

Appendix**Table A.1.** Summary of bongo data used in these analyses.

Survey Year	Number of Stations Sampled	Start Date	End Date	Number of Specimens	Mean Length (mm)	Size Range (mm)
1977	20	2 May 1977	12 May 1977	22	5.0	3.4 - 8.1
1978	69	2 May 1978	30 May 1978	221	4.0	2.4 - 9.5
1981	35	1 May 1981	26 May 1981	20	4.6	2.7 - 7.0
1982	97	20 Apr 1982	25 May 1982	75	4.1	2.0 - 10.7
1983	93	22 Apr 1983	23 May 1983	65	3.6	2.0 - 6.8
1984	71	21 Apr 1984	12 May 1984	13	4.4	3.0 - 6.0
1986	72	23 Apr 1986	22 May 1986	12	4.9	3.5 - 6.0
1987	78	21 Apr 1987	21 May 1987	10	4.7	2.3 - 9.2
1988	77	20 Apr 1988	25 May 1988	71	3.5	2.3 - 7.0
1989	85	26 Apr 1989	27 May 1989	80	4.1	2.0 - 8.0
1990	86	21 Apr 1990	31 May 1990	23	3.9	2.6 - 7.5
1991	69	20 Apr 1991	21 May 1991	9	3.5	2.4 - 6.0
1992	83	22 Apr 1992	21 May 1992	39	3.6	2.5 - 9.0
1993	83	26 Apr 1993	31 May 1993	23	5.1	3.0 - 6.2
1994	84	28 Apr 1994	31 May 1994	28	4.4	2.5 - 9.2
1995	97	20 Apr 1995	31 May 1995	35	2.7	2.1 - 5.6
1996	79	20 Apr 1996	25 May 1996	130	3.2	2.6 - 6.0
1997	74	20 Apr 1997	31 May 1997	27	3.9	2.4 - 5.9
1998	59	26 Apr 1998	30 May 1998	10	3.7	2.1 - 5.5
1999	71	24 Apr 1999	29 May 1999	27	3.9	2.8 - 6.0
2000	74	20 Apr 2000	26 May 2000	23	3.5	2.8 - 5.2
2001	71	20 Apr 2001	29 May 2001	32	2.8	1.5 - 4.5
2002	71	20 Apr 2002	28 May 2002	14	4.5	3.9 - 5.3
2003	38	14 May 2003	31 May 2003	35	2.8	1.3 - 10.2
2004	32	13 May 2004	30 May 2004	28	2.8	2.2 - 9.5
2005	74	22 Apr 2005	29 May 2005	19	2.4	1.5 - 8.5
2006	75	24 Apr 2006	29 May 2006	34	3.4	1.7 - 8.3
2007	48	20 Apr 2007	28 May 2007	23	2.8	1.5 - 6.3

Table A.2. Summary of bongo data used in these analyses.

Survey Year	Number of Stations Sampled	Start Date	End Date	Number of Specimens	Mean Length (mm)	Size Range (mm)	
1982	98	20 Apr 1982	25 May 1982	174	5.7	3.5	- 10.1
1983	92	22 Apr 1983	23 May 1983	112	5.3	3.5	- 9.0
1984	70	21 Apr 1984	12 May 1984	2	4.9	4.4	- 5.4
1986	72	23 Apr 1986	22 May 1986	47	5.6	3.3	- 8.2
1989	143	26 Apr 1989	27 May 1989	166	5.5	3.8	- 8.6
1990	147	21 Apr 1990	31 May 1990	37	5.1	3.5	- 7.0
1991	145	20 Apr 1991	22 May 1991	61	5.2	3.5	- 7.6
1992	145	22 Apr 1992	21 May 1992	17	5.2	3.2	- 6.5
1993	144	26 Apr 1993	31 May 1993	61	4.8	4.0	- 7.2
1994	132	28 Apr 1994	31 May 1994	37	5.6	4.1	- 8.0
1995	175	20 Apr 1995	31 May 1995	94	4.7	4.0	- 7.1
1996	142	20 Apr 1996	25 May 1996	80	5.0	3.8	- 8.9
1997	131	20 Apr 1997	31 May 1997	78	4.1	3.2	- 6.9
1998	117	26 Apr 1998	30 May 1998	133	5.3	2.5	- 8.5
1999	136	24 Apr 1999	29 May 1999	78	5.2	3.0	- 9.0
2000	144	20 Apr 2000	26 May 2000	73	4.8	4.0	- 8.0
2001	133	20 Apr 2001	29 May 2001	51	4.9	3.6	- 8.5
2002	123	20 Apr 2002	28 May 2002	53	5.3	3.8	- 7.7
2003	72	14 May 2003	31 May 2003	75	5.9	3.9	- 9.4
2004	66	13 May 2004	30 May 2004	20	5.1	3.7	- 7.0
2005	143	22 Apr 2005	29 May 2005	25	4.8	3.4	- 7.2
2006	126	23 Apr 2006	29 May 2006	137	5.3	3.5	- 9.1
2007	79	20 Apr 2007	28 May 2007	29	4.9	4.0	- 6.3

