Indices of age-1 red drum abundance in the South Carolina fishery-independent trammel net survey

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Methods, Gears and Coverage

The SC trammel net survey has been conducted since 1991 (Wenner, 2000) and is an ongoing program. It uses a stratified random sampling design and has long-term data sets for seven strata within four major SC estuary systems. Sites in each stratum are selected at random on a monthly basis (without replacement) and sampled primarily during early-, mid- and late-ebb tide. The trammel nets are 184 m long by 2.1 m deep with 177 mm outer mesh and 63 mm inner mesh. Nets are set close to shore (<2 m depth) by a fast moving boat and, before retrieval, the water surface is vigorously disturbed along the full length to chase fish into the mesh. The strata include Ace Basin (AB), Ashley River (AR), Charleston Harbor (CH), Lower Wando River (LW), McBanks (MB), Cape Romain Harbor (RH) and Winyah Bay (WB). AB is in the Ace Basin estuary system (AB); AR, LW and CH are in the Charleston Harbor system (CH); MB and RH are in the Cape Romain system (CR); WB is in the Winyah Bay system (WB). The main areas covered by the survey are shown in **Fig. 1**.

The catch data presented in this report are for age-1 red drum. For fish that settle in the estuaries in the fall of year Y, full recruitment to the trammel gear occurs in July of year Y+1. Indices of abundance for each year class were calculated using catch data from Jul-Dec of year Y+1 and Jan-Mar of year Y+2, when the Y year class is easily discernable due to non-overlapping size distributions. For the purposes of this report we refer to these fish as age-1, although the actual data straddle the calendar year (i.e. the age-1 to age-2 transition).

In some years of the survey, cultured red drum have been released into areas covered by the trammel net survey as part of an experimental stocking program. For the 1989-1993 year classes, stocked fish were identified in the trammel catches by external tags (Smith et al, 1997). The data extracted from the trammel database excluded these fish, so no correction factor has been applied for them. In other years when stocking occurred, the percentage contribution of stocked fish was determined by matching microsatellite genotypes of fin-clipped trammel-caught fish against the parental brood stock. This was performed on fish caught in the stratum that was stocked, as well as neighboring strata in the same estuarine system. To calculate catch rates of just the wild red drum component, the catch of each set was adjusted according to the percentage contribution of stocked fish in that year class and stratum, as shown in **Table 1**. Genotype data are not yet available for the 2007 year class, so no adjustment has been made for it.

Sampling intensity and time series

Table 2 shows the number of July-March trammel sets that were analyzed for the 1989-2007 year classes, totaling 8,773 trammel sets over the entire period. Only data from random sets made during

daylight hours and during early-, mid- and late-ebb tide are included (catch rates are affected by tide - see Wenner, 2000). The number of strata increased from 2 to 7 over the time series. Mean sampling intensity also increased from *ca* 15 sets per stratum initially to about *ca* 90-100 sets per stratum from the mid-1990s onwards. The 1989 year class was only sampled during Jan-Mar 1991 (no Jul-Dec 1990 data available). The reduced number of sets for the 2007 year class is because the Jan-Mar 2009 trammel data are not yet available.

Age and length data

Assuming a birth date of Sept 1, all red drum were 11-19 months old in the July-March trammel sets. Least squares means of total length (controlling for year class, stratum and month of capture) are given by year class in **Table 3** and by sample month in **Table 4**. Mean values for each year class across all the months sampled varied between 350.9 mm and 391.5 mm and showed evidence of density dependence. On average, TL increased from 268 mm in July to 419 mm in March.

Catch

Table 5 shows the total catch for each year class and stratum. Only data from sets made during daylight hours and during early-, mid- and late-ebb tide are included. A total of 13,920 age-1 red drum were caught from the 1989-2007 year classes, with mean values per stratum and year class varying between 64.5 and 345.7.

Catch Rates

The catch number in each trammel set was $\log_e$-transformed (Ln[Catch+1]. To examine whether different strata showed similar year class trends in catch per unit effort (CPUE), data were initially explored at the stratum level. CPUE was calculated as the least squares means catch ($\log_e$-transformed, wild fish only) per trammel set using a general linear model (GLM) with year class, month of capture and tide (early-, mid- or late-ebb) as fixed factors. The output from these models showed that although absolute catch rates differed between strata, the overall trends in relative year class strength were consistent (**Fig. 2**).

To calculate a South Carolina-wide CPUE, least squares means were derived using a GLM that included the $\log_e$-transformed catch data from all strata, with stratum added as a model factor. Two runs were performed, first using catches of all fish (wild + stocked), and secondly using catches of just the wild fish (i.e. catches adjusted for stocked fish contributions).

