

ESTIMATES OF SWORDFISH DISCARDED DEAD BY U.S. LONGLINE VESSELS SINCE 1991

SCRS/1994/115

Col.Vol.Sci.Pap. ICCAT, 44 (3) : 149-155 (1995)

Cramer, J., A.R. Bertolino, G.P. Scott

National Marine Fisheries Service, Southeast Fisheries Center, 75 Virginia Beach Drive, Miami, Florida 33149, U.S.A.

SUMMARY

Self reported catch per unit effort (CPUE) of swordfish discarded dead by U.S. longline vessels tends to be lower than observer reported CPUE. Furthermore, size information for discarded swordfish is available only from observer data. General linear models techniques are used to estimate numbers of dead swordfish discarded, and estimated numbers are then distributed over the size frequencies reported by observers to estimate total weight of dead discards.

RESUME

La capture par unité d'effort (CPUE) d'espados rejetés morts, déclarée par les palangriers des Etats-Unis est en général inférieure à la CPUE déclarée par les observateurs. En outre, l'information sur la taille des espados rejetés n'est disponible qu'à partir des données des observateurs. Les techniques de modèles linéaires généralisés sont utilisées pour évaluer le nombre d'espados rejetés morts, et les chiffres estimés sont alors calculés en fonction des fréquences de taille déclarées par les observateurs, pour évaluer le poids total des rejets morts.

RESUMEN

La captura comunicada por unidad de esfuerzo (CPUE) de pez espada descartado muerto por los barcos palangreros de Estados Unidos tiende a ser inferior a la CPUE comunicada por observadores. Además, sólo se dispone de información sobre tallas de pez espada descartado a partir de datos de observadores. Las técnicas de modelos lineales generalizados se emplean para estimar números de ejemplares de pez espada descartados muertos, y los números estimados se distribuyen entonces en las frecuencias de talla comunicadas por observadores para estimar el peso total de los descartes muertos.

INTRODUCTION

The percentage of undersized, < 25 kg live weight, swordfish landed by U.S. longline boats has decreased since June 1991 when domestic regulations limited the take of undersized swordfish to 15% based on number of swordfish landed per trip (Figure 1). During this period, the percentage of reported discarded swordfish increased from 6% in 1990 to 35% in 1993 (Table 1). Since 50% of the discarded swordfish reported were dead, cryptic mortality (mortality not evident in the landings data) has become a larger part of overall swordfish mortality since implementation of the minimum size regulation.

Cramer *et al.* 1993 compared 1992 mandatory observer data (OBS) to 1992 mandatory self reported logbook data (LB) and concluded that observed catch rates of swordfish discarded dead were generally higher than self reported. Comparison of mean and median catch rates of swordfish discarded dead in 1993 OBS and 1993 LB indicate that this trend has continued into 1993. However, differences between catch rates of swordfish discarded dead reported by OBS and by LB do not tend to be as large as in 1992 (Figures 2a-2g).

The purpose of this paper is to present estimates of U.S. dead, discarded catch of swordfish, based on analysis of logbook, observer, and landings data. Incorporation of these estimates into stock assessment will provide a more accurate basis for providing advice about the status of this resource.

MATERIALS AND METHODS

Data from three main sources were used in this analysis. Landed catch at size was available through the usual methods applied for reporting annual catch at size to ICCAT. Reports of daily kept and discarded catch as well as daily effort expended during the period 1991 - 1993 were recorded in the mandatory self reported logbook (LB). However, no information on the size of the kept or discarded catch is available in logbook reports. Observer data (OBS) on daily catch and effort were available from the sampled portion of the fleet in 1992 and 1993. Catch at size data (for both the kept and discarded portion of the catch) were also available from OBS.

