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STANDARDIZED CATCH RATES FOR SWORDFISH *(XIPHIAS GLADIUS)* FROM THE U.S. LONGLINE FLEET THROUGH 1995

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SUMMARY

Swordfish catch, size and effort data collected from the U.S. longline fleet operating over a wide geographical range of the western north Atlantic Ocean were used to develop age-specific indices of abundance of north Atlantic swordfish. Standardized catch rates were estimated using the Generalized Linear Modelling approach. Indices were also computed using sex-specific catch-at-age information for use in sex-specific evaluations of north Atlantic swordfish resource status.

RÉSUMÉ

Les données de capture, d'effort et de taille de l'espadon, provenant de palangriers américains actifs dans une large zone de l'Atlantique Nord-Ouest, ont été utilisées pour élaborer des indices d'abondance spécifiques de l'âge pour l'espadon de l'Atlantique Nord. Les taux de capture standardisés ont été estimés avec le Modèle Linéaire Généralisé. Des indices ont également été calculés avec des données de prise par taille spécifique du sexe, afin d'être utilisés dans des évaluations spécifiques du sexe de l'état du stock d'espadon de l'Atlantique Nord.

RESUMEN

Se usaron datos de captura, talla y esfuerzo, del pez espada, obtenidos de la flota palangrera estadounidense que opera en una amplia zona geográfica del Atlántico, para desarrollar índices de abundancia específicos de la edad del pez espada del Atlántico norte. Las tasas de captura normalizadas se estimaron mediante técnicas del Modelo Lineal Generalizado. También se computaron índices usando información de captura por edad específica de la talla para aplicarla a evaluaciones específicas del sexo para el recurso de pez espada en el Atlántico norte.

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Introduction

Information on the relative abundance of swordfish age classes is necessary to tune age-sequenced analyses (VPA). Data collected from the US longline fleet has been previously used to develop standardized catch per unit effort (CPUE) indices of abundance. This report documents the analytical methods applied to the available US longline fleet data through 1995 and presents age-specific, standardized CPUE indices for use in tuning swordfish VPAs, updating the material presented in Scott *et.al.* (1992, 1993) and Scott and Bertolino(1994, 1995). Swordfish catch, size and effort data collected from the US longline fleet operating over a wide geographical range of the western north Atlantic Ocean were used to develop age-specific indices of abundance of north Atlantic swordfish. Standardized catch rates were estimated using the General Linear Modeling (GLM) approach.

Methods

Hoey and Bertolino (1988) described the available catch and effort data for swordfish from the US longline fishery. Hoey *et. al.* (1989), Scott and Bertolino (1991,1994,1995) and Scott *et. al.* (1992, 1993) described the GLM method of analysis employed for indexing swordfish abundance from those data. The present analysis is an application of the GLM techniques to updated catch and effort data (through 1994) from the US longline fleet. Age-specific indices of abundance (ages 1, 2, 3, 4, and 5^+ groupings) are developed after ageing the swordfish catch using the age slicing method applying the ICCAT Gompertz growth model for pooled sexes in the fashion described by Nelson *et. al.* (1990) and as used by the 1992-94 SCRS swordfish species groups. In addition, sex-specific catch rate analyses were conducted using the Erhardt (1995) sex-specific growth models and sex-ratio at size estimates for the US catch (Turner and Arocha 1995, Turner SCRS/96/xxx). For the sex-specific analyses, the data set was limited to the period 1985-present since sex-ratio data prior to that period were considered too sparse to support the analysis (Turner SCRS/96/xxx).

For the present analysis, the analytical data base on US longline catch and effort for 1981 through 1995 was reviewed and updated based on fishermen's reports and/or interviews received since the previous update. A total of 5859 vessel trips, representing 123 different vessels from which at least two years catch and effort observations were available were used for analysis (Table 1). This represents an approximately 11% increase in observations compared to the 1995 analysis (Scott and Bertolino 1995). As described in Hoey *et.al.* (1989), Nelson *et.al.* (1990), Scott and Bertolino (1991, 1994, 1995), and Scott *et.al.* (1992, 1993), the available catch and effort data were cross classified by year, calendar quarter, area of fishing, size of set, proportion of total landed catch in a trip comprised of swordfish, operation style, and age class. Nominal CPUE values were calculated as fish caught per thousand hooks set. Average nominal values from the updated data set by year, age, and fishing area, using the Gompertz growth equation for pooled sexes are shown in Table 2.

Implementation of US regulations, which are in conformity with the ICCAT recommendations for conservation of swordfish and limit the allowable landings of swordfish by US fishermen, resulted in changes in both the type of data obtained and the manner in which the US data are obtained for analysis. Three regulatory effects in particular, are of importance to the present analysis. The first is implementation of the ICCAT recommended minimum size of 25 kg whole weight. The second is implementation of additional reporting requirements wherein US fishermen are required to report both their daily fishing effort and the individual sizes for all swordfish landed. Prior to implementation of these regulations, reporting of fish sizes was voluntary and incomplete for many vessels. The third is a restriction on the total allowable landed harvest level by US fishermen since 1991.