In general, the influence of stocked fish on the SC-wide CPUE was negligible (**Fig. 3, Table 6**). There was a general decline in CPUE across the 1990-1999 year classes, followed by a sharp rise for the 2000 year class. CPUE then underwent a second period of decline, but the 2006 and 2007 year classes show an increasing trend and are close to the long-term mean for the whole time series.

Uncertainty and Measures of Precision

Standard errors for the least squares means SC-wide CPUE are shown in **Fig. 3** and **Tables 6**. There is less confidence in the earlier years of the survey because fewer estuarine systems and strata were covered,

fewer trammels were set, and the 1989 year class was only sampled over three months (rather than 9). Values for the 2007 year class are preliminary because neither the Jan-Mar 2009 trammel data nor the percentage contribution of stocked fish to the AR, LW and CH strata are available yet. Evidence from previous years suggests that the effect of stocking is probably negligible to the SC-wide values.

Comments on adequacy of assessment

The randomized stratified design of the trammel net survey is a statistically robust sampling protocol. There is close agreement in CPUE trends across strata, as well as with indices from the South Carolina red drum electroshock survey, which covers lower salinity areas of the trammel survey estuary systems (SC DNR, 2009).

References

SC DNR (2009). SC red-drum electro-fishing survey. (Report prepared by Wenner, C.A.). SEDAR18-DW11.

Smith, T.I.J., Jenkins, W.E., Denson, M.R. (1997). Overview of an experimental stock enhancement program for the red drum in South Carolina. Bull. Natl. Res. Inst. Aquacult., Suppl. 3: 109-115. SEDAR18-RD68.

Wenner, C.A. (2000). Contributions to the biology of red drum, *Sciaenops ocellatus*, in South Carolina. Final Report, Federal number NA47FM0143. SEDAR 18-RD36.

Table 1. Percent contribution of stocked red drum to the age-1 trammel net catches for each year classes and stratum. Blanks indicate no stocking. Stratum names are Ace Basin (AB), Ashley River (AR), Charleston Harbor (CH), Lower Wando River (LW), McBanks (MB), Cape Romain Harbor (RH) and Winyah Bay (WB).

Year Class	Ace Basin	Charleston Harbor			Cape Romain		Winyah Bay
	AB	AR	CH	LW	MB	RH	WB
1990		*	*	*			
1991		*	*	*			
1992		*	*	*			
1993		*	*	*			
1994							
1995							
1996							
1997							
1998							
1999		90.0%	31.0%	15.0%			
2000		35.6%	6.7%	13.5%			
2001		29.0%	1.6%	2.0%			
2002		0.0%	0.0%	0.0%			
2003							
2004							11.5%
2005	13.6%	3.1%	3.2%	0.0%			35.3%
2006		0.0%	0.0%	1.0%			
2007		**	**	**			**

* Stocking occurred, but stocked fish (tagged) were excluded from the retrieved database catch data.

** Contribution from stocked fish not yet determined.

Table 2. Number of trammel sets used for assessing the 1989-2007 year classes of age-1 red drum in South Carolina. Trammel sets cover the months July-March during daylight hours and mid- to late-ebb tide. (Strata names as in Table 1).

Year Class	Ace Basin AB	AR	Charleston Harbor CH	LW	Cape Romain MB	RH	Winyah Bay WB	Total	Mean
1989			10	21				31	15.5
1990			36	54				90	45.0
1991		49	36	71				156	52.0
1992	16	70	40	70				196	49.0
1993	84	82	60	78				304	76.0
1994	86	81	84	83				334	83.5
1995	89	98	88	84				359	89.8
1996	107	106	89	85	103	96		586	97.7
1997	102	107	91	90	95	102		587	97.8
1998	103	108	87	89	95	108		590	98.3
1999	91	106	88	90	82	98		555	92.5
2000	103	108	89	88	92	104		584	97.3
2001	102	108	87	87	91	87	45	607	86.7
2002	91	107	87	85	99	101	86	656	93.7
2003	104	106	88	90	101	99	87	675	96.4
2004	92	108	90	90	102	92	99	673	96.1
2005	86	107	86	90	91	102	83	645	92.1
2006	102	106	88	90	97	91	100	674	96.3
2007	74	79	60	65	75	70	48	471	67.3
Total	**1432**	**1636**	**1384**	**1500**	**1123**	**1150**	**548**	**8773**	

Table 3. Total length of age-1 red drum during the period surveyed. Values are least squares means during the period July-March, controlling for year class, stratum and month of capture.

Year Class	TL (mm)	SE
1989	375.8	5.5
1990	363.7	3.5
1991	359.4	3.1
1992	361.8	2.8
1993	364.8	2.5
1994	377.7	2.7
1995	368.3	2.7
1996	373.4	2.1
1997	381.4	2.1
1998	391.5	2.0
1999	384.8	2.0
2000	359.3	1.9
2001	374.4	2.0
2002	350.9	2.0
2003	374.5	2.2
2004	380.2	2.1
2005	379.6	2.1
2006	365.5	2.1
2007	358.6	2.6

Table 4. Total length of red drum. Values are least square means of TL by month of sample, controlling for stratum, year class and month.