Discarded Catch At Size

Observer data were used to estimate the discarded catch at size in the U.S. longline fleet. Observers measure LJFL (cm) of both the kept and discarded portions of the catch. Lengths of discarded swordfish estimated and recorded in OBS were grouped by year, area and quarter to create size frequency samples which were raised by estimates of discarded catch to estimate discarded catch at size. Lengths from 1992 and 1993, and quarters 3 and 4, were combined to make size frequency samples for each area for quarters 3 and 4 of 1991. In cases where area

and/or quarter was unknown, size frequencies were based on average length frequencies for the whole year or, in the case of 1991, combined 1992 and 1993 lengths from quarters 3 and 4.

Weights (DW, kg) were estimated for each fish in the catch at size file from the observer measured length using the formula:

$$DW = 4.592 * 10^{-6} * LJFL^{3.1370}$$

from Turner, 1986. Whole weight was taken as $DW * 1.33$.

Numbers of swordfish discarded dead reported for gears other than longline were multiplied by the average weight from the observed catch at size for the appropriate year.

Discarded Catch

Several approaches were taken to model catch rate of dead discards for longline gear in OBS compared to LB using general linear model (GLM) techniques. Model variables included year, quarter (time of year), area (Caribbean (CAR), Gulf of Mexico (GOM), Florida East Coast (FEC), South Atlantic Bight (SAB), Mid Atlantic Bight (MAB), Northeast Coastal (NEC), and Northeast Distant (NED)), source (OBS/LB), light sticks (present/absent), mainline length, number of bigeye and yellowfin tuna kept (tuncr), sea surface temperature, and number of hooks. Number of swordfish discarded dead is referred to as swod and Ln refers to the natural log.

The first approach, which will be referred to as the median ratio method, was similar to that used by Cramer *et al.* 1993. By this method, the estimate of discarded catch is taken as:

$$\hat{C}_{OBS} = \hat{C}_{LB} \left(\frac{CPUE_{OBS}}{CPUE_{LB}} \right)$$

where \hat{C}_{OBS} is the estimated catch of dead discards, C_{LB} is the reported catch of dead discards from logbooks, and $CPUE_{OBS}$ and $CPUE_{LB}$ are the GLM estimates of marginal median dead discard catch rates for the observer data and the logbook data sets.

To estimate the ratio $CPUE_{OBS}/CPUE_{LB}$, GLMs were fit for each year and area, and each year (areas combined). Since observer data were not available for 1991, estimates for the second half of 1991 were made by combining 1992 and 1993 data from quarters 3 and 4. Similarly, since observer coverage of the southern areas (CAR GOM FEC AND SAB) in early 1992 was minimal, the 1992 estimates for those areas were based on combined 1992 and 1993 data for all quarters within each area. Estimates from GLMs on combined areas were used

when the area of the reported discarding was unknown. In these cases area was included as a model variable. Catch of dead discards was estimated as the product of the reported number of discarded dead swordfish and the ratio of the appropriate OBS and LB model estimated median CPUE. Application of this method does not take into account the actual distribution of effort among classification variables in the models applied.

In order to explicitly take into account the distributions of effort among classification variables we used GLM model predictions of catch, assuming the catch rates were as estimated by observers. In the second approach, referred to as the +const. transformation method, a GLM was developed to estimate:

$$\text{Ln}(\text{swod} + \text{const.}) = \text{year area quarter light source tuncr main Ln}(\text{hooks}).$$

In this approach, a GLM was fit to the data which included LB from the last two quarters of 1991 and OBS and LB from 1992 and 1993. This approach allowed the model to estimate catches that would have occurred in 1991 given the differences in observed and self reported catch rates for 1992 and 1993. The parameter value for source = LB was used as the standard so the estimates of catch based on observer catch rates could be made by adding the parameter value for source = OBS to all the LB predicted values and then summing these values (after back transformation). To evaluate the sensitivity of the estimates to the value of the constant (const.) added, 2 values were used: 1 and 0.13.