Table A.3. Parameters of the zero-inflated binomial model for bongo tows. The prefix *o* denotes those parameters in the occupancy submodel, while the prefix *d* denotes those parameters in the detection submodel.

Survey Year	Number of Stations Sampled	Start Date	End Date	Number of Specimens	Mean Length (mm)	Size Range (mm)
1977	20	2 May 1977	12 May 1977	22	5.0	3.4 - 8.1
1978	69	2 May 1978	30 May 1978	221	4.0	2.4 - 9.5
1981	35	1 May 1981	26 May 1981	20	4.6	2.7 - 7.0
1982	97	20 Apr 1982	25 May 1982	75	4.1	2.0 - 10.7
1983	93	22 Apr 1983	23 May 1983	65	3.6	2.0 - 6.8
1984	71	21 Apr 1984	12 May 1984	13	4.4	3.0 - 6.0
1986	72	23 Apr 1986	22 May 1986	12	4.9	3.5 - 6.0
1987	78	21 Apr 1987	21 May 1987	10	4.7	2.3 - 9.2
1988	77	20 Apr 1988	25 May 1988	71	3.5	2.3 - 7.0
1989	85	26 Apr 1989	27 May 1989	80	4.1	2.0 - 8.0
1990	86	21 Apr 1990	31 May 1990	23	3.9	2.6 - 7.5
1991	69	20 Apr 1991	21 May 1991	9	3.5	2.4 - 6.0
1992	83	22 Apr 1992	21 May 1992	39	3.6	2.5 - 9.0
1993	83	26 Apr 1993	31 May 1993	23	5.1	3.0 - 6.2
1994	84	28 Apr 1994	31 May 1994	28	4.4	2.5 - 9.2
1995	97	20 Apr 1995	31 May 1995	35	2.7	2.1 - 5.6
1996	79	20 Apr 1996	25 May 1996	130	3.2	2.6 - 6.0
1997	74	20 Apr 1997	31 May 1997	27	3.9	2.4 - 5.9
1998	59	26 Apr 1998	30 May 1998	10	3.7	2.1 - 5.5
1999	71	24 Apr 1999	29 May 1999	27	3.9	2.8 - 6.0
2000	74	20 Apr 2000	26 May 2000	23	3.5	2.8 - 5.2
2001	71	20 Apr 2001	29 May 2001	32	2.8	1.5 - 4.5
2002	71	20 Apr 2002	28 May 2002	14	4.5	3.9 - 5.3
2003	38	14 May 2003	31 May 2003	35	2.8	1.3 - 10.2
2004	32	13 May 2004	30 May 2004	28	2.8	2.2 - 9.5
2005	74	22 Apr 2005	29 May 2005	19	2.4	1.5 - 8.5
2006	75	24 Apr 2006	29 May 2006	34	3.4	1.7 - 8.3
2007	48	20 Apr 2007	28 May 2007	23	2.8	1.5 - 6.3

Table A.4. Parameters of the zero-inflated binomial model for neuston tows. The prefix *o* denotes those parameters in the occupancy submodel, while the prefix *d* denotes those parameters in the detection submodel.

