Fishery Independent Surveys of Sub-Adult Red Drum in South Carolina

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Sub-adult red drum fishery independent surveys:

1) SCDNR Rotenone survey (1986-1994)
2) SCDNR Stop net survey (1985-1998)
3) SCDNR Trammel net survey (Nov 1990 – present)
4) SCDNR Electofishing survey (May 2001 – present)

1) SCDNR Rotenone survey (1986-1994)

Data Collection

Survey Methods

Fish were collected from 50 m sections of creek that had been blocked at each end with a net (0.8 mm square-mesh) one hour before predicted low tide (when the creek was <5 m wide and <1 m deep). Rotenone (150-200 ml, 5% Fish Tox; Woolfolk Chemical Works, Fort Valley, Georgia, USA) was added at the upstream end and fish that succumbed were collected either from the end nets, or by dip (1 mm square-mesh) and seine netting (3.2 mm square-mesh) the blocked section. Potassium permanganate was applied downstream of the blocked section to detoxify residual rotenone.

Sampling Intensity

A total of 304 rotenone collections were made from 1986 through 1994. Fourteen sites were visited, with most of the collections occurring at four of the sites (R001-R004) (**Table Rot-1**). Sampling occurred in every month of the year, but not necessarily at every site, or in every year of the survey. A total of 1,792 red drum were caught.

Biological Sampling

Red drum were counted and the majority (n = 1679) measured for TL and/or SL to the nearest millimeter. Otoliths were aged from 6 fish. Inspection of the size-frequency distribution by month (data pooled acros all years and sites) (**Table Rot-2**) indicates that only age 0 red drum were caught from Sep-Dec. From January – July, only age 1 fish were caught. During August, both age 0 and age 1 fish were caught.
Age 0 and age 1 indices of abundance were calculated using Sep-Dec data and Mar-Jul data, respectively (**Tables Rot-3**, **Fig. Rot-1**).

Biases

A relatively small number of fixed stations were visited. The sampling design was unbalanced, with stations visited and sampling intensity in different months varying between years. No data were available for calculating age 0 indices for the 1985, 1988, 1992 or 1993 year classes. There is reasonable agreement in year class strength when compared with overlapping years from the SCDNR stop net and trammel net surveys, and also when compared with relative year class composition derived from otolith of adult red drum (Arnott et al., 2010).

2) SCDNR Stop-net survey (1985-1998)

Data Collection

Survey Methods

A net was used to enclose a section of flooded intertidal habitat (~0.2 km^2) during high tide. It was set just above the low water mark with each end anchored on shore, enabling fish to be collected as they became stranded by the retreating tide. Net dimensions were 366 m x 2.4 m at one of the sites that was visited repeatedly (site 0001), and 274 m x 2.4 m at another (site 0270). Nets were fitted with a float line and lead-core bottom line and were made of 50.8 mm stretched-mesh dipped nylon multifilament.

Sampling Intensity

A total of 150 collections were made at nine stations between 1985 and 1998. Sites 0001 (Grice Cove, Charleston Harbor, SC) and 0270 (Bulls Island, Bulls Bay, SC) were sampled most frequently (**Table Stop-1**). Although collections occurred in all months across the full duration of the survey, each month was not necessarily sampled within each calendar year. The survey captured a total of 8,132 red drum between 1985 and 1998.

Biological Sampling

Captured red drum were counted and measured (TL and SL). TL ranged between 33 mm and 910 mm (mean = 431 mm, median = 390 mm) (**Table Stop-2**). For red drum caught during the months Jul-Dec, age 1 red drum were assigned based on size ranges shown in **Table Stop-3** (assuming Jan 1 age transition).

Otoliths and/or scales were taken from a sub-sample of red drum for aging. Red drum TL ≥ 350 mm were tagged before releasing them. Ages were assigned to 7,756 red drum based on length (L), otoliths (O) or scales (S) (**Table Stop-3**).
Sex and maturity data were obtained from a total of 1,656 and 305 red drum, respectively (**Table Stop-4**).

Based on available data, indices of abundance for age 1 red drum were calculated separately for Sites 0001 and 0270 using age 1 catch data from the months Jul-Dec (**Table Stop-5**, **Fig. Stop-1**). Indices of abundance for all red drum were calculated for just site 0001 using data from all catch data from the months Jan-Sep (**Table Stop-5**, **Fig. Stop-2**).

Biases

The survey used a fixed station survey design, concentrating mainly on just two sites. Sampling was monthly in some years, but sporadic in others. Despite the data being from fixed stations, there is reasonable agreement in year class strength when compared with overlapping years from the SCDNR rotenone and trammel net surveys, and also when compared with relative year class composition derived from otolith of adult red drum (Arnott et al., 2010).

3) SCDNR Trammel net survey (Nov 1990 – present)

Data Collection

Survey Methods

The trammel net survey uses a stratified random sampling design. On each sampling day, trammel nets are typically set at 10-12 sites per stratum, although weather, tide or other constraints sometimes hinder this target. Sites are selected at random (without replacement) from a pool of 22-30 possible sites per stratum, with the exception that adjacent sites (unless separated by a creek mouth) cannot be sampled on the same day to avoid sampling interference.

Fish are collected using a 183 x 2.1 m trammel net fitted with a polyfoam float line (12.7 mm diameter) and a lead core bottom line (22.7 kg). The netting comprises an inner panel (0.47 mm #177 monofilament; 63.5 mm stretched-mesh; height = 60 diagonal meshes) sandwiched between a pair of outer panels (0.9 mm #9 monofilament; 355.6 mm stretch-mesh; height = 8 diagonal meshes). The trammel net is set along the shoreline (10-20 m from an intertidal marsh flat, <2 m depth) during an ebbing tide using a fast moving boat. Each end is anchored on the shore, or in shallow marsh. Once the net has been set, the boat makes two passes along the length of the enclosed water body at idle speed (taking <10 minutes), during which time the water surface is disturbed with wooden poles to promote fish entrapment. The net is then immediately retrieved and netted fish are removed from the webbing as they are brought on board and placed in a live-well. Once the net has been fully retrieved, all fish are identified to species and counted. Measurements (TL and SL) are taken from all individuals of target species (including red drum), and up to 25 individuals of non-target species. Any red drum between 350 and 549 mm TL are tagged with disc belly tags, and any greater than 549 mm TL are tagged with a steel shoulder tag. The majority of all fish caught (>95%) are released alive at the site of capture.

Sampling Intensity

At present (2014), seven strata are surveyed monthly (strata AB, CH, AR, LW, MB, RH and WB; see **Table Tram-1**) and two are surveyed quarterly (strata CT and BR;

see **Table Tram-1**). The two quarterly strata are sampled less frequently due to the extra time and costs involved.

Historical data also exist from an additional seven strata that were sampled over varying periods of time (strata AC, CP, CR, CS, LB, MI and UW; see **Table Tram-1**). Stratum CR (Cape Romain) covered some of the sites incorporated in the present-day strata MB and RH strata (allowing time-series from the latter strata to be extended back to 1994).

A total of 17,853 random trammel set were made at 549 sites along the South Carolina coastline between November 1990 and December 2013 (**Table-Tram 1**). An additional 2,840 non-random sets were made between 1987 and 2013, primarily for the purpose of biological sampling and tagging). The combined random and non-random sets caught a total of 73,013 red drum.

Biological Sampling

All red drum were measured for total and standard length. Sizes of captured red drum varied between approximately 200 and 900 mm and comprised mostly sub-adult red drum less than ~5 years old (**Fig-Tram 1**). Numbers of red drum sampled for sex, maturity, weight and age shown in **Table-Tram 2**.

Monthly aggregate CPUE of red drum in each of the currently surveyed strata are shown in **Fig-Tram 2**. Age 1 fish were identified in the catches from their cohort-specific size, enabling annual CPUE indices to be calculated using data from July – December, when they are vulnerable to the gear (**Fig-Tram 3**). Age 1 red drum that had been stocked by the SCDNR Mariculture Section were removed from these analyses using estimates of stocked fish, as identified by genotyping fin-clip samples (**Table Tram-3)**. Similar analyses were performed for the aggregate catches of all red drum (all sizes and ages combined) using January – December data (**Fig-Tram 4**). Indices of abundance of age 2 red drum in different strata were calculated using age-length keys derived over three month periods within each year of sampling (Jan-Mar, Apr-Jun, etc.) (**Fig-Tram 5**).

Arnott et al (2010) found that trammel net CPUE of red drum is reasonably synchronous along the South Carolina coastline. For the stock assessment, combined (statewide) indices of abundance for age 1 and 2 red drum were derived using data from

just 1994 through 2013, and from just five strata that had been sampled for the entirety of that period: ACE Basin, Charleston Harbor, Wando River, Muddy & Bulls Bays and Cape Romain (**Table Tram-4, Table Tram-5, Fig-Tram 6**). The years 1991-1993 were not included because of unbalance sampling among strata, and due to concerns about changes in the gear (see below).