The third GLM approach, referred to as the Lo method, applied the delta-lognormal approach described by Lo *et al.* (1992) in which the log-transformed positive catch of dead discards (without any constant added) and the proportion of observations (sets) for which there was a positive catch of dead discards were modelled separately to produce an estimate as:

$$\hat{C} = \hat{C}_p \hat{S} = [\Psi_c e^{\beta_c}] [\Psi_s e^{\beta_s} - 1],$$

where \hat{C} represents the estimated annual catch, \hat{C}_p , the annual standardized positive catch of dead discards, and \hat{S} the annual standardized proportion of sets fished in which swordfish were discarded dead. Following Lo *et al.* (1992), a value of 1 was added to the observed S values to permit inclusion of 0 values in modelling the log-transformed observations. In the above equation, β_c and β_s , represent the log-scale, standardized GLM estimates of marginal mean (LSMEAN) catch and proportion of sets fished on which swordfish were discarded dead, and Ψ_c and Ψ_s , the log-transformation bias adjustments for β_c and β_s , respectively. Variance in \hat{C} was estimated via the delta method. The appropriate equations for estimating this variance and calculating the log-transformation bias adjustment terms are provided in Lo *et al.* (1992).

Another estimate of dead discarded catch for 1993 only was made by comparison of the observed catch at size distribution (by 5cm LJFL intervals) for the kept and discarded dead catch with the estimated landed catch at size (by 5 cm LJFL intervals). The 1993 U.S. longline landed

catch at size (75,361 fish) and observed k. pt plus dead discarded catch at size (4,891 fish) are shown in Figure 3. The estimated number of fish discarded dead was made by scaling the assumed fully-represented observed catch at size to the landed catch at size over the same size ranges. The scaling factor used was that which resulted in a minimum Chi-square statistic over the assumed fully-represented size ranges.

$$\sum \frac{(O_i - L_i)^2}{L_i}$$

where O_i represents the observed and L_i , the landed catch in LJFL interval i . The first fully-represented size interval was taken as the modal interval in either the observed catch at size distribution (140-144 cm LJFL) or the landed catch at size distribution (130-134 cm LJFL). The scaling factor was then multiplied by the observed catch at size for each interval to produce a scaled catch at size distribution. The difference between the scaled catch at size and the landed catch at size for the length intervals smaller than the assumed fully-represented interval was taken as an estimate of dead discarded fish in 1993.

Numbers of dead discards reported and estimated numbers of swordfish discarded dead for each year, area, and quarter from the median ratio, +const. transformation (const.=1), and Lo methods were multiplied by average weights from the appropriate catch at size file to arrive at estimates of cryptic catch in metric tons (Table 2). The model using the +const. transformation (with const.= 0.13) was discarded on the basis of poorly distributed residuals.

RESULTS

Estimates of dead swordfish discarded based on GLM techniques were consistently higher than reported (Table 2). Estimated metric tons of dead swordfish discarded varied between methods. Logbook reports ranged from 186-318mt between 1991 and 1993; the median ratio method estimates ranged from 427-608mt; the +const.=1 method estimates ranged from 277-482 mt; and the Lo method estimates ranged from 216-413mt. The +const. transformation and Lo methods were preferred over the median ratio method because these methods had the advantage of accounting for the distributions of effort among classification variables explicitly. Because of the high incidence of zero catch rates in the data, the Lo method was considered the most appropriate of the GLM techniques. Lo method estimates of the catch of swordfish discarded dead were 15,534 (216mt) in 1991, 25,638 (388mt) in 1992 and 28,326 (413mt) in 1993.

To evaluate the potential accuracy of the Lo estimates, an alternative estimate, which

compares the distributions of landed and observed catch was made. This method was applied to the aggregate data for 1993 only and does not explicitly account for differential sampling among areas and times which could affect the results. A more detailed analysis involving quarterly and area stratified data would be required to help control for these effects. The target sampling fraction for observer coverage in the U.S. permitted large pelagic fleet is 5% of the prior year reported fishing effort (longline sets). Application of this method to the data in Figure 3 results in a scaling factors of 20.19 and 21.04, values which are close to the expected scaler resulting from a random sample at a realized 5% sampling fraction of fishing effort. Application of these scalars to the observed catch at size distribution results in a estimates of 1993 dead discarded catch by the observed U.S. longline fleet of 24,191 and 28,945 fish (Table 3). These numbers are close to the Lo method estimate for 1993 catch from longline gear of 28,066.

