.8747	0.74109363
	4	-0.014121285 B	-0.02	0.9855	0.77788871
	5	-0.026860323 B	-0.04	0.9711	0.74109363
	6	0.001487748 B	0.00	0.9985	0.78279440
	7	-0.015883495 B	-0.02	0.9822	0.71062858
	8	-0.015883495 B	-0.02	0.9822	0.71062858
	9	0.249958020 B	0.35	0.7252	0.71062858
	10	0.696891812 B	0.98	0.3273	0.71062858
	11	0.247147406 B	0.35	0.7282	0.71062858
	12	0.000000000 B			
AREA*MONTH	1 1	-1.358306651 B	-1.66	0.0971	0.81680746
	1 2	-0.718032635 B	-0.79	0.4296	0.90810686
	1 3	-0.495060047 B	-0.61	0.5448	0.81680746
	1 4	-0.122352010 B	-0.14	0.8857	0.85033258
	1 5	-0.276662049 B	-0.34	0.7350	0.81680746
	1 6	-1.572647893 B	-1.84	0.0670	0.85621812
	1 7	-2.525724244 B	-3.19	0.0015	0.79078150
	1 8	-2.809457004 B	-3.56	0.0004	0.78927031
	1 9	-2.811270879 B	-3.56	0.0004	0.79078150
	1 10	-2.588110539 B	-3.27	0.0012	0.79078150
	1 11	-0.476122182 B	-0.60	0.5474	0.79078150
	1 12	0.000000000 B			
	2 1	-1.045304575 B	-1.02	0.3092	1.02659208
	2 2	-0.895111677 B	-0.83	0.4070	1.07848466
	2 3	-1.101307704 B	-1.10	0.2720	1.00123865
	2 4	-1.400537137 B	-1.36	0.1738	1.02810772
	2 5	-2.793146374 B	-2.76	0.0061	1.01244214
	2 6	-2.641842115 B	-2.56	0.0108	1.03183108
	2 7	-3.692606133 B	-3.77	0.0002	0.97880084
	2 8	-2.336436579 B	-2.39	0.0174	0.97880084
	2 9	-2.539020608 B	-2.59	0.0098	0.97880084
	2 10	-2.251372525 B	-2.30	0.0219	0.97880084
	2 11	-0.886920347 B	-0.91	0.3654	0.97880084
	2 12	0.000000000 B			
	3 1	0.114349949 B	0.12	0.9026	0.93387409
	3 2	0.035526953 B	0.04	0.9718	1.00377259
	3 3	-0.516579710 B	-0.56	0.5756	0.92199553
	3 4	-0.514891555 B	-0.54	0.5888	0.95182290
	3 5	0.092365949 B	0.10	0.9202	0.92199553
	3 6	0.214448907 B	0.22	0.8226	0.95583632
	3 7	0.538139441 B	0.60	0.5492	0.89769091
	3 8	0.132542684 B	0.15	0.8827	0.89769091
	3 9	-0.307704570 B	-0.35	0.7296	0.88949135
	3 10	-0.737687774 B	-0.82	0.4117	0.89769091
	3 11	-0.376095975 B	-0.41	0.6796	0.90992428
	3 12	0.000000000 B			
	4 1	0.000000000 B			
	4 2	0.000000000 B			
	4 3	0.000000000 B			
	4 4	0.000000000 B			
	4 5	0.000000000 B			
	4 6	0.000000000 B			
	4 7	0.000000000 B			
	4 8	0.000000000 B			
	4 9	0.000000000 B			
	4 10	0.000000000 B			
	4 11	0.000000000 B			
	4 12	0.000000000 B			

Appendix 4. General Linear Model (GLM) output for sailfish from the combined Senegal, Côte d'Ivoire, and Ghana artisanal and recreational sailfish fishery.