Seven geographical areas of fishing were used for classification as defined in Hoey *et.al.* (1990), Scott and Bertolino (1991, 1994, 1995) and Scott *et.al.* (1992, 1993). The areas used for classification were: Caribbean (CAR), Gulf of Mexico (GOM), Florida east coast (FEC), South Atlantic Bight (SAB), mid-Atlantic Bight (MAB), New England coastal (NEC) and northeast distant waters (NED). Four set size classifiers were used: 1, <100 hooks/set; 2, 100-299 hooks/set; 3, 300-499 hooks/set; and 4, ≥500 hooks/set. Set size was assumed to control for changes in gear deployment hypothesized to affect CPUE. The levels used in classification approximated the quartiles in the data set. Four levels of the proportion swordfish in the total landed catch in a trip were used corresponding to the quartiles into which the proportion of swordfish fell (*i.e.* ≤25%, >25-≤50%, >50-≤75%, and >75%). The proportion swordfish classifier was assumed to control for effects on swordfish CPUE through the diversification of the US longline fleet into a mixed species fishery and associated targeting on different species.

Nominal CPUE data were normalized through the natural log transform. Based on the results of Scott *et.al.* (1992) and the recommendation of the 1991 SCRS (SCRS Swordfish Assessment Group 1992), zero CPUE information was incorporated into the analyses by adding the zero CPUE effort uniformly across all other observations in the same analytical stratum.

Based on the 1991 SCRS recommendations (SCRS Swordfish Assessment Group, 1992), and those of Scott *et.al.* (1992) only models were fit to the data for which Least Square Means (LSM) for each year effect were estimable. In this analysis, due to the nature of the missing information, only main effect models resulted in estimable year effect LSMs. The final models fit to the CPUE data included main effects for year, calendar quarter, area, set size, operation style, and proportion swordfish. Standards were defined as the earliest year, and the highest classification level for all other main effects.

Results and Discussion

Analysis of variance (ANOVA) results for the models fit to the CPUE data are shown in Table 3. In all cases, the resulting F-statistic was highly significant. For the Gompertz age-slicing method the main effect models fit explained between 50 and 65% of the variability in the observed data, depending on the age groupings modeled. For the sex-specific analyses, the main effect models fit explained between 32 and 57% of the variability in the observed age groupings modeled.

Indices of age-specific abundance, based on the yearly LSM estimates from the models fit are also presented in Table 4 along with their 95% confidence regions (back transformed to arithmetic scale including a logarithmic bias correction) for the Gompertz ageing model. Graphically, these data are presented in Figure 1. As observed in prior GLM analyses of these data, the LSM estimates are sufficiently precise to allow discrimination of trend in the data for some ages. Indicies of age-specific abundance from the sex-specific analysis are presented in Table 5 along with their 95% confidence regions. Graphically, these results are shown in Figure 2.

Because the landing and sale of fish smaller the minimum size was restricted from 1991-present, catch rates estimated from landings data are underestimates of the actual catch rates. For this reason, estimates of standardized catch rates for fish aged 1 and 2 via either method of ageing were only computed through 1990.

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Table 1. Trip data with swordfish size, catch, and effort information available for analysis from the US longline fleet, 1981-1993.

	Year															
AREA	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	Total
CAR	0	0	0	0	10	39	88	150	63	49	59	51	72	95	82	758
GOM	0	1	7	5	36	39	75	64	78	58	48	81	58	56	60	666
FEC	26	28	26	76	60	100	278	361	208	136	181	250	208	265	222	2425
SAB	3	10	18	4	4	18	31	55	28	52	21	62	67	63	82	518
MAB	9	43	57	51	31	67	99	44	34	63	77	82	94	74	68	893
NEC	2	13	18	18	12	15	28	5	10	12	4	45	48	19	31	280
NED	3	6	9	13	19	18	27	41	30	23	26	32	30	24	18	319
Total	43	101	135	167	172	296	626	720	451	393	416	603	577	596	563	5859

Table 2. Nominal average swordfish CPUE (fish/1000 hooks) by area and age based on the SCRS 1992 ageing method from the US Longline fishery.