REFERENCES CITED

- Cramer, J., A. R. Bertolino, and G. P. Scott. 1993. Estimates of the catch of undersized swordfish by the U.S. large pelagic fleet based on logbook reports and scientific observations. SCRS/93/103
- Lo, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. *Can. J. Fish. Aquat. Sci.* 49:2515-2526.
- Turner, S. 1986. Length to weight and weight to length conversions for swordfish in the Western North Atlantic and Gulf of Mexico. *Swordfish Workshop Working Paper* 86/11.

Table 1. Yearly tabulations for swordfish from the mandatory self reported logbook for 1990 through 1993. Information includes % fish kept; % discarded; (discarded live and discarded dead where available); Effort in hooks; number of sets; and average of the individual catch rates of kept fish, equivalent to cpue [AVG(C/E)], in fish/1000 hooks. These tables include sets from all gears which include hooks and report to this database.

SWORDFISH TOTALS FOR 1990 - 1993							
YEAR	HOOKS	SETS	%KEPT	%DISC			AVG(C/E)
				all	dead	alive	
1990	6865305	16521	94	6			0.2312
1991	7493976	15679	78	22			0.1886
1992	8361699	15455	67	31	19	12	0.1557
1993	9056417	15220	65	35	23	12	0.0667

Table 2. Estimates in Numbers (#) and metric tons (MT) of swordfish discarded dead reported (LB) and estimated using the median ratio (MR), + C transformation (const.=1; +1), Lo and size distribution (SZ) methods.

ESTIMATED SWORDFISH DISCARDED DEAD
ALL GEAR TYPES

Swordfish discarded dead

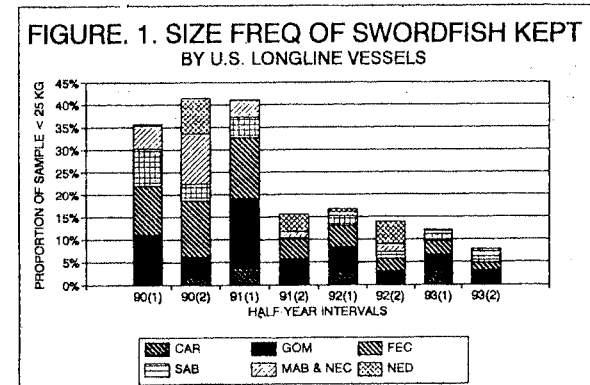
YEAR	numbers				
	LB	MR	+1	Lo	SZ*
91	12,760	28,766	20,191	15,534	
92	18,757	38,395	31,301	25,638	
93	22,224	42,492	33,330	28,326	24,192-28,945

YEAR	metric tons			
	LB	MR	+1	Lo
91	186	427	277	216
92	284	593	471	388
93	318	608	482	413

*longline only (add 260 fish for other gear types in 1993)

Table 3. Estimates of 1993 kept and discarded dead swordfish by U.S. longline gear by comparison of landed catch at size (LAND) and observed kept and discarded dead catch at size (OBS) by length categories (LEN). The scaling factor found to most closely match the landed catch at size for fish a) >140 cm LJFL was 20.19, or b) >130 cm LJFL was 21.04, values which were multiplied against the data in the OBS column to produce the data in the SCALED column.