Biases

- During the first couple of years of the trammel net survey, a wider range of sites were initially included in the pool of available sites for sampling. Some of these were then dropped due to their low productivity. These sites were removed from the dataset.
- During the time series, it was occasionally necessary to add new sites to the pool of available sites within a stratum, since some of the original ones were lost due to changing coastal features (e.g. erosion, building of new docks, etc.).
- Trammel net catches of red drum generally increase as the tide ebbs, presumably because fish become more available to the gear as they retreat from intertidal marsh habitat. Therefore, only data from early-ebb, mid-ebb and late-ebb were analyzed (these tidal stages are sampled equally in all strata, months and years).
- Net soak times are variable and have changed over time (**Fig-Tram 7**). During the first several year of the survey (before ~1995), soak times were typically longer. This was likely due to much larger catches of blue crabs and hardhead catfish during the early 1990s (these species are difficult to remove from the net and slow the net retrieval process). However, catch rates of other species (including red drum) also prolong soak times, so standardizing for any potential effects of soak time on red drum catches is difficult to address.
- Prior to 1994, a slightly finer monofilament was in the outer mesh panels of the trammel net (although the mesh size was the same). This may have entangled fish more easily (possibly contributing to higher soak times - see above). Therefore, the stock assessment indices of abundance were only calculated from 1994 onwards.

- There has been a general shift towards higher salinities in all of the strata sampled due to changes in rainfall patterns (and possibly river water extraction rates) (**Fig-Tram 8**). Hypothetically, this may have affected recruitment or survival of red drum (i.e. actual population numbers), or it may have affected catchability in the trammel net survey by altering habitat use (i.e. apparent population numbers red drum).
- In some years and locations, stocking of larval or fingerling red drum occurred. In order to estimate the percentage of stocked fish, fin clips were taken from red drum captured by the SCDNR trammel net and electrofishing surveys. Fin clips of age 1 and some age 2 red drum were genotyped using a suite of microsatellite markers and matched against broodstock genotypes. **Table Tram-3** shows stocking contributions to different year classes in different trammel strata. When calculating age 1 abundance indices, catch numbers were adjusted using these numbers in order to estimate abundance of wild-spawned red drum. Data from Ashley River were not used for calculating final indices (stocking had the biggest contribution in that system).

4) SCDNR Electrofishing survey (2002 – present)

Data Collection

Survey Methods

The SCDNR electrofishing survey uses a stratified random sampling design. The river banks of each stratum are sectioned into 926 m sites, and monthly sets are made at sites drawn at random (without replacement) from a pool of 35-60 possible sites per stratum. In certain months and strata, the pool of possible sites was shifted either up- or downriver (increasing the total number of sites sampled across all years) due to salinity fluctuations brought about by drought or flood conditions. This was necessary because the electrofishing gear is only effective at salinities < ~10 psu. Fish are collected using an electrofishing boat (Smith-Root Inc., Vancouver, WA, USA) operating at ~3000 W pulsed direct current. Stunned fish are placed into a live well using dip nets (4.5 mm

square-mesh) over a 15 minute period while the boat moves with the current at drift or idle speed along the river bank.

Sampling Intensity

Although the SCDNR electrofishing survey has operated in numerous rivers, the longest datasets come from five strata: the Combahee River (CO), Lower Edisto River (LE), Ashley River (UA), Cooper River (UC) and Winyah Bay (EW; Waccamaw/Sampit Rivers). The survey began in May 2001, with the exception of Winyah, where sampling began in November 2003. Sampling occurs in each month of the years, with average of ~60 sets per stratum per year (~300 sets per year total). A total of 3,690 random and 200 non-random sets were performed in these strata, catching a total of 9,898 red drum.

Biological Sampling

All red drum were measured for total and standard length. Sizes of captured red drum varied between approximately 50 and 800 mm and comprised mostly red drum ages 1 and 2 (**Fig-Elec 1**). Numbers of red drum sampled for sex, maturity, weight and age shown in **Table-Elec 1**.

Age 1 fish were identified in the catch data by their cohort-specific size, enabling annual CPUE indices to be calculated using data from July – December (**Fig-Elec 2, Table Elec-1**). Age 1 red drum that had been stocked by the SCDNR Mariculture Section were removed from these analyses using estimates of stocked fish, as identified by genotyping fin-clip samples. Similar analyses were performed for the aggregate catches of all red drum (all sizes and ages combined) using January – December data (**Fig-Elec 3**).

Biases

- Vulnerability of fish to electrofishing gear is affected by multiple factors such as fish length, species, water temperature, salinity and depth. The electricity wattage was standardized as best as possible in the survey, although methods of measuring power output are not well developed.

TABLES

Table Rot-1 Number of SCDNR rotenone collections in different years and at different sites.

Number of Collections	SITE														
Year	0060	R001	R002	R003	R004	R005	R006	R007	R008	R009	R010	R011	R012	R013	Grand Total
1986				7	7							7		7	28
1987				8	12	7	1	1	5	1	5	8		8	56
1988					7	7			7		7				28
1989		7	10	10	9							1	1		38
1990		12	12	12	12										48
1991		13	12	12	12										49
1992	1	6	6	6	6										25
1993		4	4	4	4										16
1994		4	4	4	4										16
Grand Total	**1**	**46**	**48**	**63**	**73**	**14**	**1**	**1**	**12**	**1**	**12**	**16**	**1**	**15**	**304**

Table Rot-2 Size-frequency distribution of red drum in the SCDNR rotenone survey during different months of the year (data pooled acros all years and sites). From September to December, only age 0 fish were caught. From January – July, only age 1 fish (age assignment assumes a Jan 1 age transition). During August, both age 0 and age 1 fish were caught.

Size-frequency distribution	MONTH												
TL mm (floored bins)	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
475	0	0	0	0	0	0	1	0	0	0	0	0	1
325	0	0	0	0	0	0	1	0	0	0	0	0	1
300	0	0	0	0	0	0	0	2	0	0	0	0	2
275	0	0	0	0	0	0	2	2	0	0	0	0	4
250	0	0	0	0	0	1	2	0	0	0	0	0	3
225	0	0	0	0	0	0	6	0	0	0	0	0	6
200	0	0	0	0	0	11	2	0	0	0	0	0	13
175	0	0	0	0	10	41	1	0	0	0	0	0	52
150	0	0	0	3	14	50	0	0	0	0	0	0	67
125	0	0	0	17	34	9	0	0	0	0	0	0	60
100	0	0	0	26	16	0	0	0	0	0	0	0	42
75	1	5	20	39	1	0	0	0	0	0	34	6	106
50	2	28	29	9	0	0	0	0	0	1	27	42	138
25	7	6	4	0	0	0	0	0	18	65	141	46	287
0	0	0	0	0	0	0	0	75	608	202	12	0	897
Grand Total	**10**	**39**	**53**	**94**	**75**	**112**	**15**	**79**	**626**	**268**	**214**	**94**	**1679**

Table Rot-3 Arithmetic mean CPUE of age 0 and age 1 red drum in the SCDNR. (Age assignment assumes a Jan 1 transition). Data were pooled across all sites.

AGE 0 (SEP-DEC)

Gear Rotenone

Mo SEP-DEC

YEARCLASS	SampleYear	Catch.ArithMean	SD	Sets	SE	PSE(%)
1986	1986	23.56	27.50	16	6.88	29.18
1987	1987	7.31	11.79	16	2.95	40.29
1988	1988					
1989	1989	10.53	16.52	17	4.01	38.05
1990	1990	23.94	34.74	16	8.69	36.29
1991	1991	16.19	23.38	16	5.84	36.10
1992	1992					
1993	1993					
1994	1994					

AGE 1 (MAR-JUL)

Gear Rotenone

Mo MAR-JUL

YEARCLASS	SampleYear	Catch.ArithMean	SD	Sets	SE	PSE(%)
1985	1986	1.13	1.73	8	0.61	54.3
1986	1987	6.74	12.43	23	2.59	38.5
1987	1988	2.35	3.28	20	0.73	31.2
1988	1989	0.75	1.44	16	0.36	47.9
1989	1990	1.25	2.12	20	0.48	38.0
1990	1991	2.33	2.44	21	0.53	22.8
1991	1992	1.00	1.50	17	0.36	36.4
1992	1993	0.50	0.73	16	0.18	36.5
1993	1994	1.69	3.22	16	0.80	47.7

Table Stop-1 Number of collections taken per year at different sites by the SCDNR stop net survey.

Number of Collections	Sites									
Year	0001	0039	0041	0063	0086	0198	0270	0275	0340	Grand Total
1985	1									1
1986	6									6
1987	14	1	1							16
1988	13			1						14
1989	13			5	4	1	1	1	2	27
1990	12						7		1	20
1991	13						4			17
1992	13						4			17
1993	12						5			17
1994	9						2			11
1995	1									1
1996	1						1			2
1998	1									1
Grand Total	**109**	**1**	**1**	**6**	**4**	**1**	**24**	**1**	**3**	**150**

Table Stop-2 Monthly size frequency distributions of red drum caught by the SCDNR stop net survey. Data have been pooled across sites and years.