		Age				
AREA	YR	1	2	3	4	5+
CAR	85	1.42	2.44	6.95	11.03	12.89
CAR	86	1.80	8.43	12.23	15.06	13.80
CAR	87	1.81	7.50	9.46	8.37	8.18
CAR	88	2.14	7.97	10.81	7.13	5.90
CAR	89	0.54	4.97	9.66	7.92	8.70
CAR	90	0.91	4.62	7.37	5.97	6.71
CAR	91	.	.	8.36	9.20	11.16
CAR	92	.	.	4.92	5.64	7.26
CAR	93	.	.	5.49	4.88	8.40
CAR	94	.	.	7.86	6.41	5.12
CAR	95	.	.	6.77	6.02	5.25
GOM	82	0.00	8.60	7.37	2.46	7.37
GOM	83	5.58	10.91	13.42	6.35	8.20
GOM	84	4.67	20.14	8.77	5.11	4.39
GOM	85	3.33	6.76	5.01	2.73	2.21
GOM	86	3.96	4.30	1.73	0.62	0.60
GOM	87	0.46	2.04	1.51	0.58	0.73
GOM	88	2.74	4.00	2.68	1.56	1.59
GOM	89	2.52	9.67	5.01	2.11	2.84
GOM	90	2.80	5.50	5.06	2.05	2.59
GOM	91	.	.	2.87	1.70	2.07
GOM	92	.	.	2.32	1.15	1.06
GOM	93	.	.	3.16	1.54	0.98
GOM	94	.	.	2.07	1.15	0.55
GOM	95	.	.	3.89	1.70	0.88
FEC	81	4.19	8.22	8.43	6.00	14.52
FEC	82	0.86	4.70	9.06	9.38	17.44
FEC	83	2.96	4.34	5.58	5.86	8.78
FEC	84	3.28	7.53	6.69	4.16	5.90
FEC	85	1.98	4.11	5.62	4.29	6.56
FEC	86	8.08	11.24	6.47	3.04	3.10
FEC	87	4.16	11.14	7.98	3.63	3.41
FEC	88	4.57	10.02	8.92	4.01	3.55
FEC	89	3.30	11.35	6.99	3.64	3.92
FEC	90	5.00	10.89	8.26	3.42	3.16
FEC	91	.	.	9.88	4.97	3.81
FEC	92	.	.	7.83	3.52	3.52
FEC	93	.	.	7.14	3.40	3.60
FEC	94	.	.	7.79	4.00	3.04
FEC	95	.	.	8.43	4.20	4.00
SAB	81	6.97	21.78	49.16	13.95	18.33
SAB	82	4.08	15.45	15.88	8.28	11.59
SAB	83	8.90	19.64	11.50	4.47	10.32
SAB	84	1.94	8.91	10.42	2.39	5.26
SAB	85	7.12	10.71	11.95	5.19	3.47
SAB	86	15.84	27.44	10.86	1.96	1.48
SAB	87	9.30	38.46	17.58	4.33	2.20
SAB	88	6.41	17.52	14.99	4.61	2.67
SAB	89	3.43	16.36	7.98	2.88	1.62
SAB	90	4.39	13.14	11.73	3.11	2.34
SAB	91	.	.	8.30	2.62	2.77
SAB	92	.	.	14.60	4.91	1.96
SAB	93	.	.	10.11	3.25	1.94
SAB	94	.	.	10.74	3.32	1.94
SAB	95	.	.	10.49	3.62	1.77

		Age				
AREA	YR	1	2	3	4	5+
MAB	81	4.56	11.57	18.68	9.87	19.49
MAB	82	9.66	16.02	7.39	6.23	14.05
MAB	83	3.88	12.59	6.78	3.05	6.52
MAB	84	3.90	6.88	6.10	3.45	4.40
MAB	85	7.49	11.41	4.75	2.51	4.33
MAB	86	5.07	11.03	6.79	2.56	3.15
MAB	87	2.46	7.40	4.89	2.56	2.90
MAB	88	3.40	5.54	4.04	1.79	1.97
MAB	89	1.76	5.14	3.03	1.79	1.83
MAB	90	3.55	4.01	3.12	1.30	1.93
MAB	91	.	.	1.64	1.04	1.33
MAB	92	.	.	1.22	0.63	0.92
MAB	93	.	.	1.17	0.67	0.90
MAB	94	.	.	1.03	0.46	0.81
MAB	95	.	.	0.95	0.50	1.05
NEC	81	1.35	3.64	2.95	2.05	3.37
NEC	82	5.40	5.55	5.73	6.35	8.59
NEC	83	1.72	5.41	3.32	2.60	5.31
NEC	84	0.57	5.10	7.40	5.34	9.73
NEC	85	2.73	6.83	8.62	6.20	6.94
NEC	86	2.94	7.87	6.73	3.74	5.11
NEC	87	2.52	6.32	5.51	2.45	3.62
NEC	88	0.69	3.41	4.57	2.01	2.15
NEC	89	5.14	10.84	5.73	2.29	3.01
NEC	90	4.24	5.16	5.48	2.42	2.52
NEC	91	.	.	4.52	4.34	4.21
NEC	92	.	.	1.62	0.64	1.05
NEC	93	.	.	1.27	0.87	0.79
NEC	94	.	.	1.17	0.57	0.71
NEC	95	.	.	0.95	0.44	0.39
NED	81	0.02	0.27	1.46	3.28	5.74
NED	82	0.02	0.56	5.13	6.38	8.40
NED	83	0.08	1.62	3.89	7.18	12.21
NED	84	0.71	4.60	11.69	11.66	15.19
NED	85	1.53	8.03	23.81	23.82	24.14
NED	86	2.19	9.82	11.56	11.88	13.04
NED	87	3.20	9.83	11.87	7.90	9.74
NED	88	2.16	16.46	17.27	9.80	8.39
NED	89	2.54	12.08	16.40	7.86	6.15
NED	90	1.67	8.86	17.51	10.05	6.48
NED	91	.	.	13.56	9.61	7.36
NED	92	.	.	9.94	7.12	5.99
NED	93	.	.	11.26	6.69	5.23
NED	94	.	.	10.41	6.40	4.25
NED	95	.	.	10.23	4.90	3.37

Table 3. US LL swordfish CPUE ANOVA results, using distributed effort method.