Survey Year	Number of Stations Sampled	Start Date	End Date	Number of Specimens	Mean Length (mm)	Size Range (mm)
1977	20	2 May 1977	12 May 1977	22	5.0	3.4 - 8.1
1978	69	2 May 1978	30 May 1978	221	4.0	2.4 - 9.5
1981	35	1 May 1981	26 May 1981	20	4.6	2.7 - 7.0
1982	97	20 Apr 1982	25 May 1982	75	4.1	2.0 - 10.7
1983	93	22 Apr 1983	23 May 1983	65	3.6	2.0 - 6.8
1984	71	21 Apr 1984	12 May 1984	13	4.4	3.0 - 6.0
1986	72	23 Apr 1986	22 May 1986	12	4.9	3.5 - 6.0
1987	78	21 Apr 1987	21 May 1987	10	4.7	2.3 - 9.2
1988	77	20 Apr 1988	25 May 1988	71	3.5	2.3 - 7.0
1989	85	26 Apr 1989	27 May 1989	80	4.1	2.0 - 8.0
1990	86	21 Apr 1990	31 May 1990	23	3.9	2.6 - 7.5
1991	69	20 Apr 1991	21 May 1991	9	3.5	2.4 - 6.0
1992	83	22 Apr 1992	21 May 1992	39	3.6	2.5 - 9.0
1993	83	26 Apr 1993	31 May 1993	23	5.1	3.0 - 6.2
1994	84	28 Apr 1994	31 May 1994	28	4.4	2.5 - 9.2
1995	97	20 Apr 1995	31 May 1995	35	2.7	2.1 - 5.6
1996	79	20 Apr 1996	25 May 1996	130	3.2	2.6 - 6.0
1997	74	20 Apr 1997	31 May 1997	27	3.9	2.4 - 5.9
1998	59	26 Apr 1998	30 May 1998	10	3.7	2.1 - 5.5
1999	71	24 Apr 1999	29 May 1999	27	3.9	2.8 - 6.0
2000	74	20 Apr 2000	26 May 2000	23	3.5	2.8 - 5.2
2001	71	20 Apr 2001	29 May 2001	32	2.8	1.5 - 4.5
2002	71	20 Apr 2002	28 May 2002	14	4.5	3.9 - 5.3
2003	38	14 May 2003	31 May 2003	35	2.8	1.3 - 10.2
2004	32	13 May 2004	30 May 2004	28	2.8	2.2 - 9.5
2005	74	22 Apr 2005	29 May 2005	19	2.4	1.5 - 8.5
2006	75	24 Apr 2006	29 May 2006	34	3.4	1.7 - 8.3
2007	48	20 Apr 2007	28 May 2007	23	2.8	1.5 - 6.3

Table A.5. Indices of larval bluefin tuna (number under 100 m² of sea surface) collected in bongo tows developed from the Pennington delta-distribution method, the delta-lognormal model and zero-inflated delta-lognormal model. The total number of samples included in analyses per year, the number of samples containing larvae per year, and the nominal frequency of occurrence per year are represented by n , m , and f , respectively. Coefficients of variation ($CV = \text{standard error of the index value}/\text{index value}$) and lower and upper 95% confidence limits (LCL and UCL, respectively) are provided.