Size-frequency distribution	MONTH												
TL mm (floored bins)	1	2	3	4	5	6	7	8	9	10	11	12	Grand Total
625	44	28	6	11	18	24	8	3	10	9	29	31	221
600	30	31	6	15	36	20	2	4	8	13	30	48	243
575	38	24	10	14	26	12	8	6	14	24	34	62	272
550	21	12	7	20	21	1	10	7	13	35	20	51	218
525	6	3	7	5	7	5	18	6	11	26	14	26	134
500	3	2	1	3	5	5	42	12	11	10	3	2	99
475	3	3	.	2	15	21	58	25	12	2	2	8	151
450	20	12	6	6	47	22	65	23	9	.	5	7	222
425	49	33	22	20	84	44	48	4	.	6	26	36	372
400	109	86	49	33	116	39	17	.	3	14	66	126	658
375	134	116	76	42	85	16	1	2	7	72	171	171	893
350	62	68	32	14	22	3	2	3	66	144	151	120	687
325	6	13	6	3	1	.	7	37	173	125	58	44	473
300	3	3	1	.	.	.	35	124	201	39	11	20	437
275	.	1	1	.	.	4	240	198	99	.	4	5	552
250	.	.	.	.	.	15	524	149	25	.	.	.	713
225	.	.	.	.	.	44	266	60	2	.	.	.	372
200	.	.	.	.	4	82	53	5	.	.	.	.	144
175	.	.	.	.	14	70	12	.	.	.	.	1	97
150	.	.	.	.	.	7	7	.	.	.	.	.	14
125	.	.	.	.	.	8	.	.	.	.	.	.	8
100	.	.	.	.	.	3	.	.	.	.	.	.	3
75	.	.	1	.	.	.	.	.	.	.	1	.	2
50	.	.	1	.	.	.	.	.	.	.	2	.	3
25	.	.	.	.	.	.	.	.	.	.	2	.	2
Grand Total	528	435	232	188	501	445	1423	668	664	519	629	758	6990

Table Stop-3 Size ranges used for assigning age 1 red drum in the SCDNR stop net survey (assuming a Jan 1 age transition).

Month	Min TL (mm)	Max TL (mm)
7	150	375
8	200	400
9	200	425
10	200	450
11	200	475
12	200	500

Table Stop-3 Number of aged red drum specimens caught by the SCDNR stop net survey (aging method: L, length cohort; O, otolith; S, scales).

Number of Red Drum Aged	Method			
Year	L	O	S	Grand Total
1985		1		1
1986	150	42	127	319
1987	713	36	120	869
1988	596	1	168	765
1989	563	11	545	1,119
1990	578	5	163	746
1991	985	4	263	1,252
1992	817	17	341	1,175
1993	449	28	370	847
1994	277	9	172	458
1995	28		23	51
1996	50		20	70
1998	45		39	84
Grand Total	**5,251**	**154**	**2,351**	**7,756**

Table Stop-4 Number of red drum specimens caught by the SCDNR stop net survey used for determining sex and maturity.

Year	Sex	Maturity
1985	1	1
1986	324	61
1987	198	108
1988	379	22
1989	459	21
1990	193	9
1991	37	33
1992	39	24
1993	7	7
1994	13	13
1995	6	6
1996	0	0
1998	0	0
Total	**1656**	**305**

Table Stop-5 Arithmetic mean CPUE of age 1 red drum in the SCDNR stop net survey during July-December. (Age assignment assumes a Jan 1 transition).

SITE 0001 (Grice Cove, Charleston Harbor, SC)

YEARCLASS	SampleYear	Catch.ArithMean	SD	Sets	SE	PSE(%)
1985	1986	43.60	29.17	5	13.04	29.92
1986	1987	105.00	45.67	6	18.64	17.76
1987	1988	62.83	24.85	6	10.14	16.14
1988	1989	56.17	42.46	6	17.33	30.86
1989	1990	56.33	71.40	6	29.15	51.74
1990	1991	82.57	53.44	7	20.20	24.46
1991	1992	54.83	20.76	6	8.48	15.46
1992	1993	36.50	12.72	6	5.19	14.23
1993	1994	43.67	16.77	3	9.68	22.18

SITE 0270 (Bulls Island, Bulls Bay, SC)

YEARCLASS	SampleYear	Catch.ArithMean	SD	Sets	SE	PSE(%)
1989	1990	48.00	62.00	3	35.80	74.57
1990	1991	78.00	73.54	2	52.00	66.67
1991	1992	21.50	7.78	2	5.50	25.58
1992	1993	17.67	17.50	3	10.11	57.20

Table Stop-6 Arithmetic mean CPUE all red drum in the SCDNR stop net survey during Jan-Sep at Site 0001 (Grice Cove, Charleston Harbor, SC).

YEARCLASS	SampleYear	Arith.Mean.CPUE	SD	Sets	SE	PSE
All	1986	46.50	29.35	4	14.68	31.56
All	1987	58.55	71.63	11	21.60	36.89
All	1988	49.10	34.19	10	10.81	22.02
All	1989	52.56	40.72	9	13.57	25.83
All	1990	45.00	66.31	9	22.10	49.12
All	1991	66.20	58.56	10	18.52	27.97
All	1992	66.20	65.81	10	20.81	31.44
All	1993	57.11	35.93	9	11.98	20.97
All	1994	46.78	17.89	9	5.96	12.75

Table-Tram 1 Number of random sets per year by the SCDNR trammel net survey in different strata. Abbreviations of present-day strata: AB ACE Basin, AR Ashley River, BR Broad River, CH Charleston Harbor, CT Colleton River, LW Lower Wando River, MB Muddy & Bulls Bays, RH Romain Harbor, WB Winyah Bay. Abbreviations of historical strata: AC ACE Basin (alternative), CP Cooper River, CR Cape Romain, CS Calibogue Sound, MI Murrels Inlet, MN Morgan Island, UW Upper Wando River, LB Lower Bulls Bay. (Note that some of the historical CR sites are incorporated in the present-day MB and RH strata).

Random Collections	Stratum																
Year	AB	AC	AR	BR	CH	CP	CR	CS	CT	LB	LW	MB	MI	MN	RH	UW	WB	Total
1990			4		8					8	13							**33**
1991		52			71		19			29	131		8					**310**
1992			25		48						93					23		**189**
1993			95		48						94					51		**288**
1994	100		114		81		109	31			110							**545**
1995	135		136		108		137	13			114							**643**
1996	127		140		116		140				118							**641**
1997	132		142		120		72				118	69			68			**721**
1998	137		142		120						119	125			129			**772**
1999	138		145		120	47					119	141			132			**842**
2000	136		143		118	145					120	115			133			**910**
2001	126		145		117	144					119	119			134			**904**
2002	137		144		119	96					118	119			120		27	**880**
2003	121		144		111						118	130			133		106	**863**
2004	135		141		118						117	133			133		116	**893**
2005	128		142		115						118	131			126		131	**891**
2006	115		143		114						120	123		46	136		115	**912**
2007	130		142		112						120	130		60	120		133	**947**
2008	129		142		110						115	132		50	127		103	**908**
2009	122		140	23	113				24		119	124		34	125		121	**945**
2010	135		143	48	116				48		120	120			133		95	**958**
2011	140		142	43	116				46		119	111			142		115	**974**
2012	129		142	45	114				42		109	136			140		113	**970**
2013	126		137	25	112				46		118	106			116		128	**914**
Total	**2578**	**52**	**2933**	**184**	**2445**	**432**	**477**	**44**	**206**	**37**	**2679**	**2064**	**8**	**190**	**2147**	**74**	**1303**	**17853**

Table-Tram 2 Biological sampling of red drum caught by the SCDNR trammel net survey. Aging is performed either using otoliths (O), scales (S) or by length (L, for distinct cohort sizes).

Year	Sex	Maturity	Weight	Age_O	Age_S	Age_L
1987	-	-	-	-	-	28
1988	-	-	-	-	5	6
1990	-	-	-	-	9	94
1991	26	24	33	21	211	604
1992	80	79	97	57	605	1,092
1993	238	236	297	187	1,249	1,061
1994	181	186	200	38	1,404	1,243
1995	133	123	141	76	1,412	1,216
1996	100	96	103	46	1,925	1,029
1997	111	111	109	65	1,724	1,259
1998	71	71	70	26	1,383	926
1999	62	62	58	22	1,373	942
2000	52	52	53	17	1,040	598
2001	195	191	191	24	1,396	1,743
2002	172	168	173	25	1,253	2,409
2003	210	207	211	90	2,507	2,384
2004	240	229	231	105	3,071	1,659
2005	84	81	80	65	2,971	906
2006	43	43	43	37	438	723
2007	43	42	43	33	405	1,203
2008	67	65	65	51	390	1,754
2009	182	179	180	106	401	1,884
2010	102	102	109	76	512	2,313
2011	105	99	101	96	660	1,272
2012	72	72	71	67	772	1,000
2013	62	59	60	tbd	tbd	901
Total	2,631	2,577	2,719	1,330	27,116	30,249

Table-Tram 3 Estimates of the percent contribution of stocked red drum in South Carolina from different year classes and in different trammel net strata. Abbreviations of present-day strata: AB ACE Basin, AR Ashley River, CH Charleston Harbor, LW Lower Wando River, MB Muddy & Bulls Bays, RH Romain Harbor, WB Winyah Bay.