GOMPERTZ AGEING, POOLED SEXES:

Dependent Variable: Ln(age 1/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	30	2363.02778401	78.76759280	81.81	0.0001
Error	1719	1655.04008952	0.96279237		
Corrected Total	1749	4018.06787353			
	R-Square	C.V.	Root MSE		T2CPU1 Mean
	0.588101	111.3423	0.98121984		0.88126386
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	9	45.18955082	5.02106120	5.22	0.0001
QTR	3	1595.83390662	531.94463554	552.50	0.0001
AREA	6	106.30887077	17.71814513	18.40	0.0001
OP	6	100.56529703	16.76088284	17.41	0.0001
SZST	3	75.76043465	25.25347822	26.23	0.0001
TARG	3	76.96333367	25.65444456	26.65	0.0001

Dependent Variable: Ln(age 2/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	30	1865.66349925	62.18878331	94.52	0.0001
Error	2820	1855.49446223	0.65797676		
Corrected Total	2850	3721.15796149			
	R-Square	C.V.	Root MSE		T2CPU2 Mean
	0.501366	44.96371	0.81115767		1.80402742
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	9	108.68679414	12.07631046	18.35	0.0001
QTR	3	421.69576481	140.56525494	213.63	0.0001
AREA	6	96.88677373	16.14779562	24.54	0.0001
OP	6	114.08638140	19.01439690	28.90	0.0001
SZST	3	68.13427558	22.71142519	34.52	0.0001
TARG	3	290.77718228	96.92572743	147.31	0.0001

Dependent Variable: Ln(age 3/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	35	4581.10619936	130.88874855	283.70	0.0001
Error	5319	2454.02019948	0.46136872		
Corrected Total	5354	7035.12639884			
	R-Square	C.V.	Root MSE		T2CPU3 Mean
	0.651176	42.87766	0.67924128		1.58413789
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	14	65.15496939	4.65392639	10.09	0.0001
QTR	3	7.73843260	2.57947753	5.59	0.0008
AREA	6	295.12197618	49.18699603	106.61	0.0001
OP	6	91.50289536	15.25048256	33.05	0.0001
SZST	3	136.03837753	45.34612584	98.29	0.0001
TARG	3	821.53283160	273.84427720	593.55	0.0001

Dependent Variable: Ln(age 4/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	35	3729.23525171	106.54957862	233.24	0.0001
Error	4702	2147.97526694	0.45682162		
Corrected Total	4737	5877.21051865			
	R-Square	C.V.	Root MSE		T2CPU4 Mean
	0.634525	64.63188	0.67588581		1.04574686
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	14	79.94743259	5.71053090	12.50	0.0001
QTR	3	256.11923640	85.37307880	186.88	0.0001
AREA	6	456.54378876	76.09063146	166.57	0.0001
OP	6	63.77851577	10.62975263	23.27	0.0001
SZST	3	67.43823386	22.47941129	49.21	0.0001
TARG	3	503.59191934	167.86397311	367.46	0.0001

Dependent Variable: Ln(age 5+/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	35	3661.84061919	104.62401769	203.50	0.0001
Error	4678	2405.07209489	0.51412400		
Corrected Total	4713	6066.91271409			
	R-Square	C.V.	Root MSE		T2CP5P Mean
	0.603576	70.71291	0.71702441		1.01399364
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	14	375.72129462	26.83723533	52.20	0.0001
QTR	3	308.27536373	102.75845458	199.87	0.0001
AREA	6	410.71866155	68.45311026	133.15	0.0001
OP	6	43.25744457	7.20957410	14.02	0.0001
SZST	3	77.19888314	25.73296105	50.05	0.0001
TARG	3	374.01003333	124.67001111	242.49	0.0001

SEX-SPECIFIC AGEING:

Dependent Variable: Ln(age 1/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	26	1434.70541984	55.18097769	73.92	0.0001
Error	2455	1832.53468044	0.74644997		
Corrected Total	2481	3267.24010029			
	R-Square	C.V.	Root MSE		T2CPU1 Mean
	0.439118	52.95013	0.86397336		1.63167376
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	5	58.42982009	11.68596402	15.66	0.0001
QTR	3	324.72439885	108.24146628	145.01	0.0001
AREA	6	86.24168727	14.37361455	19.26	0.0001
OP	6	263.98176802	43.99696134	58.94	0.0001
SZST	3	93.15543145	31.05181048	41.60	0.0001
TARG	3	79.68205612	26.56068537	35.58	0.0001

Dependent Variable: Ln(age 2/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	26	1052.36784733	40.47568644	76.16	0.0001
Error	2466	1310.64337992	0.53148556		
Corrected Total	2492	2363.01122725			
	R-Square	C.V.	Root MSE		T2CPU2 Mean
	0.445350	47.34777	0.72903056		1.53973573
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	5	12.46435493	2.49287099	4.69	0.0003
QTR	3	13.70022799	4.56674266	8.59	0.0001
AREA	6	204.08011387	34.01335231	64.00	0.0001
OP	6	175.56490403	29.26081734	55.05	0.0001
SZST	3	62.45141620	20.81713873	39.17	0.0001
TARG	3	69.96743958	23.32247986	43.88	0.0001

Dependent Variable: Ln(Age 3/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	3647.81810911	117.67155191	198.78	0.0001
Error	4678	2769.19239157	0.59196075		
Corrected Total	4709	6417.01050068			
	R-Square	C.V.	Root MSE		T2CPU3 Mean
	0.568461	88.57773	0.76938986		0.86860415
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	10	49.49342569	4.94934257	8.36	0.0001
QTR	3	99.69938862	33.23312954	56.14	0.0001
AREA	6	644.12556725	107.35426121	181.35	0.0001
OP	6	244.37663061	40.72943843	68.80	0.0001
SZST	3	189.92823172	63.30941057	106.95	0.0001
TARG	3	275.95109520	91.98369840	155.39	0.0001

