Estimating the size and age composition of the B–2 fish (caught and released alive) in the recreational fishery for red drum and spotted seatrout in South Carolina

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Introduction

When examining a stock or population of fish, the determination of the different characteristics necessary to determines it's relative condition are dependent on the amount and quality of the data available for that population. Fish populations, like all natural systems, undergo constant changes in rates of increase (reproduction) and decline (mortality). In a balanced system these two rates cancel each other out and the population reaches a steady state. In reality, the myriad factors that influence these rates are in constant flux and if rates of decline remain higher than the rates of replenishment the population will ultimately go extinct. In an unexploited fish population, rate changes are driven by natural variations in the environment (e.g. temperature, food and predation levels), but when fishing pressure is added the fish stock has to contend with both natural and fishing mortality. The fishing mortality caused by harvesting can be estimated by monitoring of fish landings, which is achieved by port sampling or other direct measures where weight, size, and age information can be directly taken. However, a proportion of fish that are caught and released alive by the fishery die soon afterwards, and so information on these fish is also required. Previous stock assessments (Vaughn & Carmichael, 2001) have assumed a 0% mortality on adult red drum because they were considered outside the fishery. However, hooking mortality studies have since shown that anglers do have an effect on released adult fish with mortality rates ranging from 2% to 15% depending on hook type and hook placement (Anguilar et al., 2002; Gearhart, 2002; Vecchio & Wenner, 2007). Without more specific information on what types of hooks are used, the best estimate for hooking mortality in South Carolina in adult red drum was the 2.0% determined by Vecchio & Wenner (2007).

One of the techniques to estimate the condition of exploited fish populations is to follow the disappearance of a yearclass (cohort) through the fishery. When a population is overexploited by recreational anglers, several traditional fishery methods have been used to reduce fishing mortality. Included in these are size limits (minimum, maximum, slot), bag limits, seasonal closures, area closures, and limited entry. When size and/or bag limits are established, the landed catch is a modification of the actual catch. For example, if the landings before regulation were comprised of four age groups (age 1 through 4) and after the establishment of a slot, the catch was made up of two age groups, the losses are difficult to determine. This is because the sublegal fish and the the larger fish were released alive, and the catch and mortality suffered by these fish can not be assigned to a specific cohort.

The MRFSS (Marine Recreational Fisheries Statistical Survey) conducted by the National Marine Fisheries Service and the state's recreational survey both provide data on the number and sizes of harvested fish, but there is very little data on the size of the B-2 (caught and released alive) fish. There are methods available to assign fishes of a given length to a specific age group or cohort. The size composition can be used to estimate the age structure. If one has an estimate of the catch and release mortality by size (age) of the fish, then the B-2 losses due to fishing can be assigned into year-classes.

Strictly recreational fisheries, such as South Carolina's red drum and spotted seatrout fisheries, suffer losses in the population from natural and fishery related causes. Natural factors include things like disease, predation and environmental problems. Fishery related activities include harvest

and the loss from catch and release. When all sizes of fish are released after capture (sublegal fish less than 15 in; legal fish 15 to 23 in; large fish greater than 23 in total length for red drum and fish 14 in. or larger in spotted seatrout) there is no way to track what happens to these fish. While there are experimental estimates of hooking mortality of fishes of different sizes in the fishery, there is very little information on the sizes or ages of red drum and spotted seatrout that are captured and released (B-2 fish). This was a noted data deficiency for red drum in the last stock assessment for this species (Vaughn and Carmichael, 2000).

To estimate the condition of the population through present day techniques, the size and age composition of the B-2 fish is required. The purpose of this study was to establish the size structure of B-2 red drum in South Carolina using log book data from recreational angling guides. Additional information is also presented for spotted seatrout, southern flounder, and black drum, for which incidental data were also collected.

Methods

South Carolina Department of Natural Resources (SCDNR) biologists worked in cooperation with selected fishing guides and the Inshore Fisheries Fishery Independent Tagging Program. Log books were provided to fishing guides monthly. The information recorded by the guides was date, location, number caught, number retained, number released alive, and individual lengths of the released and retained fish. Individual lengths were recorded as total length (L_T) in inches, which were then converted to millimeters for the analysis. Logbooks were collected once a month. The primary species of interest was red drum, but length data were also collected on spotted seatrout, southern flounder and black drum. The main target species for these recreational guides were red drum and spotted seatrout, and flounder and black drum were captured incidentally. The length data collected for red drum and spotted seatrout was analyzed for frequency of occurrence within different size classes and then applied to existing age-length keys. Combined age length keys from South Carolina's fishery independent surveys (trammel net, electroshock boat, long line surveys) covering the same time period were applied to the annual size frequency distributions of B-2 red drum and spotted seatrout to derive age distributions. Southern flounder and black drum were analyzed for length frequencies only because of limited age data on both of these species. Results from this study have been distributed to the Red Drum Technical Committee and Stock Assessment subcommittee of the Atlantic States Marine Fisheries Commission (ASMFC) for incorporation into the current stock assessment for the purposes of estimating age structure and fishing mortality in the B-2 fish.