YearClass	YearSampling	AB	AR	CH	LW	MB	RH	WB
1990	1991			12.5				
1991	1992				1.8			
1992	1993				2.3			
1993	1994							
1994	1995							
1995	1996			1.4	1.8			
1996	1997							
1997	1998							
1998	1999							
1999	2000		90.0	31.0	15.0			
2000	2001		35.6	6.7	13.5			
2001	2002		29.0	1.6	2.0			
2002	2003		0.0	0.0	0.0			
2003	2004							
2004	2005							
2005	2006	13.6	3.1	3.2	0.0			35.3
2006	2007		0.0	0.0	0.0			
2007	2008		30.2	3.8	2.0			14.7
2008	2009		29.9	0.8	0.0			16.1
2009	2010		76.0	9.4	3.1			
2010	2011		44.0	13.1	56.3			
2011	2012							
2012	2013							

Table Tram-4 Indices of abundance for wild-spawned age 1 red drum in the SCDNR trammel net survey during the months July-December. Data are from the ACE Basin, Charleston Harbor, Wando River, Muddy & Bulls Bays and Cape Romain strata, which were all surveyed from 1994 through 2013.

Sampling Year	Sets	Positive Catch Sets	Nominal CPUE	SE	PSE	Total Catch
1994	182	70	1.962	0.418	21.3%	357
1995	231	102	2.840	0.456	16.1%	656
1996	242	78	1.262	0.222	17.6%	305
1997	311	116	2.267	0.575	25.4%	705
1998	300	82	1.180	0.219	18.5%	354
1999	317	102	1.271	0.206	16.2%	403
2000	292	74	0.542	0.075	13.9%	158
2001	299	161	3.503	0.474	13.5%	1047
2002	278	138	2.856	0.334	11.7%	793
2003	286	157	3.965	0.516	13.0%	1134
2004	313	104	1.633	0.312	19.1%	511
2005	291	114	1.344	0.171	12.7%	391
2006	282	81	0.952	0.140	14.7%	268
2007	294	136	2.153	0.292	13.6%	633
2008	279	137	2.456	0.342	13.9%	685
2009	283	140	2.756	0.384	13.9%	780
2010	310	175	3.630	0.404	11.1%	1125
2011	298	105	1.307	0.217	16.6%	389
2012	301	94	1.086	0.153	14.1%	327
2013	271	99	1.391	0.192	13.8%	377

Table Tram-5 Indices of abundance for age 2 red drum in the SCDNR trammel net survey during the months January-December. Data are from the ACE Basin, Charleston Harbor, Wando River, Muddy & Bulls Bays and Cape Romain strata, which were all surveyed from 1994 through 2013.

Sampling Year	Sets	Positive Catch Sets	Nominal CPUE	SE	PSE	Total Catch
1994	328	99	1.460	0.353	24.2%	479
1995	439	141	0.993	0.158	15.9%	436
1996	464	143	1.659	0.279	16.8%	770
1997	546	148	0.678	0.106	15.6%	370
1998	601	168	0.892	0.138	15.5%	536
1999	626	166	0.635	0.116	18.3%	397
2000	595	157	0.697	0.096	13.8%	415
2001	586	134	0.385	0.047	12.1%	226
2002	586	227	2.426	0.490	20.2%	1421
2003	582	246	1.887	0.227	12.0%	1098
2004	610	272	1.941	0.216	11.1%	1184
2005	589	240	1.006	0.117	11.6%	593
2006	584	228	1.111	0.131	11.8%	649
2007	587	119	0.539	0.096	17.8%	316
2008	586	173	1.114	0.159	14.3%	653
2009	576	170	1.141	0.186	16.3%	657
2010	597	181	1.096	0.146	13.3%	655
2011	599	128	0.761	0.153	20.1%	456
2012	605	108	0.526	0.120	22.8%	318
2013	558	146	0.385	0.050	13.1%	215

Table-Elec 1 Biological sampling for red drum caught by the SCDNR red drum survey. Aging was performed either using otoliths (O), scales (S) or by length (L, for distinct cohort sizes).

Year	Sex	Maturity	Age_O	Age_S	Age_L
2001	5	6		39	467
2002	46	46		125	722
2003	-			176	708
2004	2	2	2	209	626
2005	3	4	3	252	446
2006	1	1	1	20	385
2007	-			1	408
2008	-				717
2009	3	3			860
2010	-				721
2011	-			76	612
2012	6	7	7	100	623
2013	-			139	791
TOTAL	66	69	13	1,137	8,086

Table Elec-2 Indices of abundance of wild-spawned age 1 red drum in the SCDNR electrofishing survey during the months July-December. Data are from the Combahee River, Lower Edisto River, Upper Ashley River and Upper Cooper River.

Year of Sampling	Number of Sets	Positive Catch Sets	Nominal CPUE	Nominal SE	PSE	TOTAL CATCH
2001	119	63	1.860	0.230	12.4%	222
2002	130	72	1.990	0.270	13.6%	258
2003	128	81	2.870	0.380	13.2%	367
2004	123	39	0.670	0.130	19.4%	82
2005	117	50	1.270	0.290	22.8%	149
2006	126	33	0.440	0.090	20.5%	56
2007	116	56	1.280	0.180	14.1%	148
2008	123	53	0.920	0.170	18.5%	113
2009	129	68	2.060	0.370	18.0%	266
2010	122	61	1.170	0.180	15.4%	143
2011	106	46	1.390	0.250	18.0%	147
2012	108	42	1.030	0.170	16.5%	111
2013	129	57	1.400	0.230	16.4%	180

FIGURES

Fig Rot-1 Arithmetic mean CPUE (±SE) of age 0 (Sep-Dec) and age 1 (Mar-Jul) red drum in the SCDNR rotenone survey. (Age assignment assumes a Jan 1 transition). Data were pooled across all sites.

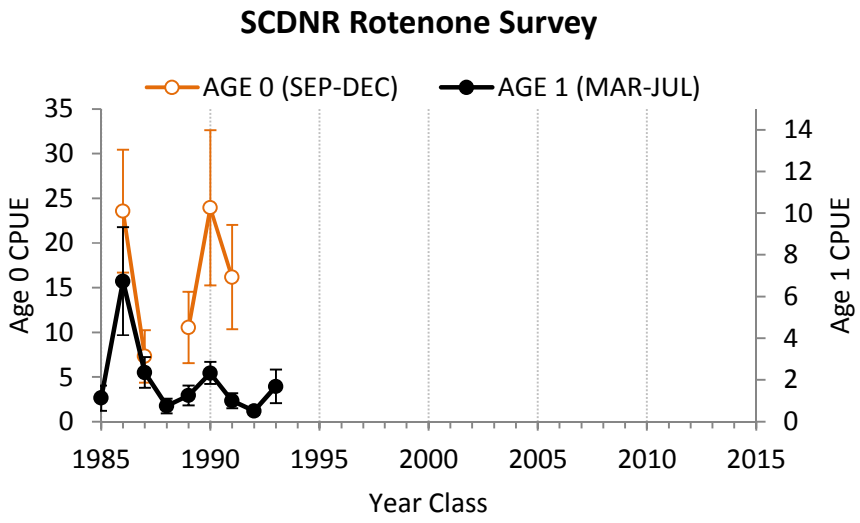


Fig Stop-1 Arithmetic mean CPUE (±SE) of age 1 red drum in the SCDNR stop net survey during the months Jul-Dec. (Age assignment assumes a Jan 1 transition).

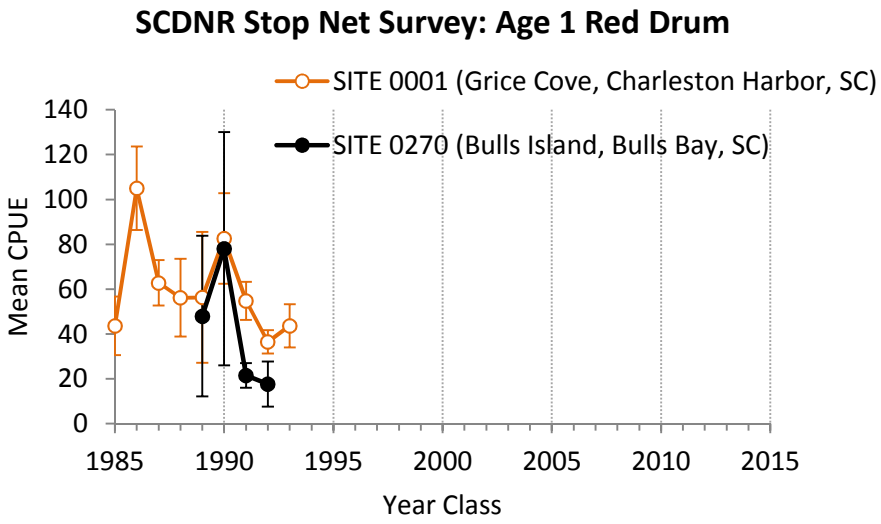


Fig Stop-2 Arithmetic mean CPUE (±SE) all red drum in the SCDNR stop net survey at site 0001 during the months Jan-Sep.