Dependent Variable: Ln(Age 4/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	3126.66995043	100.86032098	176.88	0.0001
Error	4354	2482.67010934	0.57020443		
Corrected Total	4385	5609.34005977			
	R-Square	C.V.	Root MSE		T2CPU4 Mean
	0.557404	226.9518	0.75511882		0.33272212
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	10	66.53234923	6.65323492	11.67	0.0001
QTR	3	93.43227856	31.14409285	54.62	0.0001
AREA	6	652.99881132	108.83313522	190.87	0.0001
OP	6	224.33559954	37.38926659	65.57	0.0001
SZST	3	118.24887774	39.41629258	69.13	0.0001
TARG	3	186.91551050	62.30517017	109.27	0.0001

Dependent Variable: Ln(Age 5/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	2313.73678702	74.63667055	142.56	0.0001
Error	3839	2009.93895199	0.52355795		
Corrected Total	3870	4323.67573901			
	R-Square	C.V.	Root MSE		T2CPU5 Mean
	0.535132	-897.5520	0.72357304		-0.08061628
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	10	56.14964993	5.61496499	10.72	0.0001
QTR	3	70.12706568	23.37568856	44.65	0.0001
AREA	6	476.47866618	79.41311103	151.68	0.0001
OP	6	162.48621645	27.08103607	51.73	0.0001
SZST	3	124.90569591	41.63523197	79.52	0.0001
TARG	3	135.68345293	45.22781764	86.39	0.0001

Dependent Variable: Ln(Age 6/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	1606.62999612	51.82677407	94.96	0.0001
Error	3339	1822.36407113	0.54578139		
Corrected Total	3370	3428.99406725			
	R-Square	C.V.	Root MSE		T2CPU6 Mean
	0.468543	-183.9320	0.73877019		-0.40165394
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	10	74.25039051	7.42503905	13.60	0.0001
QTR	3	93.76953722	31.25651241	57.27	0.0001
AREA	6	338.80446121	56.46741020	103.46	0.0001
OP	6	110.42347890	18.40391315	33.72	0.0001
SZST	3	79.50855248	26.50285083	48.56	0.0001
TARG	3	89.90366013	29.96788671	54.91	0.0001

Dependent Variable: Ln(Age 7/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	1232.00797366	39.74219270	70.77	0.0001
Error	2853	1602.22771389	0.56159401		
Corrected Total	2884	2834.23568755			
	R-Square	C.V.	Root MSE		T2CPU7 Mean
	0.434688	-110.2112	0.74939576		-0.67996346
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	10	87.08151163	8.70815116	15.51	0.0001
QTR	3	137.72457737	45.90819246	81.75	0.0001
AREA	6	207.47432249	34.57905375	61.57	0.0001
OP	6	88.82766635	14.80461106	26.36	0.0001
SZST	3	47.34500944	15.78166981	28.10	0.0001
TARG	3	94.11796066	31.37265355	55.86	0.0001

Dependent Variable: Ln(Age 8/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	638.53198123	20.59780585	29.87	0.0001
Error	1976	1362.57614835	0.68956283		
Corrected Total	2007	2001.10812958			
	R-Square	C.V.	Root MSE		T2CPU9 Mean
	0.319089	-60.38790	0.83039920		-1.37510859
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	10	129.96654344	12.99665434	18.85	0.0001
QTR	3	127.12352228	42.37450743	61.45	0.0001
AREA	6	58.56266213	9.76044369	14.15	0.0001
OP	6	30.79941648	5.13323608	7.44	0.0001
SZST	3	48.22840753	16.07613584	23.31	0.0001
TARG	3	20.59346503	6.86448834	9.95	0.0001

Dependent Variable: Ln(Age 9/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	638.53198123	20.59780585	29.87	0.0001
Error	1976	1362.57614835	0.68956283		
Corrected Total	2007	2001.10812958			
	R-Square	C.V.	Root MSE		T2CPU9 Mean
	0.319089	-60.38790	0.83039920		-1.37510859
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	10	129.96654344	12.99665434	18.85	0.0001
QTR	3	127.12352228	42.37450743	61.45	0.0001
AREA	6	58.56266213	9.76044369	14.15	0.0001
OP	6	30.79941648	5.13323608	7.44	0.0001
SZST	3	48.22840753	16.07613584	23.31	0.0001
TARG	3	20.59346503	6.86448834	9.95	0.0001

Dependent Variable: Ln(Age 10+/1000 hooks)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	31	3132.07662092	101.03472971	105.86	0.0001
Error	3908	3729.93069496	0.95443467		
Corrected Total	3939	6862.00731588			
	R-Square	C.V.	Root MSE		T2CP5P Mean
	0.456437	-150.4090	0.97695172		-0.64953019
Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	10	577.45549499	57.74554950	60.50	0.0001
QTR	3	250.33493325	83.44497775	87.43	0.0001
AREA	6	341.26236122	56.87706020	59.59	0.0001
OP	6	96.22318346	16.03719724	16.80	0.0001
SZST	3	134.02700665	44.67566888	46.81	0.0001
TARG	3	236.52050345	78.84016782	82.60	0.0001

Table 4. Annual, standardized age-specific CPUE from the distributed effort method for the Gompertz aged CPUE for pooled sexes, expressed relative (REL column) to the 1981 mean, with approximate upper and lower 95% confidence intervals (UREL and LREL).