Results/Discussion

There were 855 logged trips by seven guides between August 2007 and December 2008. The majority of the trips (84.6%) occurred in the Winyah Bay and Cape Romain systems (Table 1). The next greatest number of trips occurred in the Charleston Harbor system (12.4%) followed by Port Royal Sound and St. Helena Sound (3%). There were 12,226 specimens caught, representing 28 species of fish (Table 2). The most numerous species in the study were spotted seatrout (48.8% of the total) followed by red drum (40.8%), southern flounder (3.8%), and black drum (2.3%).

Red Drum

There were 5,003 red drum captured during the study and almost all of them were released (4,992). Specimens ranged in size from 191 to 1295 mm total length (L_T) with a mean size of 577 ± 2.7 mm L_T (Fig. 1). The overall length frequency distribution was bi-modal with major peaks occurring within the legally harvestable slot limit (382 – 585 mm) and just above the slot limit at 675-725 mm L_T for most months of the year (Fig. 2). Red drum were captured every month of the year with the highest catches occurring from August through December. Specimens caught within the slot limit range represented 48.6% of the catch, with fish smaller than the slot (< 382 mm L_T) making up 9.1% of the total, and fish greater than the slot (> 585 mm L_T) representing 42.3% of the total. Adult fish (approximately ≥ 5 years in age and > 900 mm L_T) made up 7.05% of the total catch. The results indicate that South Carolina's red drum recreational fishery is based almost entirely on sexually immature juveniles, which has been noted in previous studies (Wenner, 2001; Vaughn & Carmichael, 2001). Red drum first recruit to the recreational fishery in September-October when they are slightly smaller than the legal size slot and at an age of approximately 12 months old. These same months were also when the greatest number of large adults were caught (Fig. 2), although adult fish were caught from May through October. While the majority of fishing effort occurs inshore targeting juveniles and sub-adults, the current data illustrates that some fishing pressure is also directed at mature adult fish.

In order to estimate an age distribution for the red drum in this study, an age-length key (ALK) was applied to a cross-tabulated data matrix of numbers of B-2 red drum in 25 mm size categories. The ALK was derived for the latest red drum stock assessment (SEDAR 18) and is based on age estimates from scales and otoliths, which were collected during fishery independent surveys of red drum in SC waters carried out by SCDNR. The resulting age distribution for each size category is in Table 3. Ages in the ALK ranged from 1-38 with the majority of specimens (93.9%) being age 9 or younger across the entire size distribution. The remaining specimens occurred in age classes 10 or greater (Fig. 3), which was almost equal to the percentage of adult fish (7.05%) from the size distribution data.

The catch per unit effort (CPUE) of red drum was estimated by dividing the mean monthly number of fish caught by the number of trips per month by estuarine system and as a combined total across all the estuaries (Table 4). The guides were successful at locating red drum on most trips with red drum occurring in 753 out of 855 logged trips (88.1%). Winyah Bay was the only system that had logged trips every month and represented the only collections made in January and February. Cape Romain was the next most sampled area by month (March through December), followed by Charleston Harbor (May through December) and both Port Royal Sound and St. Helena Sound were sampled from August through December. Comparisons of CPUE between estuarine systems was only possible during the months when all of the estuaries were sampled (Aug. to Nov.). During these months, the two southern systems (Port Royal and St. Helena Sounds) had higher catch levels in all months except October (Fig. 4). Catch levels in St. Helena sound remained the most consistent throughout the entire time period. Winyah Bay catch levels increased noticeably in October but were lower than any of the other systems in September and November. Winyah Bay and Cape Romain were both fished by the same

participating guides who fish year round and accounted for 85.8% of all trips logged in the study. The warmer months of the year (May through November) accounted for 74.7% of all logged trips. The CPUE values for January and February only represented Winyah Bay and the value for January was significantly higher ($p = 0.05$) than all the other months, representing 144 red drum caught over 8 trips that month, while the lower value in February came from 45 fish caught over 9 trips. Given the schooling behavior of red drum during winter in South Carolina's estuaries, a fishing guide's enhanced ability to locate large schools in January and February would have a significant effect on how many fish they catch. Also, the fewest number of days sampled occurred in January and February, so greater effort over the entire month might have resulted in CPUE values closer to that seen in other months.