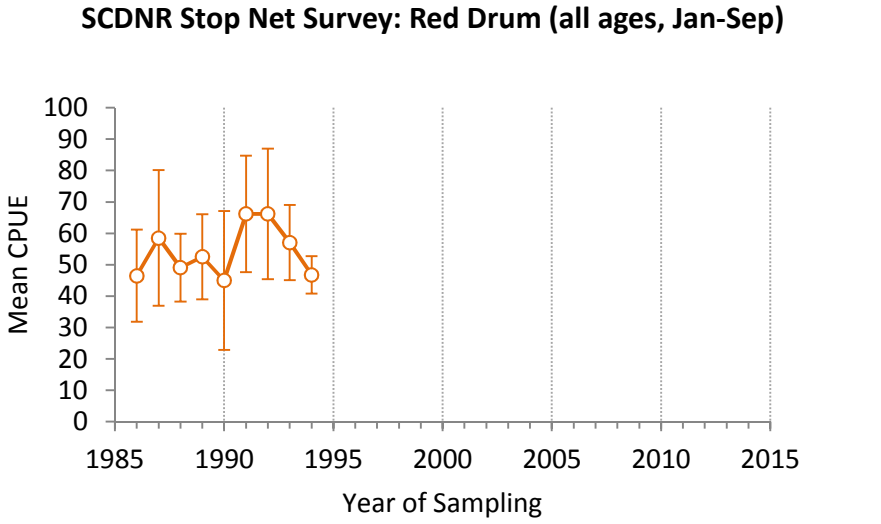


Fig-Tram 1 Sizes of red drum caught by the SCDNR trammel net survey. Data have been pooled across strata and years.

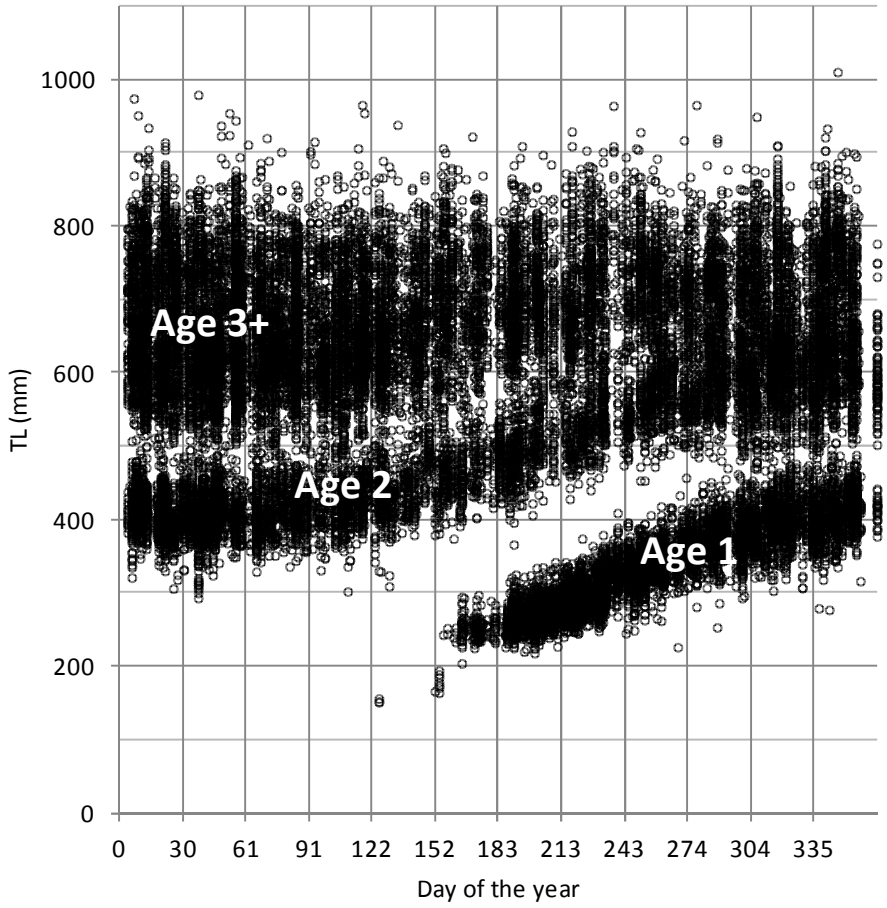


Fig-Tram 2 Monthly CPUE of red drum in the SCDNR trammel net survey (data pooled across all years).

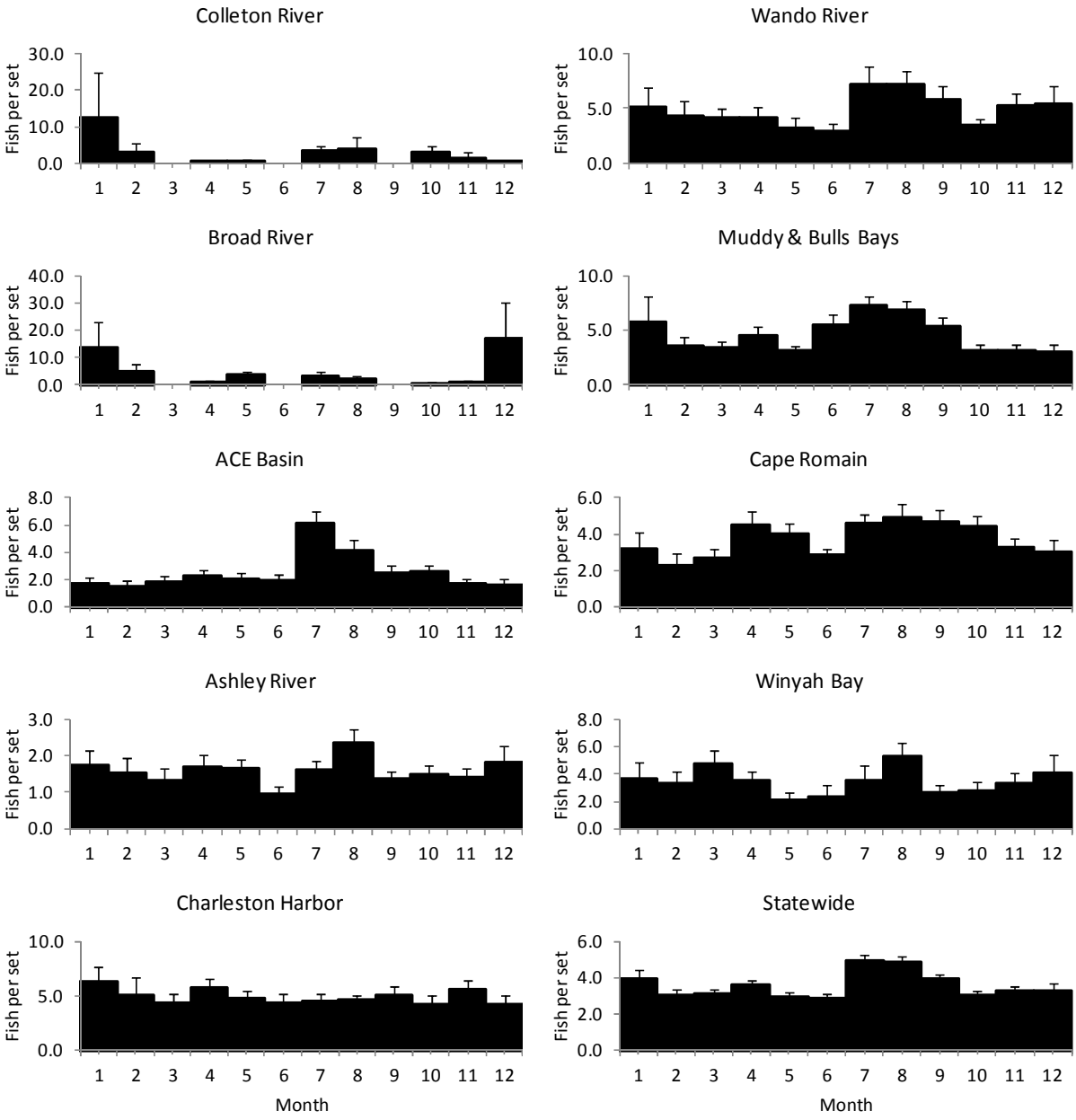


Fig-Tram 3 Jul-Dec CPUE (arithmetic mean ± SE) of wild (non-stocked) age 1 red drum in the SCDNR trammel net survey. (Red crosses show CPUE of wild + stocked red drum). The 'statewide' panel (bottom right) is a compilation of all strata (except Colleton and Broad Rivers) expressed as z-scores (standard deviations from the 2003-2013 mean – i.e. years in which all seven strata have coverage; statewide black line is the mean across all strata).