Yr	UREL	REL	LREL
		Age 1:	
81	0.58501	1.00000	1.70938
82	0.80597	1.28964	2.06356
83	0.77396	1.18181	1.80458
84	0.81427	1.23448	1.87155
85	1.00438	1.52502	2.31554
86	1.41440	2.06350	3.01050
87	1.14422	1.65502	2.39385
88	1.31485	1.90351	2.75571
89	1.21851	1.75632	2.53150
90	0.94980	1.38953	2.03282
		Age 2:	
81	0.72701	1.00000	1.37550
82	0.61155	0.81406	1.08364
83	0.72291	0.93508	1.20951
84	0.78266	1.00286	1.28502
85	0.79792	1.02648	1.32050
86	1.25951	1.58556	1.99601
87	1.29994	1.61711	2.01167
88	1.36710	1.70113	2.11678
89	1.48093	1.84678	2.30300
90	1.08477	1.35833	1.70088
		Age 3:	
81	0.78460	1.00000	1.27454
82	0.66299	0.80460	0.97645
83	0.56070	0.66773	0.79520
84	0.70086	0.82574	0.97289
85	0.73460	0.87006	1.03051
86	0.76403	0.88589	1.02718
87	0.82337	0.94285	1.07968
88	0.86378	0.98864	1.13156
89	0.76850	0.88306	1.01470
90	0.80059	0.92323	1.06466
91	0.83111	0.95919	1.10701
92	0.69943	0.80217	0.92001
93	0.61223	0.70169	0.80422
94	0.65322	0.75004	0.86122
95	0.70743	0.81251	0.93319

Yr	UREL	REL	LREL
		Age 4:	
81	0.78325	1.00000	1.27674
82	0.71613	0.88122	1.08436
83	0.45406	0.54986	0.66587
84	0.50980	0.61061	0.73135
85	0.56181	0.67550	0.81220
86	0.46271	0.54672	0.64597
87	0.44352	0.51701	0.60267
88	0.45226	0.52692	0.61391
89	0.41483	0.48463	0.56617
90	0.40618	0.47743	0.56117
91	0.49911	0.58636	0.68887
92	0.40865	0.47751	0.55799
93	0.36826	0.43033	0.50287
94	0.37152	0.43435	0.50782
95	0.40929	0.47857	0.55958
		Age 5+:	
81	0.78455	1.00000	1.27461
82	0.67258	0.82800	1.01934
83	0.39491	0.47834	0.57940
84	0.32488	0.39058	0.46956
85	0.33601	0.40535	0.48900
86	0.22136	0.26210	0.31033
87	0.18815	0.21954	0.25617
88	0.17572	0.20475	0.23857
89	0.19379	0.22702	0.26593
90	0.17950	0.21103	0.24811
91	0.21537	0.25319	0.29766
92	0.17439	0.20363	0.23778
93	0.16645	0.19447	0.22720
94	0.13950	0.16329	0.19112
95	0.15980	0.18714	0.21916

Table 5. Annual, standardized age-specific CPUE from the distributed effort method for the sex-specific aged CPUE, expressed relative (REL column) to the 1985 mean, with approximate upper and lower 95% confidence intervals (UREL and LREL).