Survey Year				Delta-distribution method				Delta-lognormal model				Zero-inflated delta-lognormal model			
	n	m	f	$I_{\Delta,y}$	CV	LCL	UCL	I_y	CV	LCL	UCL	$I_{z,y}$	CV	LCL	UCL
1977	20	8	0.400	2.423	0.449	1.028	5.712	2.339	0.474	1.292	4.233	2.504	0.476	1.381	4.542
1978	69	33	0.478	5.214	0.242	3.235	8.403	4.808	0.240	3.518	6.569	4.869	0.234	3.589	6.605
1979	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1980	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1981	35	6	0.171	1.163	0.434	0.506	2.671	0.697	0.436	0.402	1.207	0.735	0.433	0.425	1.269
1982	97	20	0.206	1.413	0.275	0.823	2.427	1.342	0.312	0.898	2.005	1.356	0.292	0.930	1.978
1983	93	16	0.172	0.928	0.333	0.486	1.775	1.205	0.345	0.774	1.876	1.202	0.354	0.764	1.891
1984	71	6	0.085	0.301	0.506	0.116	0.782	0.337	0.706	0.146	0.780	0.367	0.556	0.185	0.728
1985	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1986	72	7	0.097	0.399	0.405	0.183	0.870	0.396	0.594	0.192	0.817	0.404	0.434	0.234	0.698
1987	78	5	0.064	0.343	0.455	0.144	0.817	0.320	0.478	0.176	0.582	0.346	0.476	0.191	0.627
1988	77	15	0.195	1.140	0.328	0.602	2.159	1.041	0.315	0.694	1.561	1.084	0.317	0.721	1.629
1989	85	14	0.165	0.797	0.362	0.395	1.607	0.702	0.351	0.448	1.100	0.765	0.368	0.478	1.224
1990	86	10	0.116	0.338	0.334	0.176	0.648	0.331	0.440	0.190	0.575	0.332	0.337	0.215	0.511
1991	69	5	0.072	0.277	0.536	0.102	0.757	0.370	0.628	0.173	0.792	0.388	0.590	0.189	0.798
1992	83	14	0.169	0.546	0.357	0.273	1.092	0.483	0.362	0.304	0.766	0.527	0.360	0.333	0.835
1993	83	6	0.072	0.605	0.617	0.194	1.883	0.438	0.718	0.187	1.025	0.498	0.670	0.223	1.112
1994	84	12	0.143	0.681	0.354	0.342	1.353	0.442	0.329	0.289	0.674	0.487	0.352	0.310	0.765
1995	97	8	0.082	0.271	0.494	0.106	0.690	0.327	0.573	0.162	0.659	0.348	0.558	0.175	0.690
1996	79	10	0.127	1.050	0.543	0.380	2.901	0.887	0.563	0.444	1.772	0.966	0.516	0.509	1.833
1997	74	11	0.149	0.442	0.401	0.204	0.956	0.376	0.425	0.220	0.643	0.408	0.412	0.242	0.688
1998	59	5	0.085	0.196	0.507	0.075	0.511	0.109	0.528	0.057	0.209	0.117	0.553	0.059	0.232
1999	71	8	0.113	0.705	0.537	0.258	1.930	0.486	0.516	0.256	0.922	0.512	0.531	0.266	0.988
2000	74	7	0.095	0.340	0.491	0.134	0.861	0.312	0.520	0.164	0.595	0.344	0.545	0.175	0.673
2001	71	11	0.155	0.492	0.373	0.239	1.013	0.387	0.351	0.247	0.607	0.387	0.383	0.238	0.630
2002	71	4	0.056	0.341	0.602	0.112	1.037	0.284	0.568	0.142	0.571	0.304	0.660	0.138	0.672
2003	38	10	0.263	1.125	0.357	0.563	2.248	0.711	0.413	0.421	1.199	0.737	0.410	0.439	1.238
2004	32	6	0.188	1.068	0.631	0.336	3.400	0.504	0.677	0.224	1.132	0.541	0.681	0.240	1.221
2005	74	13	0.176	0.274	0.316	0.148	0.508	0.221	0.362	0.139	0.350	0.230	0.327	0.151	0.351
2006	75	16	0.211	0.816	0.356	0.409	1.626	0.584	0.389	0.356	0.958	0.605	0.358	0.383	0.956
2007	48	10	0.208	0.592	0.360	0.295	1.191	0.326	0.410	0.194	0.548	0.355	0.405	0.212	0.593

Table A.6. Indices of larval bluefin tuna (number per 10-minute tow) collected in neuston tows developed from the Pennington delta-distribution method, the delta-lognormal model and zero-inflated delta-lognormal model. The total number of samples included in analyses per year, the number of samples containing larvae per year, and the nominal frequency of occurrence per year are represented by *n*, *m*, and *f*, respectively. Coefficients of variation (CV = standard error of the index value/index value) and lower and upper 95% confidence limits (LCL and UCL, respectively) are provided.