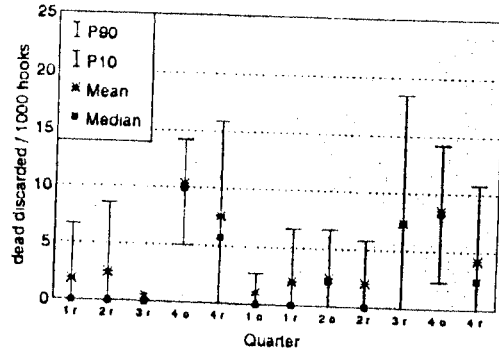
a) full-represented length: 140-144 cm, scalar = 20.19				b) full-represented length: 130-134 cm, scalar = 21.04			
LEN	LAND	OBS	SCALED	LEN	LAND	OBS	SCALED
<95cm	49.0	475	9590.25	<95 cm	49.0	475	9994.00
95- 99	47.9	118	2382.42	95- 99	47.9	118	2482.72
100-104	108.8	130	2624.70	100-104	108.8	130	2735.20
105-109	178.2	152	3068.88	105-109	178.2	152	3198.08
110-114	517.3	206	4159.14	110-114	517.3	206	4334.24
115-119	1122.7	199	4017.81	115-119	1122.7	199	4186.96
120-124	2290.9	246	4966.74	120-124	2290.9	246	5175.84
125-129	4822.8	284	5733.96	125-129	4822.8	284	5975.36
130-134	8517.2	312	6299.28	130-134	8517.2	312	6564.48
135-139	7820.8	338	6824.22	135-139	7820.8	338	7111.52
140-144	6888.3	350	7066.50	140-144	6888.3	350	7364.00
145-149	7466.2	321	6480.99	145-149	7466.2	321	6753.84
150-154	5259.4	281	5673.39	150-154	5259.4	281	5912.24
155-159	5269.3	215	4340.85	155-159	5269.3	215	4523.60
160-164	4198.0	201	4058.19	160-164	4198.0	201	4229.04
165-169	3133.8	173	3492.87	165-169	3133.8	173	3639.92
170-174	3398.9	171	3452.49	170-174	3398.9	171	3597.84
175-179	2626.8	129	2604.51	175-179	2626.8	129	2714.16
180-184	2184.4	139	2806.41	180-184	2184.4	139	2924.56
185-189	1820.7	86	1736.34	185-189	1820.7	86	1869.44
190-194	1696.5	77	1554.63	190-194	1696.5	77	1620.08
195-199	1271.1	64	1292.16	195-199	1271.1	64	1346.56
200-204	1097.4	40	807.60	200-204	1097.4	40	841.60
205-209	819.3	37	747.03	205-209	819.3	37	778.48
210-214	646.8	40	807.60	210-214	646.8	40	841.60
215-219	499.5	19	383.61	215-219	499.5	19	399.76
220-224	430.1	22	444.18	220-224	430.1	22	462.88
225-229	265.5	16	323.04	225-229	265.5	16	336.64
230-234	254.7	13	262.47	230-234	254.7	13	273.52
235-239	168.6	11	222.09	235-239	168.6	11	231.44
240-244	117.7	8	161.52	240-244	117.7	8	168.32
245-249	99.8	7	141.33	245-249	99.8	7	147.28
>=250cm	272.3	11	222.09	>=250cm	272.3	11	231.44
Totals	75360.7	4891	98749.29	Totals	75360.70	4891	102906.64
<140cm SCALED-LAND = 24191.80				<130cm SCALED-LAND = 28944.80			



FIGURES 2a - 2g.

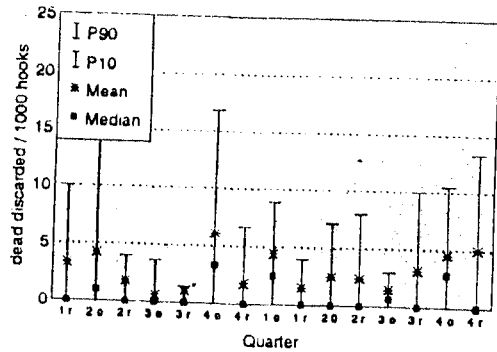
NOMINAL MEANS, MEDIANS AND 10th TO 90th PERCENTILE BARS FOR NUMBERS OF SWORDFISH DISCARDED DEAD BY LONGLINE BOATS REPORTED TO THE MANDATORY SELF REPORTED LOGBOOK (LB) AND THE MANDATORY OBSERVER PROGRAM (OBS) IN THE CARIBBEAN (2a), GULF OF MEXICO (2b), FLORIDA EAST COAST (2c), SOUTH ATLANTIC BIGHT (2d), MID ATLANTIC BIGHT (2e), NORTHEAST COASTAL (2f), AND NORTHEAST DISTANT (2g).