Yr	UREL	REL	LREL
Age 1:			
85	0.70576	1.00000	1.41691
86	1.10282	1.54523	2.16512
87	1.08039	1.49895	2.07966
88	1.12868	1.56533	2.17091
89	1.31069	1.81446	2.51184
90	0.85785	1.19438	1.66292
Age 2:			
85	0.74595	1.00000	1.34058
86	0.90990	1.20967	1.60820
87	0.87522	1.15342	1.52004
88	1.00073	1.31855	1.73730
89	0.87166	1.14649	1.50797
90	0.90340	1.19520	1.58126
Age 3:			
85	0.80537	1.00000	1.24167
86	0.69465	0.85193	1.04483
87	0.72697	0.88030	1.06597
88	0.77914	0.94237	1.13979
89	0.72808	0.88251	1.06969
90	0.74227	0.90496	1.10332
91	0.86627	1.05668	1.28893
92	0.61247	0.74346	0.90246
93	0.61727	0.74737	0.90488
94	0.63644	0.77219	0.93690
95	0.67709	0.82168	0.99715
Age 4:			
85	0.79530	1.00000	1.25738
86	0.71187	0.88541	1.10125
87	0.65152	0.80079	0.98426
88	0.62832	0.77162	0.94761
89	0.65211	0.80173	0.98567
90	0.63172	0.78175	0.96740
91	0.75068	0.92934	1.15051
92	0.53210	0.65523	0.80685
93	0.53232	0.65589	0.80814
94	0.52937	0.65227	0.80371
95	0.52615	0.64823	0.79862
Age 5:			
85	0.78117	1.00000	1.28014
86	0.76244	0.96567	1.22306
87	0.63739	0.79812	0.99937
88	0.62981	0.78760	0.98494
89	0.66264	0.82860	1.03613
90	0.60543	0.76306	0.96174
91	0.74953	0.94529	1.19219
92	0.53568	0.67302	0.84557
93	0.59939	0.75071	0.94023
94	0.52298	0.65656	0.82426
95	0.51945	0.65318	0.82133
Age 6:			
85	0.74445	1.00000	1.34328
86	0.75584	1.00721	1.34218
87	0.59508	0.78479	1.03499
88	0.55729	0.73422	0.96731
89	0.58179	0.76906	1.01660
90	0.53352	0.70755	0.93834
91	0.67144	0.89103	1.18243
92	0.47516	0.62687	0.82703
93	0.51363	0.67710	0.89258
94	0.42882	0.56750	0.75103
95	0.46816	0.62021	0.82165
Age 7:			
85	0.76810	1.00000	1.30191
86	0.63775	0.82363	1.06369
87	0.49132	0.62450	0.79378
88	0.42339	0.53741	0.68214
89	0.48064	0.60992	0.77397
90	0.41581	0.53286	0.68286
91	0.51952	0.66620	0.85429
92	0.41652	0.53145	0.67811
93	0.40010	0.51133	0.65347
94	0.34274	0.43879	0.56174
95	0.38841	0.49686	0.63559
Age 8:			
85	0.65154	1.00000	1.53484
86	0.51109	0.78048	1.19185
87	0.39766	0.60045	0.90666
88	0.32792	0.49436	0.74528
89	0.39520	0.59443	0.89410
90	0.28044	0.42584	0.64665
91	0.32718	0.49779	0.75737
92	0.30229	0.45798	0.69386
93	0.29980	0.45398	0.68744
94	0.25807	0.39126	0.59320
95	0.34961	0.53142	0.80778
Age 9:			
85	0.63385	1.00000	1.57766
86	0.39073	0.61110	0.95576
87	0.28726	0.44382	0.68571
88	0.28550	0.44050	0.67964
89	0.28852	0.44427	0.68409
90	0.19788	0.30852	0.48100
91	0.23275	0.36244	0.56440
92	0.20397	0.31665	0.49159
93	0.25636	0.39816	0.61838
94	0.17899	0.27902	0.43494
95	0.27109	0.42338	0.66121
Age 10+:			
85	0.71992	1.00000	1.38904
86	0.31507	0.43289	0.59476
87	0.22140	0.29960	0.40543
88	0.19435	0.26254	0.35465
89	0.20876	0.28279	0.38307
90	0.10847	0.14783	0.20146
91	0.16420	0.22403	0.30565
92	0.12116	0.16417	0.22244
93	0.15530	0.21025	0.28465
94	0.11404	0.15492	0.21045
95	0.19487	0.26495	0.36023