Survey Year				Delta-distribution method				Delta-lognormal model				Zero-inflated delta-lognormal model			
	n	m	f	I _{Δ,y}	CV	LCL	UCL	I _y	CV	LCL	UCL	I _{Z,y}	CV	LCL	UCL
1982	98	32	0.327	3.718	0.284	2.131	6.488	3.836	0.277	2.681	5.487	3.852	0.264	2.734	5.425
1983	92	12	0.120	1.601	0.477	0.648	3.958	1.648	0.509	0.875	3.105	1.697	0.510	0.900	3.199
1984	70	1	0.014	.	.	.	.	0.023	3.695	0.003	0.199	0.025	3.244	0.003	0.198
1985	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1986	72	9	0.125	1.951	0.535	0.716	5.317	2.027	0.578	0.999	4.112	2.033	0.541	1.042	3.966
1987	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1988	0	.	.	.	.	.	.	.	.	.	.	.	.	.	.
1989	143	29	0.203	1.690	0.311	0.920	3.104	1.572	0.320	1.041	2.373	1.668	0.300	1.133	2.454
1990	147	11	0.075	0.288	0.356	0.145	0.576	0.266	0.492	0.144	0.492	0.287	0.442	0.164	0.500
1991	145	12	0.083	0.609	0.455	0.256	1.449	0.735	0.486	0.401	1.350	0.780	0.495	0.421	1.446
1992	145	9	0.062	0.142	0.385	0.067	0.299	0.112	0.655	0.051	0.246	0.126	0.548	0.064	0.247
1993	144	11	0.076	0.339	0.351	0.172	0.671	0.205	0.465	0.114	0.368	0.243	0.437	0.140	0.421
1994	132	9	0.068	0.579	0.569	0.201	1.668	0.459	0.602	0.220	0.955	0.539	0.639	0.249	1.165
1995	175	13	0.074	0.270	0.322	0.144	0.506	0.247	0.349	0.158	0.385	0.274	0.395	0.166	0.453
1996	142	9	0.063	0.702	0.505	0.271	1.820	0.580	0.525	0.303	1.111	0.674	0.564	0.337	1.347
1997	131	5	0.038	0.147	0.574	0.050	0.427	0.103	0.790	0.041	0.258	0.121	0.858	0.046	0.322
1998	117	15	0.128	2.343	0.408	1.068	5.139	1.798	0.392	1.093	2.960	2.020	0.415	1.195	3.416
1999	136	9	0.066	0.717	0.571	0.248	2.072	0.586	0.678	0.261	1.319	0.670	0.626	0.314	1.429
2000	144	13	0.090	0.396	0.379	0.190	0.823	0.321	0.468	0.179	0.577	0.368	0.444	0.211	0.644
2001	133	18	0.135	0.451	0.309	0.246	0.825	0.356	0.377	0.220	0.576	0.392	0.355	0.249	0.617
2002	123	6	0.049	0.598	0.592	0.200	1.792	0.457	0.594	0.222	0.944	0.507	0.681	0.225	1.144
2003	72	8	0.111	3.100	0.640	0.960	10.013	1.728	0.658	0.784	3.811	2.024	0.653	0.923	4.439
2004	66	6	0.091	0.382	0.439	0.165	0.885	0.193	0.600	0.093	0.400	0.232	0.559	0.116	0.460
2005	143	8	0.056	0.247	0.412	0.112	0.545	0.174	0.456	0.098	0.308	0.199	0.527	0.104	0.383
2006	126	18	0.143	1.372	0.374	0.665	2.830	1.118	0.449	0.635	1.966	1.238	0.375	0.768	1.996
2007	79	9	0.114	0.292	0.354	0.147	0.579	0.159	0.454	0.090	0.281	0.068	0.574	0.033	0.137

Table A.7. Multivariate delta-lognormal model parameters for data collected in bongo and neuston tows.