FIGURE 2a. Swordfish Discarded Dead Caribbean 1992 & 1993 by quarter



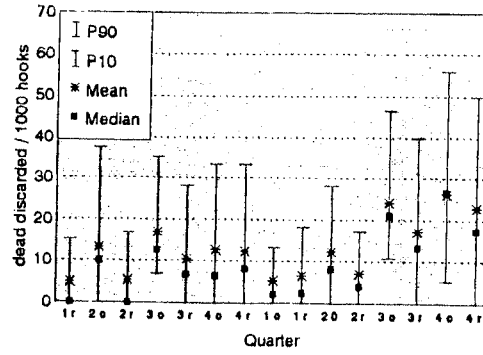
observed (o), reported (r)

FIGURE 2b. Swordfish Discarded Dead Gulf of Mexico 1992 & 1993 by quarter



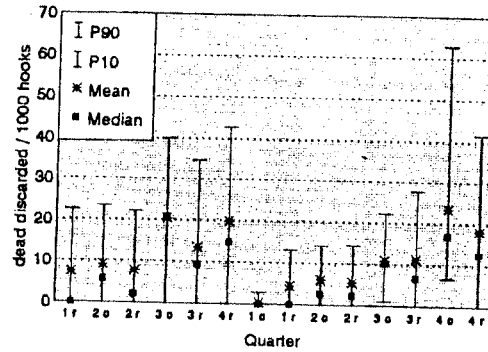
observed (o), reported (r)

FIGURE 2c. Swordfish Discarded Dead Florida East Coast 1992 & 1993 by quarter



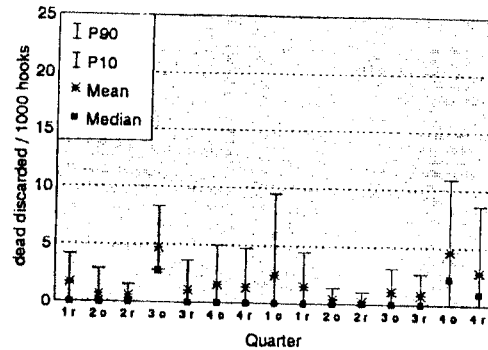
observed (o), reported (r)

FIGURE 2d. Swordfish Discarded Dead South Atlantic Bight 1992 & 1993 by quarter



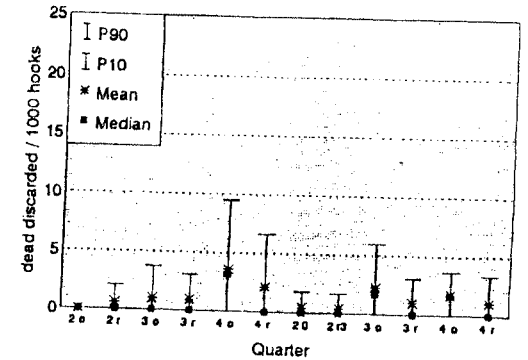
observed (o), reported (r)