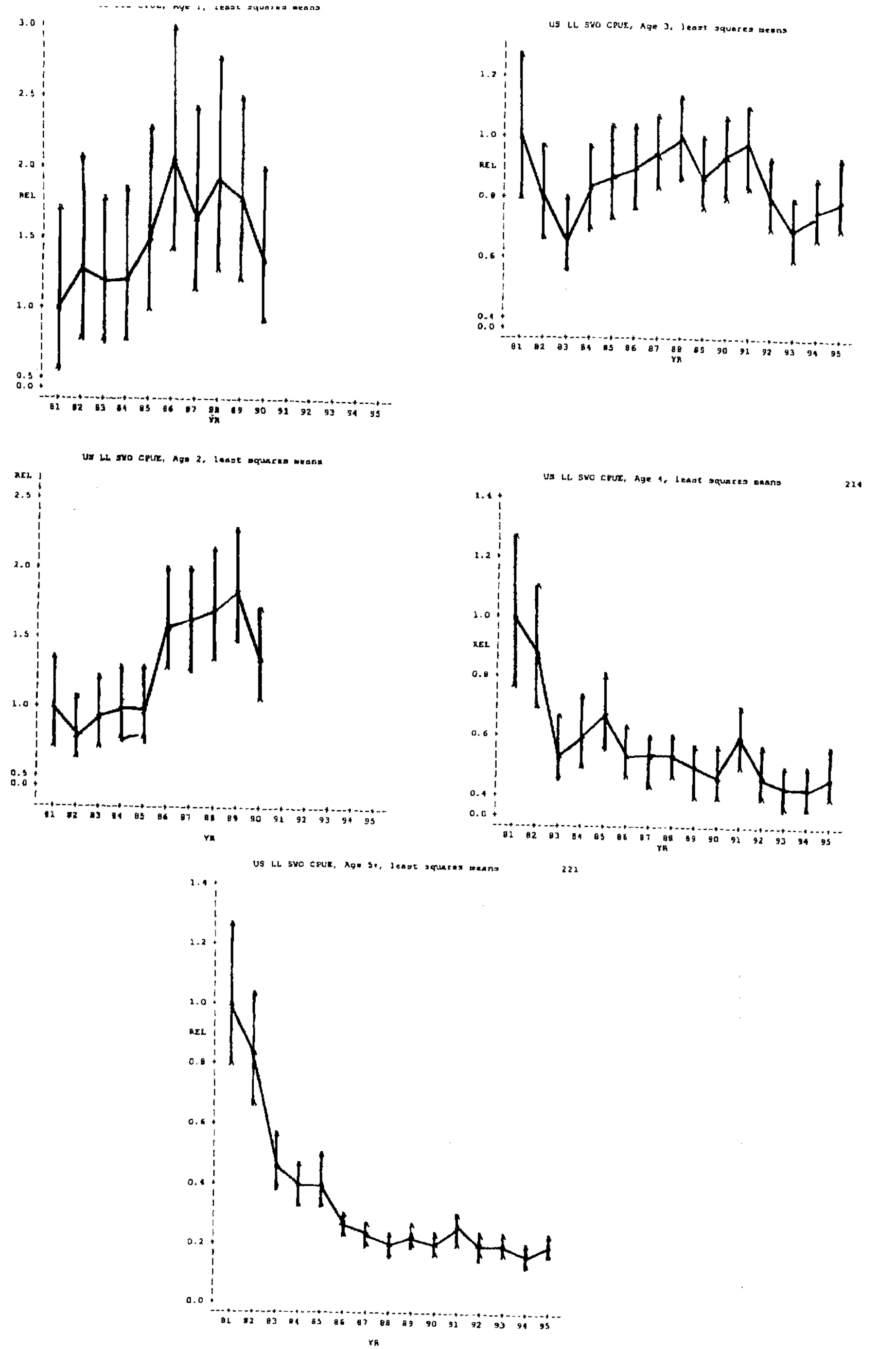

Figure 1. Standardized catch rate trajectories for Gompertz growth, pooled sexes. Associated approximate 95% confidence ranges for the age classes indicated.

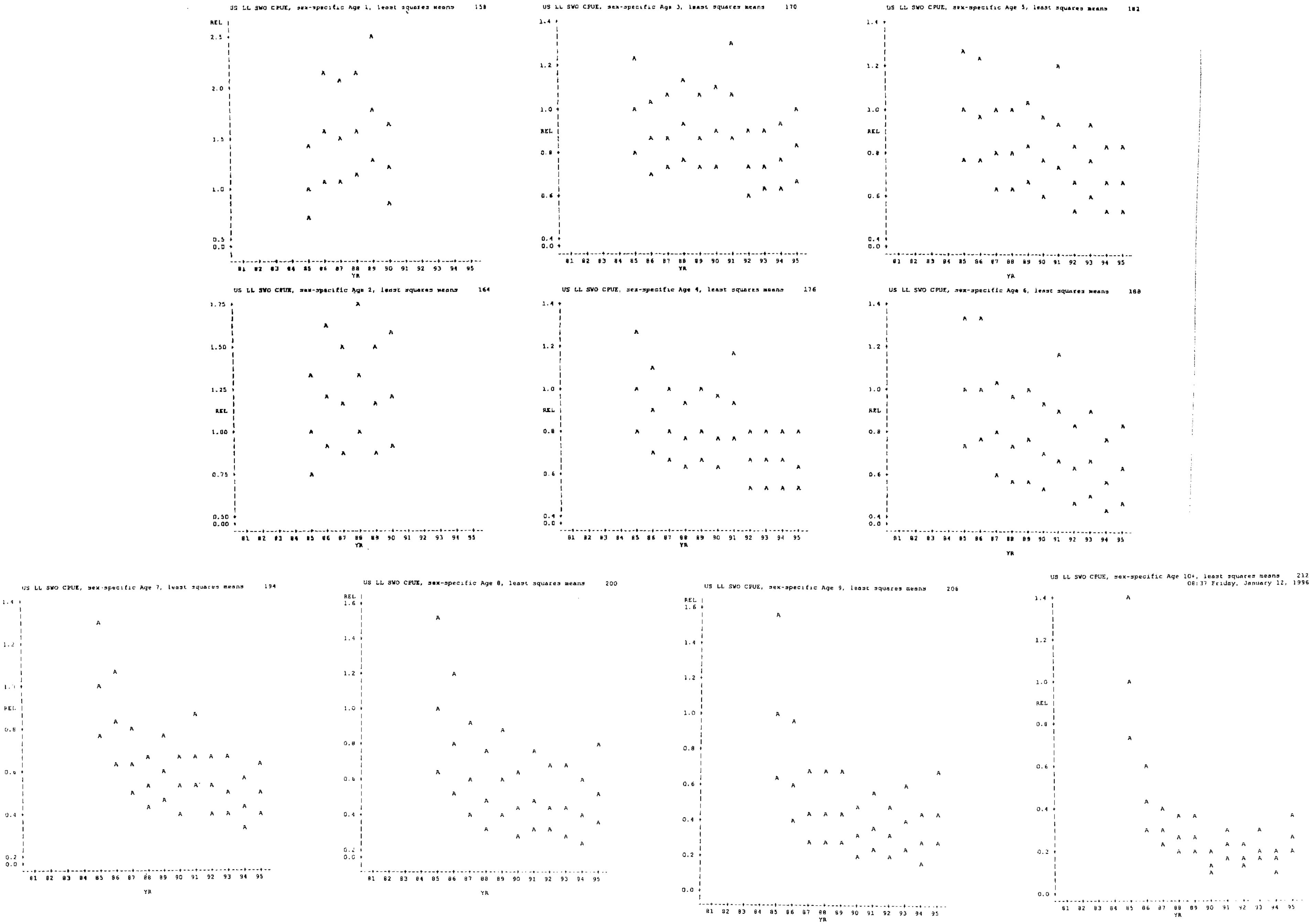

Figure 2. Standardized catch rate trajectories for sex-specific growth. Associated approximate 95% confidence ranges for the age classes indicated.