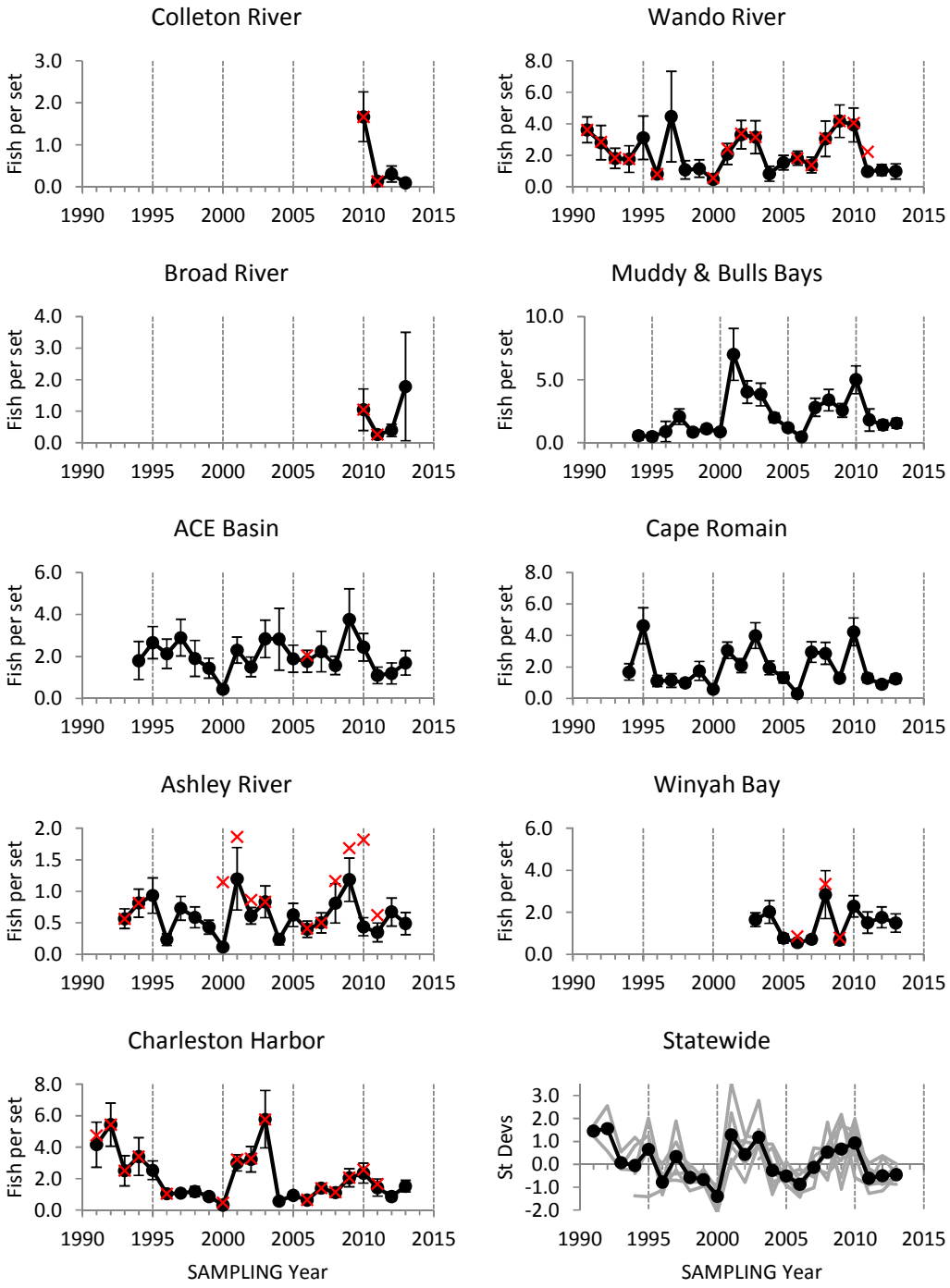


Fig-Tram 4 Jan-Dec CPUE of all red drum (arithmetic mean ± SE) in the SCDNR trammel net survey. The 'statewide' panel (bottom right) is a compilation of all strata (except Colleton and Broad Rivers) expressed as z-scores (standard deviations from the 2003-2013 mean – i.e. years in which all seven strata have coverage; statewide black line is the mean across all strata).

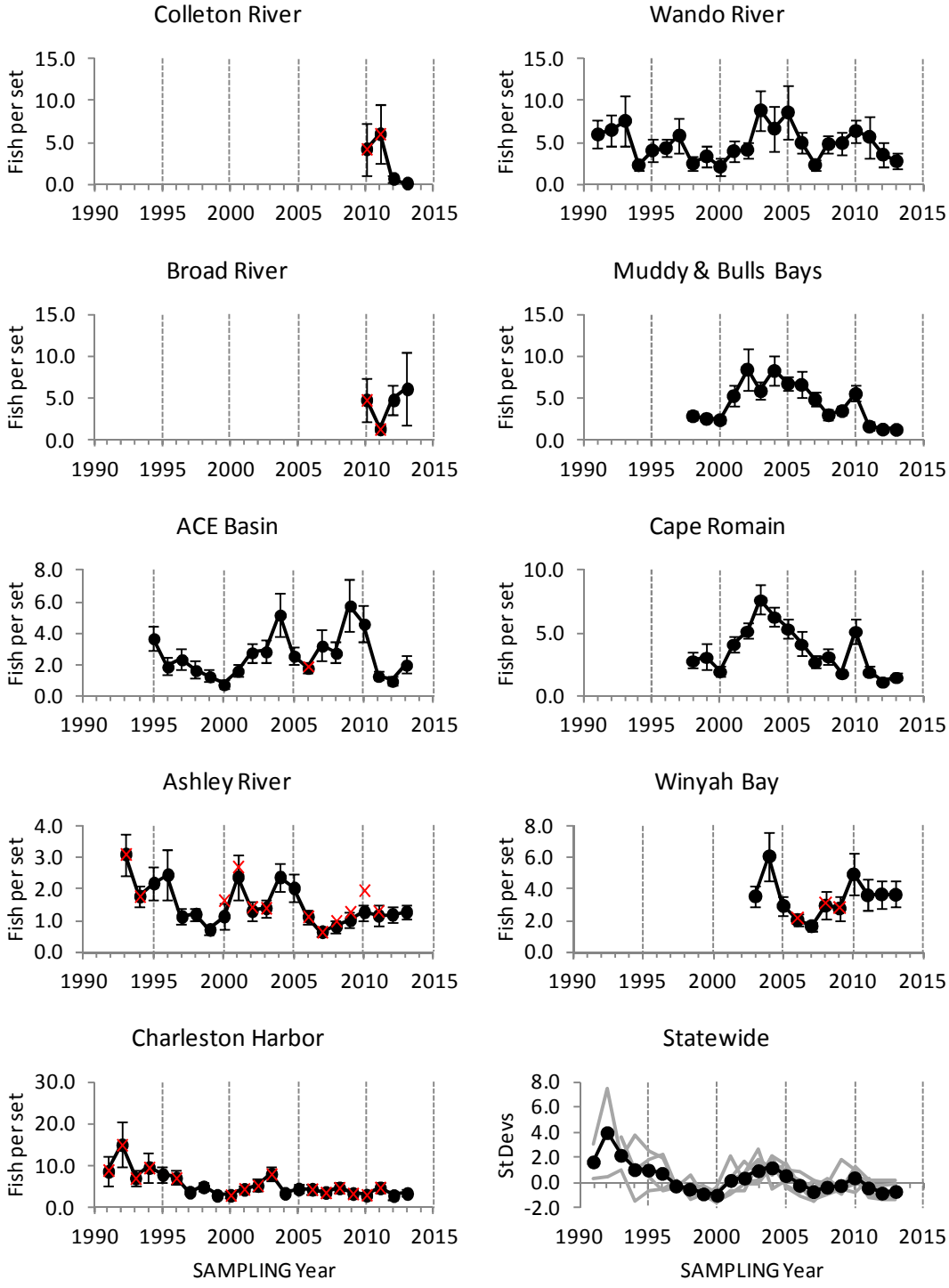


Fig-Tram 5 Jan-Dec CPUE (arithmetic mean ± SE) of age 2 red drum (arithmetic mean ± SE) in the SCDNR trammel net survey. The 'statewide' panel (bottom right) is a compilation of all strata expressed as z-scores (standard deviations from the 1994-2013 mean – i.e. years in which all seven strata have coverage; statewide black line is the mean across all strata).