FIGURE 2e. Swordfish Discarded Dead Mid Atlantic Bight 1992 & 1993 by quarter



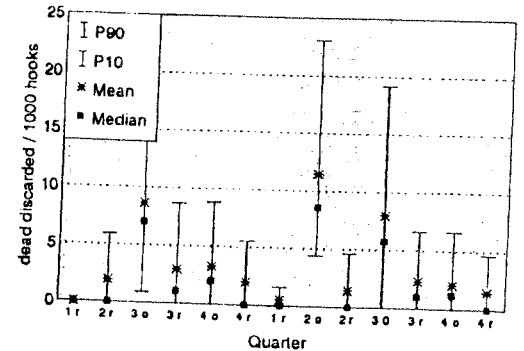
observed (o), reported (r)

FIGURE 2f. Swordfish Discarded Dead Northeast Coastal 1992 & 1993 by quarter



observed (o), reported (r)

FIGURE 2g. Swordfish Discarded Dead Northeast Distant 1992 & 1993 by quarter



observed (o), reported (r)

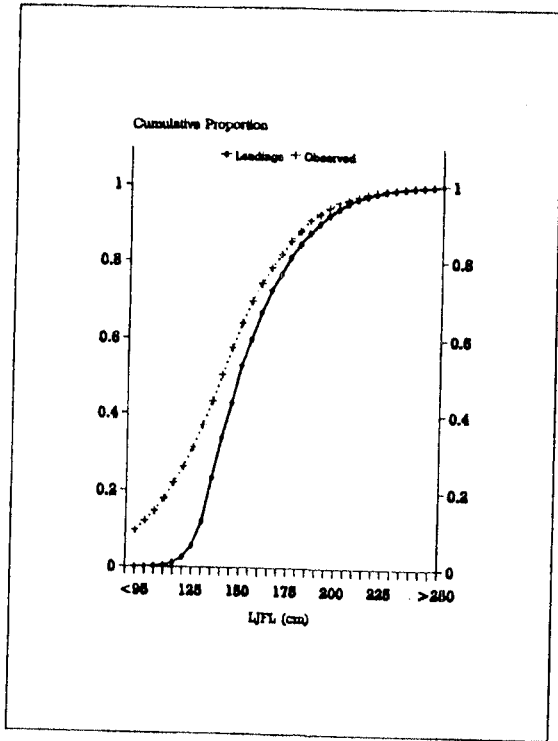


Figure 3. US longline landed catch at size compared to the observed catch at size for 1993 by 5 cm LJFL intervals.

Appendix 1. GLM output

Appendix Table 1. Method 2 $\ln(\text{swod}+1)$ = year area quarter light source tuncr main hooks

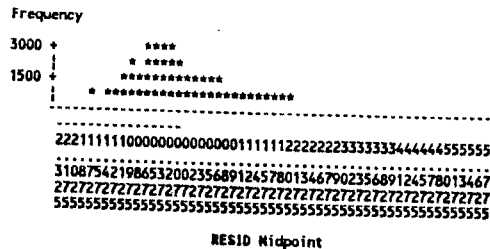
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	19	15083.84572	793.88662	1818.16	0.0001
Error	37235	16258.43699	0.43664		
Uncorrected Total	37254	31342.28271			

	R-Square	C.V.	Root MSE	CATCH Mean
	0.208335	122.6966	0.660790	0.538557

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	2	73.2718934	36.6359467	83.90	0.0001
AREA	8	811.7172661	101.4646583	232.37	0.0001
QUARTER	3	629.9073888	209.9691296	480.87	0.0001
LIGHT	1	527.7472920	527.7472920	1208.64	0.0001
TUNCR	1	2.6656008	2.6656008	6.10	0.0135
MAIN	1	29.6118593	29.6118593	67.82	0.0001
SOURCE	1	140.9571879	140.9571879	322.82	0.0001
HOOKS	1	214.8668965	214.8668965	492.09	0.0001