Month	TL (mm)	SE
Jul	267.6	1.63
Aug	298.4	1.61
Sep	343.2	1.61
Oct	377.5	1.59
Nov	398.7	1.55
Dec	407.9	1.72
Jan	412.7	1.75
Feb	412.7	1.80
Mar	418.5	1.68

Table 5. Total catches of age-1 red drum (wild + stocked) in the July-March South Carolina trammels set during day light hours and mid- to late-ebb tide. (Strata names as in Table 1).

| Year Class	Ace Basin	Charleston Harbor			Cape Romain		Winyah Bay	Total	Mean
	AB	AR	CH	LW	MB	RH	WB	Total	Mean
1989			83	46				129	64.5
1990			225	231				456	228.0
1991		45	183	285				513	171.0
1992	10	28	124	132				294	73.5
1993	126	66	201	115				508	127.0
1994	166	79	147	180				572	143.0
1995	145	18	69	91				323	80.8
1996	210	57	113	259	163	106		908	151.3
1997	109	43	85	72	113	131		553	92.2
1998	96	32	108	71	95	151		553	92.2
1999	59	118	30	42	60	42		351	58.5
2000	411	151	226	155	777	354		2074	345.7
2001	106	73	238	272	246	207	28	1170	167.1
2002	164	73	347	277	302	285	201	1649	235.6
2003	187	17	46	57	172	167	186	832	118.9
2004	111	47	85	134	157	86	67	687	98.1
2005	132	33	42	125	39	29	73	473	67.6
2006	179	35	129	103	197	223	95	961	137.3
2007	108	79	59	171	212	165	120	914	130.6
Total	**2319**	**994**	**2540**	**2818**	**2533**	**1946**	**770**	**13920**	

Table 6. Least squares means SC-wide CPUE from GLM using Ln(Catch+1) input data from all strata. Model factors were year class, stratum, month and tide.

Year Class	Wild + Stocked		Wild only	
	Least Sq Mean	Standard Error	Least Sq Mean	Standard Error
1989	0.625	0.127	0.622	0.126
1990	1.053	0.074	1.053	0.074
1991	0.633	0.057	0.634	0.056
1992	0.423	0.050	0.422	0.050
1993	0.487	0.040	0.487	0.040
1994	0.511	0.039	0.510	0.038
1995	0.344	0.037	0.343	0.037
1996	0.443	0.029	0.442	0.029
1997	0.370	0.029	0.369	0.029
1998	0.374	0.029	0.373	0.029
1999	0.313	0.030	0.256	0.030
2000	0.786	0.029	0.763	0.029
2001	0.609	0.029	0.597	0.028
2002	0.683	0.028	0.682	0.027
2003	0.449	0.027	0.448	0.027
2004	0.418	0.027	0.414	0.027
2005	0.344	0.028	0.326	0.028
2006	0.489	0.027	0.488	0.027
2007	0.561*	0.033	0.562*	0.033

* No adjustment for stocked fish (contribution not yet known for 2007 year class).