Multivariate binomial on proportion positive				Multivariate lognormal on positive catch			
Parameter	Estimate	Standard Error	Pr > |t|	Parameter	Estimate	Standard Error	Pr > |t|
beta1b	-0.7102	0.5118	0.1686	beta1b	-0.1491	0.1480	0.3175
beta1n	-2.1001	0.4757	<.0001	beta1n	0.0099	0.1014	0.9226
time_of_day_day	-1.2508	0.3466	0.0005	time_of_day_day	-0.0420	0.1209	0.7294
time_of_day_night	-1.5595	0.3064	<.0001	time_of_day_night	-0.0972	0.1074	0.3691
month_late_April	-0.8702	0.2563	0.0010	month_late_April	-0.0208	0.2395	0.9310
month_early_May	-0.1137	0.2284	0.6199	month_early_May	0.8032	0.2028	0.0002
month_middle_May	-0.1891	0.2072	0.3639	month_middle_May	0.3675	0.1672	0.0316
month_late_May	0.3624	0.2116	0.0902	month_late_May	0.7110	0.1794	0.0002
a1982	2.8336	1.5349	0.0682	a1982	1.3491	0.2704	<.0001
a1983	1.0864	0.6312	0.0887	a1983	2.0029	0.3817	<.0001
a1984	0.4909	0.9782	0.6170	a1984	0.9509	0.8313	0.2570
a1986	0.6604	0.7056	0.3518	a1986	2.0891	0.3910	<.0001
a1989	1.8829	1.3564	0.1685	a1989	1.0420	0.3065	0.0012
a1990	0.4410	0.6992	0.5298	a1990	0.1875	0.5139	0.7164
a1991	1.0334	1.0987	0.3494	a1991	0.2301	0.4353	0.5989
a1992	1.0567	0.5818	0.0727	a1992	0.2422	0.4719	0.6096
a1993	0.2319	0.7786	0.7665	a1993	0.9066	0.5296	0.0918
a1994	0.8963	0.5920	0.1335	a1994	1.7143	0.4387	0.0002
a1995	0.1811	0.7434	0.8080	a1995	0.6659	0.5657	0.2435
a1996	0.2515	0.6974	0.7192	a1996	1.6555	0.4474	0.0004
a1997	0.4454	1.0061	0.6590	a1997	0.0854	0.5107	0.8678
a1998	0.5296	0.7299	0.4700	a1998	0.7969	0.5336	0.1402
a1999	0.5810	0.7096	0.4151	a1999	0.6810	0.4136	0.1045
a2000	0.5095	0.6879	0.4608	a2000	-0.0017	0.4657	0.9971
a2001	0.8633	0.6581	0.1929	a2001	0.8796	0.6595	0.1870
a2002	0.6690	0.6751	0.3244	a2002	1.1213	0.5366	0.0406
a2003	0.8108	0.8807	0.3597	a2003	1.0739	0.4629	0.0235
a2004	0.5393	1.0733	0.6166	a2004	0.9560	1.1082	0.3916
a2005	0.4915	0.7993	0.5402	a2005	0.6252	0.6471	0.3376
a2006	1.1344	0.6200	0.0706	a2006	1.5664	0.3561	<.0001
a2007	0.5693	0.9150	0.5354	a2007	0.0409	0.5295	0.9387
s1	0.9498	0.1655	<.0001	s3	1.2893	0.2070	<.0001
cov12	-0.3338	1.3508	0.8054	s1	1.3406	0.2859	<.0001
s2	0.3514	1.4834	0.8133	cov12	-1.3083	0.3019	<.0001
				s2	0.9758	0.0167	<.0001

Table A.8. Indices of larval bluefin tuna collected in bongo and neuston tows developed from the multivariate delta-lognormal model. The number of samples included in analyses per year represented by n .

Survey Year	n	Multivariate delta-lognormal model			
		$I_{MV,y}$	CV	LCL	UCL
1982	91	3.285	0.478	1.327	8.133
1983	93	2.908	0.610	0.944	8.956
1984	70	0.736	1.161	0.116	4.667
1985	0	.	.	.	.
1986	67	2.368	0.715	0.655	8.557
1987	0	.	.	.	.
1988	0	.	.	.	.
1989	84	1.836	0.716	0.507	6.645
1990	82	0.380	0.737	0.102	1.421
1991	69	0.596	0.873	0.132	2.684
1992	76	0.610	0.573	0.210	1.773
1993	80	0.579	0.876	0.128	2.620
1994	78	1.959	0.643	0.604	6.354
1995	97	0.453	0.860	0.102	2.009
1996	79	1.154	0.771	0.294	4.523
1997	73	0.354	0.928	0.073	1.710
1998	59	0.664	0.808	0.161	2.739
1999	69	0.625	0.700	0.177	2.212
2000	74	0.349	0.688	0.100	1.211
2001	63	0.903	0.808	0.219	3.730
2002	67	0.974	0.769	0.249	3.808
2003	37	1.032	0.816	0.247	4.306
2004	32	0.766	1.405	0.095	6.184
2005	74	0.559	0.900	0.120	2.608
2006	74	1.990	0.567	0.692	5.724
2007	47	0.376	0.859	0.085	1.661