Parameter	Estimate	T for HO: Parameter=0	Pr > T	Std Error of Estimate
YEAR 91	1.869388640	26.59	0.0001	0.07029632
YEAR 92	1.867578049	26.31	0.0001	0.07099325
AREA 93	1.963426655	27.32	0.0001	0.07187254
AREA 1	0.316728858	11.48	0.0001	0.02758832
AREA 2	0.403476166	15.37	0.0001	0.02625445
AREA 3	0.629723241	23.08	0.0001	0.02728304
AREA 4	0.833389004	29.34	0.0001	0.02840316
AREA 5	0.342055360	12.58	0.0001	0.02718326
AREA 6	0.290490961	10.37	0.0001	0.02801538
AREA 7	0.493241268	17.76	0.0001	0.02777922
AREA 8	0.028468187	0.32	0.7526	0.09033006
QUARTER 1	0.000000000			
QUARTER 2	-0.370669338	-31.49	0.0001	0.01177245
QUARTER 3	-0.367463843	-32.85	0.0001	0.0118510
QUARTER 4	-0.151230990	-16.55	0.0001	0.00913915
LIGHT no	0.000000000			
LIGHT yes	-0.326220479	-34.77	0.0001	0.00938344
TUNCR no	0.000000000			
TUNCR yes	-0.00931695	-2.47	0.0135	0.00037709
MAIN OBS	0.906067503	8.24	0.0001	0.00073679
MAIN SR	0.364352866	17.97	0.0001	0.02027880
HOOKS	0.000000000			
HOOKS	-0.273257060	-22.18	0.0001	0.01231829

SOURCE	CATCH LSMEAN	Std Err LSMEAN	Pr > T HO:LSMEAN=0
OBS	0.70331832	0.02281701	0.0001
SR	0.33896545	0.01112905	0.0001



Appendix Table 2. Method 3 $\ln(\text{swod}+0.13)$ = year area quarter light source tuncr main hooks

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	19	41484.31911	2183.38522	1130.85	0.0001
Error	37235	71891.24889	1.93074		
Uncorrected Total	37254	113375.56800			

	R-Square	C.V.	Root MSE	CATCH Mean
	0.201215	-175.4184	1.389512	-0.792113

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	2	254.622046	127.311023	65.94	0.0001
AREA	8	3078.716475	384.839559	199.32	0.0001
QUARTER	3	2380.349214	793.516405	410.99	0.0001
LIGHT	1	2699.555892	2699.555892	1398.19	0.0001
TUNCR	1	2.066691	2.066691	1.07	0.3009
MAIN	1	91.601702	91.601702	47.44	0.0001
SOURCE	1	649.818682	649.818682	336.56	0.0001
HOOKS	1	768.894219	768.894219	398.24	0.0001

Parameter	Estimate	Parameter=0	Estimate
YEAR 91	1.667365436	11.28	0.14781933
YEAR 92	1.602021778	10.73	0.14928482
AREA 93	1.792351425	11.86	0.15113381
AREA 1	0.771297915	13.30	0.05801280
AREA 2	0.869631366	15.75	0.05520795
AREA 3	1.389571091	24.22	0.05737087
AREA 4	1.720513378	28.81	0.05972626
AREA 5	0.842572714	14.74	0.05716104
AREA 6	0.737160569	12.51	0.05891083
AREA 7	1.155772766	19.79	0.05841423
AREA 8	0.017918156	0.09	0.18994634
QUARTER 1	0.000000000		
QUARTER 2	-0.716929158	-28.96	0.02475514
QUARTER 3	-0.719773398	-30.60	0.02352007
QUARTER 4	-0.309855880	-16.12	0.01921783
LIGHT no	0.000000000		
LIGHT yes	-0.737809727	-37.39	0.01973152
TUNCR no	0.000000000		
TUNCR yes	-0.000820378	-1.03	0.3009
MAIN OBS	0.010671584	6.89	0.00154931
MAIN SR	0.782302418	18.35	0.04264233
HOOKS	0.000000000		
HOOKS	-0.516915951	-19.96	0.02590293

SOURCE	CATCH LSMEAN	Std Err LSMEAN	Pr > T HO:LSMEAN=0
OBS	-0.44241620	0.04797968	0.0001
SR	-1.22471862	0.02340220	0.0001