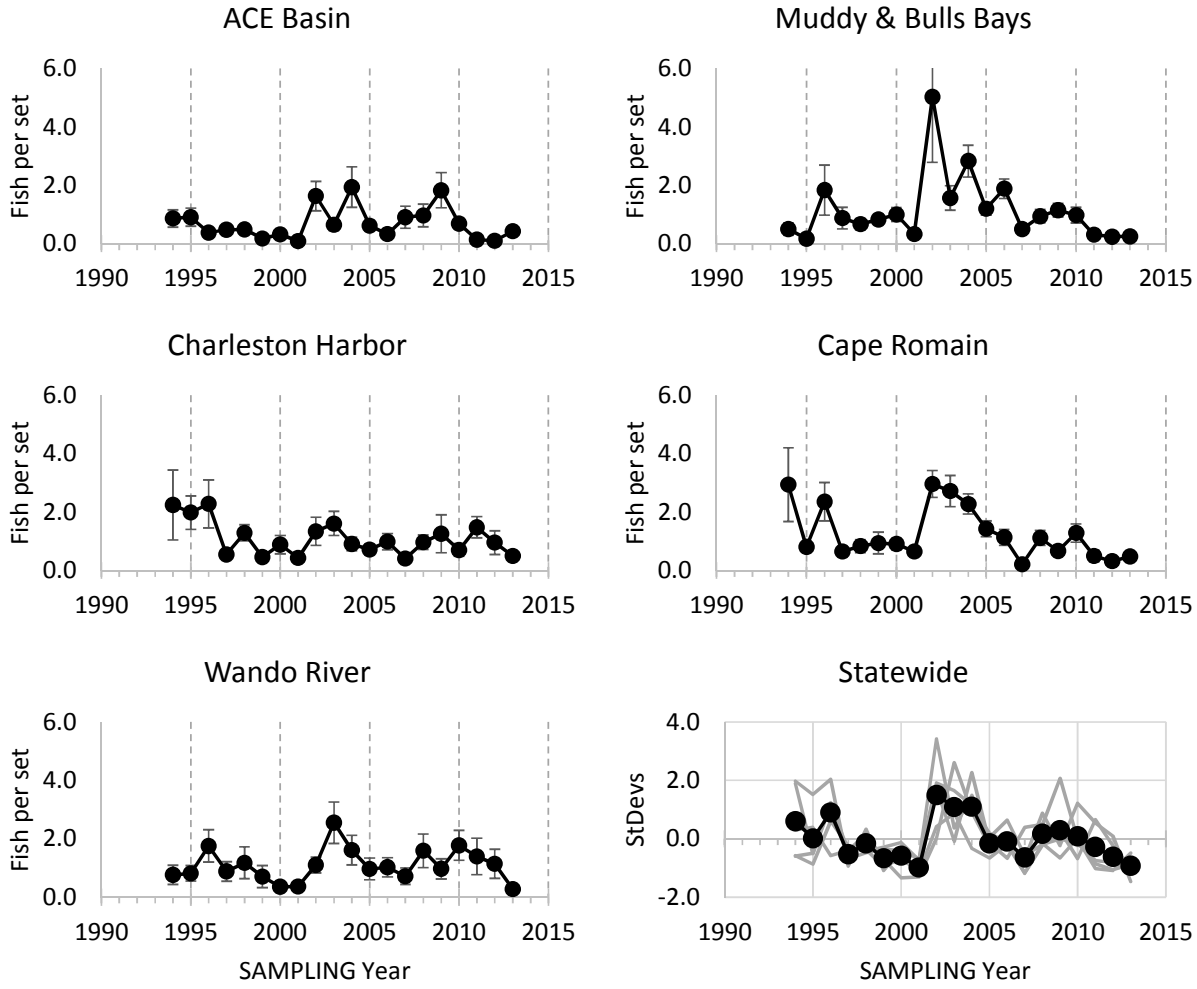
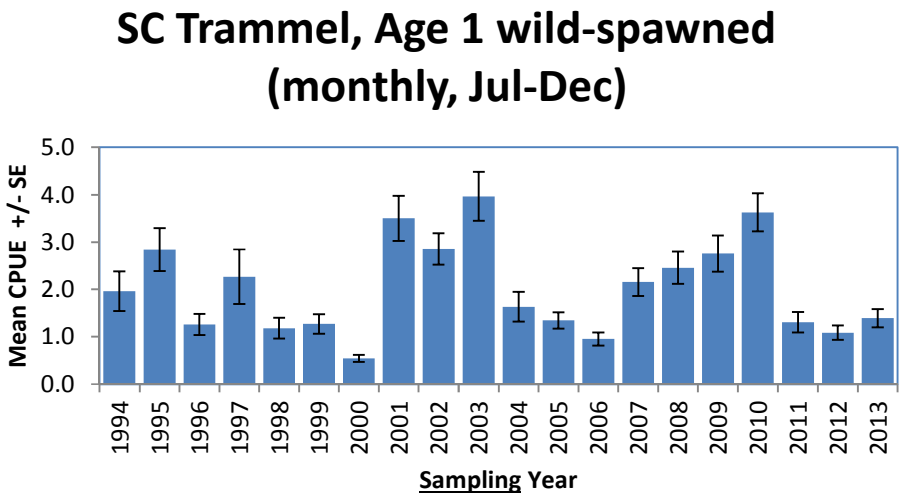


Fig-Tram 6 Mean CPUE (± se) of age 1and age 2 red drum in the SCDNR trammel net survey. Data are from the ACE Basin, Charleston Harbor, Wando River, Muddy & Bulls Bays and Cape Romain strata, which were all surveyed from 1994 through 2013.



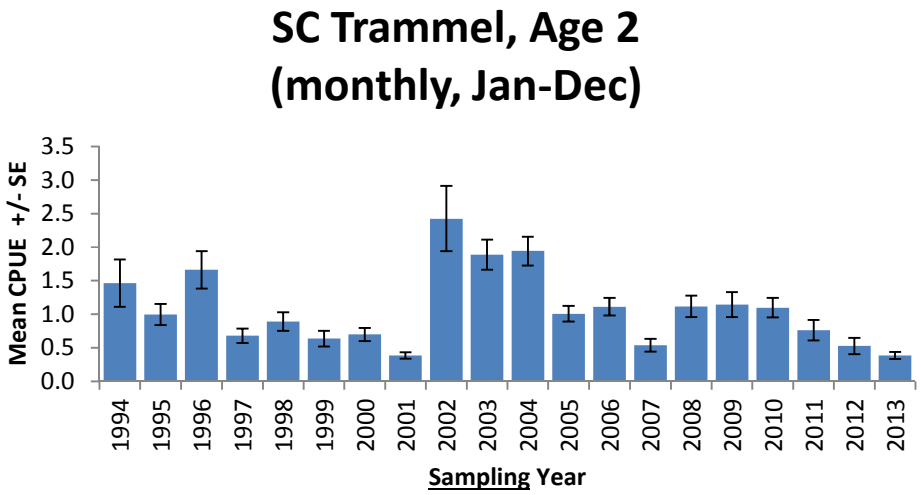


Fig-Tram 7 Mean soak time of nets by the SCDNR trammel net survey

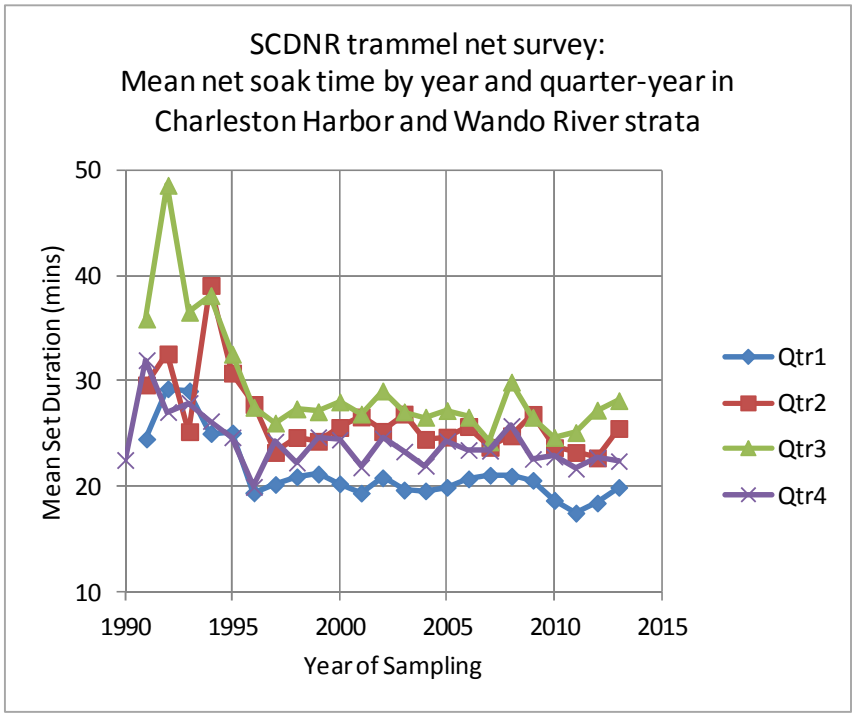


Fig-Tram 8 Mean salinity, by quarter-of-year, recorded by the SCDNR trammel net survey.