Fig. 1. Map of red drum survey areas covered by SCDNR.
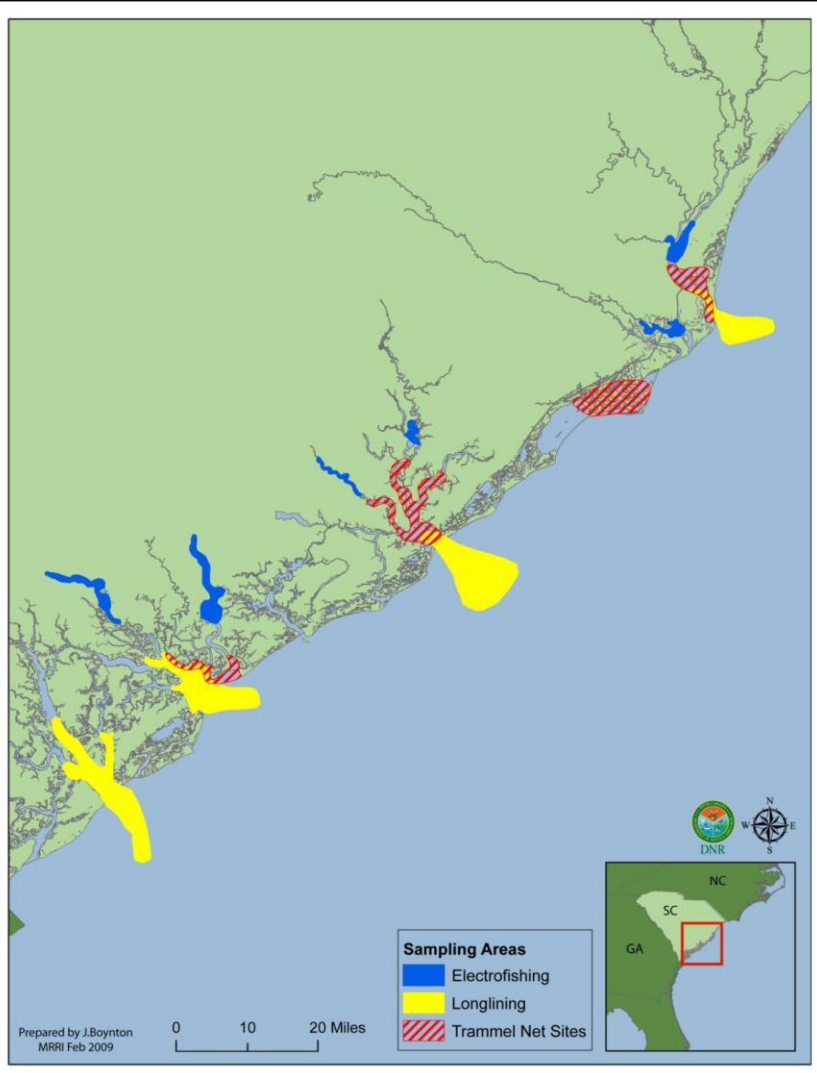
Fig. 2. Least squares means CPUE (ln[Catch+1] per trammel set) of age-1 red drum. Values were calculated using a separate model for each stratum.
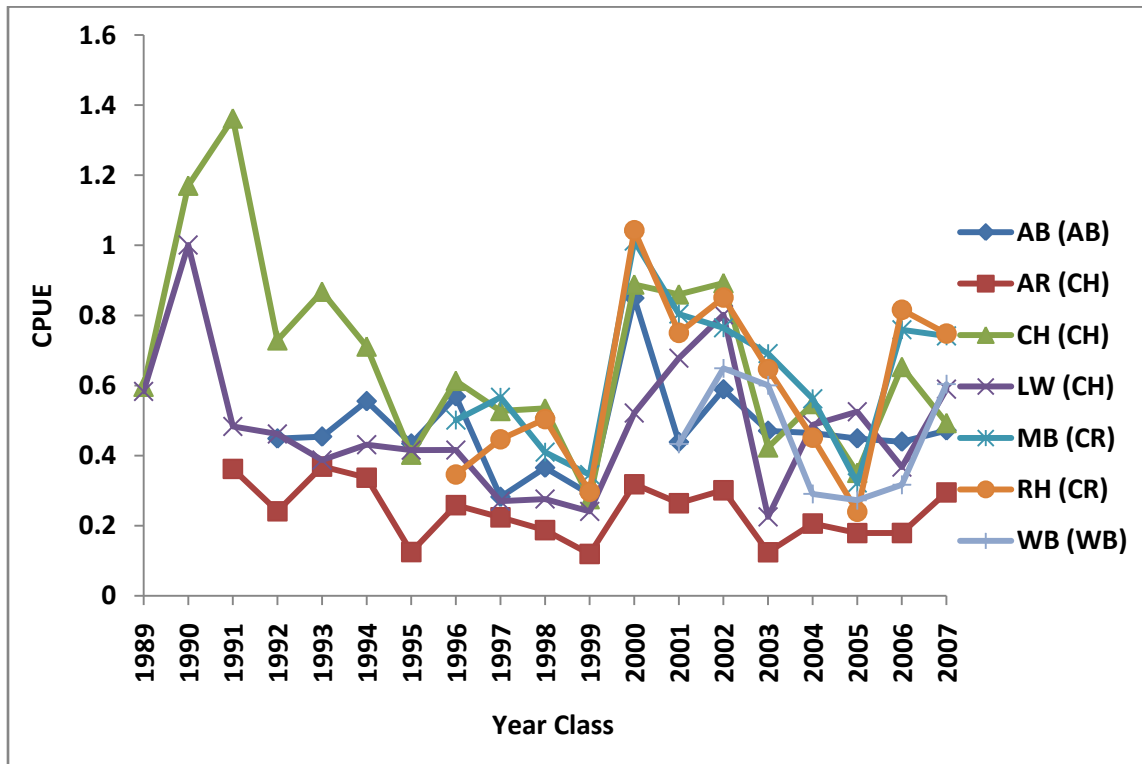
Fig. 3. Least squares means SC-wide CPUE (ln[Catch+1] per trammel set) calculated for age-1 red drum across all strata, both before and after adjusting for stocked fish contributions. Error bars represent 1 SE.