Class	Levels	Values
YEAR	22	1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996
AREA	6	1 2 3 4 5 6
GEAR	5	1 2 3 4 5
MONTH	12	1 2 3 4 5 6 7 8 9 10 11 12

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	40	179999.9	4499.998	164.44	0.0001
Error	648	17733.31	27.36622		
Corrected Total	688	197733.2			

R-Square C.V. Root MSE LNCPUE MSE  
0.910317 178.91 5.231273 2.92397

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
YEAR	21	12264.34	584.016	21.34	0.0001
AREA	4	31707.58	7926.895	289.66	0.0001
GEAR	3	2217.453	739.1509	27.01	0.0001
MONTH	11	3225.2	293.2	10.71	0.0001

Model Parameter Estimates

Parameter	Estimate	T for H0: Parameter=0	Pr >  T	Std Error of Estimate
INTERCEPT	4.562997537 B	13.40	0.0001	0.34042056
YEAR	1975 0.066443201 B	0.45	0.6537	0.14805181
	1976 1.753526743 B	11.68	0.0001	0.15013499
	1977 0.227942948 B	1.00	0.3187	0.22843714
	1978 1.364530917 B	7.80	0.0001	0.17498759
	1979 1.038156240 B	6.20	0.0001	0.16734609
	1980 0.277369033 B	1.41	0.1580	0.19621743
	1981 0.161162286 B	0.86	0.3902	0.18745240
	1982 0.820576586 B	4.85	0.0001	0.16931317
	1983 1.129121387 B	7.23	0.0001	0.15616838
	1984 0.743134328 B	4.21	0.0001	0.17650238
	1985 0.482716061 B	2.75	0.0061	0.17549560
	1986 0.658077299 B	3.62	0.0003	0.18185753
	1987 0.552211082 B	3.49	0.0005	0.15809614
	1988 0.656705223 B	5.27	0.0001	0.12468369
	1989 0.558949563 B	4.21	0.0001	0.13268234
	1990 0.522033870 B	4.04	0.0001	0.12912159
	1991 -0.003217895 B	-0.02	0.9818	0.14120712
	1992 0.194364144 B	1.50	0.1347	0.12976597
	1993 -0.077421433 B	-0.55	0.5839	0.14129477
	1994 -0.195831333 B	-1.46	0.1454	0.13433402
	1995 -0.096784666 B	-0.71	0.4810	0.13727166
	1996 0.000000000 B			

Appendix 4. (cont.)

AREA	1	-0.481075794 B	-1.47	0.1424	0.32758486
	2	-0.983911603 B	-2.58	0.0100	0.38096703
	3	-1.180953326 B	-2.39	0.0173	0.49476370
	4	-2.273077457 B	-0.57	0.5691	3.99055286
	5	-3.470056895 B	-10.72	0.0001	0.32374903
	6	0.000000000 B	.	.	.
GEAR	1	-2.283359653 B	-7.17	0.0001	0.31827347
	2	-3.644530523 B	-3.28	0.0011	1.11005290
	3	-3.660291460 B	-8.84	0.0001	0.41421490
	4	0.000000000 B	.	.	.
	5	0.000000000 B	.	.	.
MONTH	1	-0.117684134 B	-1.20	0.2304	0.09803065
	2	-0.561511924 B	-5.86	0.0001	0.09582056
	3	-0.451987639 B	-4.82	0.0001	0.09384711
	4	-0.260925877 B	-3.15	0.0017	0.08290570
	5	-0.206642135 B	-2.40	0.0167	0.08611067
	6	-1.136106361 B	-8.40	0.0001	0.13522916
	7	-0.623739105 B	-4.19	0.0001	0.14894199
	8	-0.779957272 B	-5.37	0.0001	0.14530711
	9	-0.692864314 B	-5.25	0.0001	0.13191934
	10	-0.627504369 B	-5.35	0.0001	0.11729562
	11	-0.388408376 B	-4.31	0.0001	0.09021301
	12	0.000000000 B	.	.	.