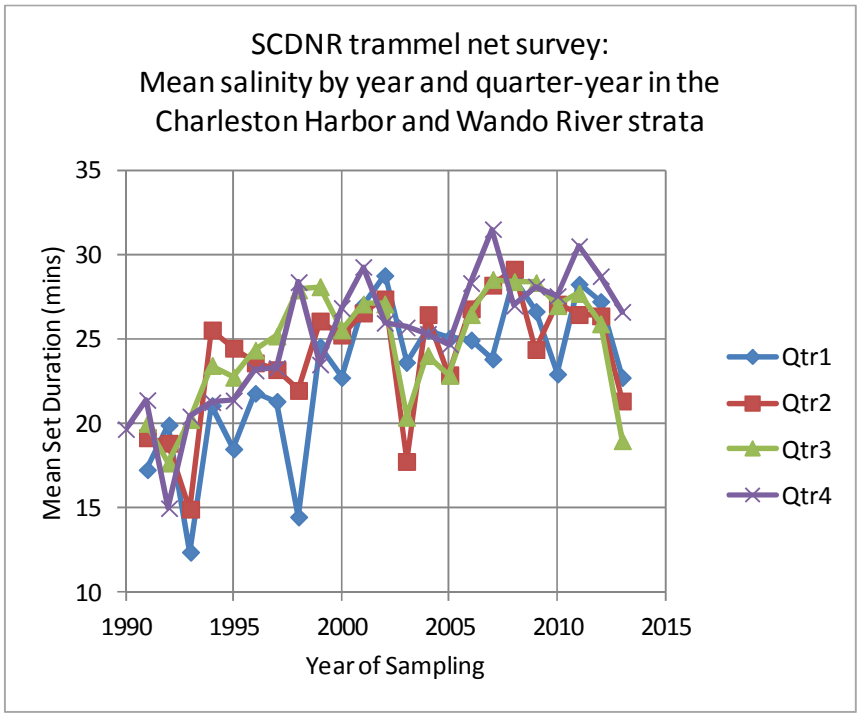


Fig-Elec 1 Total length (mm) of red drum caught by the SCDNR electrofishing survey on different days of the year (0-365). Data have been pooled actors years and strata. Black circles: age 0 red drum (calendar year age); red squares: age 1 red drum; green circles: ages 2+ red drum.

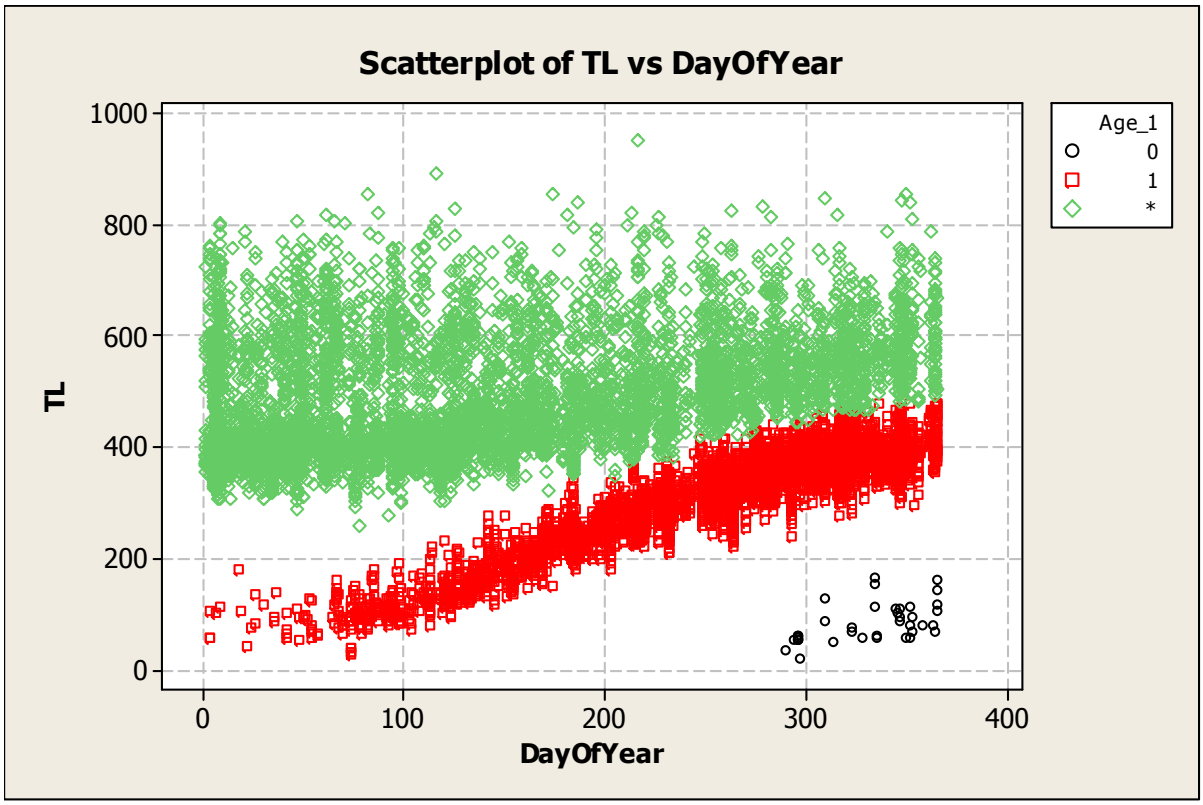


Fig-Elec 2 Jan-Dec CPUE (arithmetic mean ± SE) of wild (non-stocked) age 1 red drum in the SCDNR electrofishing net survey. (Red crosses show CPUE of wild + stocked red drum). The 'statewide' panel (bottom right) is a compilation of all strata expressed as z-scores (standard deviations from the 2002-2013 mean; statewide black line is the mean across all strata).

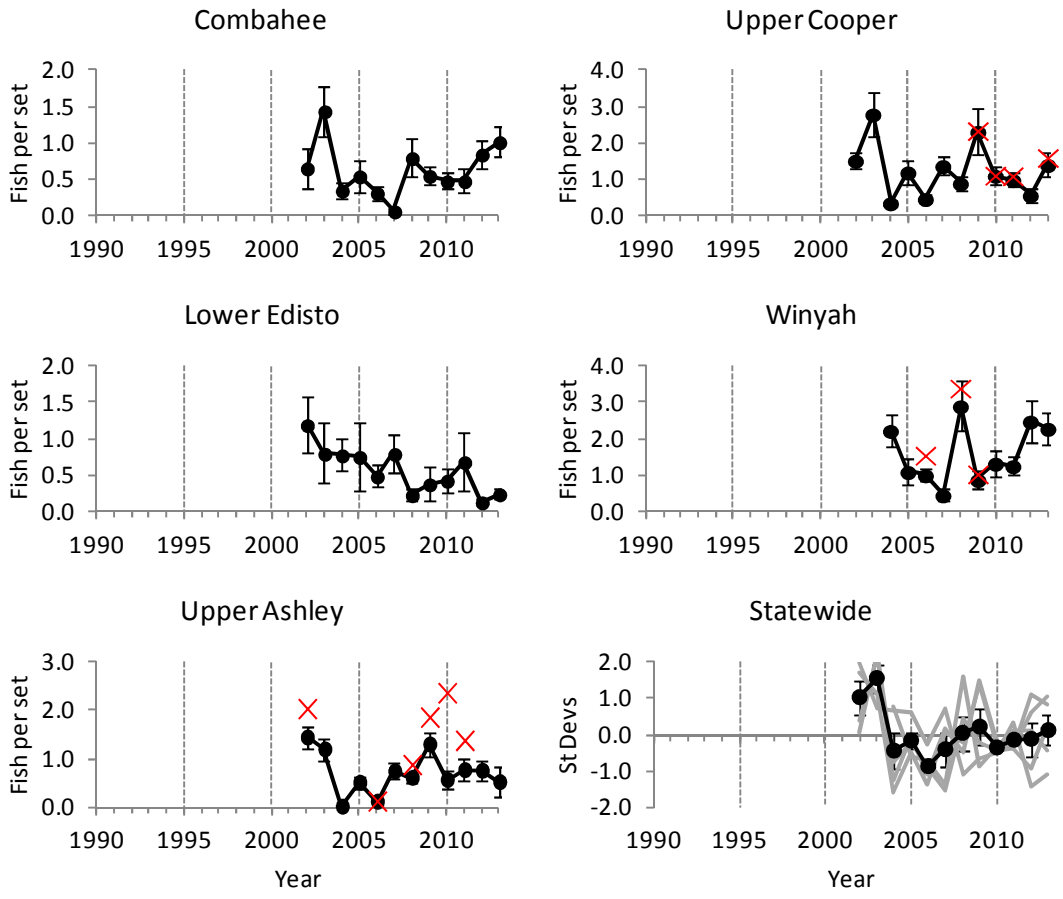


Fig-Elec 3 Jan-Dec CPUE of all red drum (arithmetic mean ± SE) in the SCDNR electrofishing survey. The 'statewide' panel (bottom right) is a compilation of all strata expressed as z-scores (standard deviations from the 2002-2013 mean; statewide black line is the mean across all strata).