Spotted Seatrout

There were 5,987 spotted seatrout captured by all the guides on 495 out of 855 reported trips (57.9%). Specimen lengths ranged from 165 to 660 mm L_T, with a mean size of 386 ± 0.69 mm L_T. The majority of the spotted seatrout reported (85.7%) were legal size (355 mm L_T or 14 inches) or larger. The overall length frequency was uni-modal (Fig. 5) with a single peak at 375-400 mm L_T size class. Spotted seatrout were captured every month of the year with the highest catches occurring from September to December. Monthly size frequency distributions indicated spotted seatrout began to show up in catches (i.e. recruiting to the fishery) at approximately 250-305 mm L_T which is when they are approaching one year in age. Spotted seatrout were captured every month of the year with the highest catches occurring from September to December (Fig. 6). Spotted seatrout reach sexual maturity at one year of age and approximately 300 mm L_T and spawn from April through August (Roumillat and Brouwer, 2004).

In order to estimate age using the B-2 length frequency distribution, an age length key (ALK) was developed using otolith and length data from fishery-independent trammel net surveys carried out by the SCDNR Inshore Fisheries group which has been monitoring spotted seatrout age structure in South Carolina since 1991. The ALK was applied to the size frequency distribution of spotted seatrout in the same manner used on red drum. Ages in the key ranged from 0 to 8 years with 1 and 2 year olds accounting for 87.1% of all the fish captured (Fig. 7). Less than 1% of the all trout in the ALK were greater than 4 years of age.

Overall mean catch levels were relatively consistent in Port Royal, St. Helena, and Charleston Harbor estuaries, with CPUE values ranging from 3.1 to 3.8 fish per trip (Table 5.). Catch levels for Cape Romain and Winyah Bay were significantly higher, particularly during the fall (Fig 8). As with red drum, CPUE values for January and February were representative of only Winyah Bay and Cape Romain. There was a slight increase seen from March through May, after which catches declined from June through August. This decrease coincided with the main part of the spawning season for spotted seatrout. For the time period where all the estuaries were sampled (Aug. to Nov.), Cape Romain showed a consistent month to month increase in catch levels not seen in any of the other systems (Fig. 8). This increase continued into December as well, which had the highest CPUE value for any month from any system. There was a similar increase in catch from August to September for Winyah Bay, but catch levels decreased in October and November. St. Helena Sound showed an increase in October as well, but was the only system

that had a decrease in catch going from October to November. This reflected decreasing effort levels in this system more than any reduction in abundance.

Southern Flounder

There were 464 southern flounder caught in 193 out of the 855 logged trips. Fish were reported every month of the year except February, with 74.3% of specimens caught from June through September. Only 9 flounder were caught during the winter months (Dec. – Feb.). Sizes ranged from 178 to 610 mm L_T with a mean size of 401 ± 3.2 mm L_T. The legal minimum total length for southern flounder in South Carolina is 14 inches (356 mm). 36.7% of the specimens caught were below the legal limit. The size frequency distribution was uni-modal with the peak occurring at the 326-350 mm L_T size class, which was just below the legal size (356 mm) (Fig. 9).

Black Drum

There were 278 black drum caught in 84 logged trips. The majority of black drum (85.6%) were caught from October through February with the highest catches occurring in January and February. Fish ranged in size from 197 to 584 mm L_T with a mean size of 390 ± 4.1 mm L_T. In South Carolina, black drum have a 14 inch minimum and 27 inch maximum size limit with a daily bag limit of 5. The size frequency distribution was uni-modal with a the peak centered around the 351-375 mm size class which included the minimum legal size (356 mm) (Fig10).

Summary

This study provides the most detailed information available to date on the size and age-frequency distributions of caught and released alive (B-2) red drum, spotted seatrout, southern flounder, and black drum in South Carolina. Both Federal and State monitoring efforts of recreational fisheries in the southeastern United States are often centered more on phone interviews and limited on-site creel sampling which do not take direct measurements of released fish and instead rely on reported size estimates. It has been noted in previous stock assessments (Vaughn and Carmichael, 2000) that no reliable data of the size and age structure of B-2 red drum exists for the southeast Atlantic coast. The fishery regulations on red drum in particular mandate that both undersized and oversized fish be released and as such the direct measurements of these B-2 fish do not exist. This study presents data on the full range of sizes and ages that are susceptible to the recreational fishery. While the major portion of the red drum fishery occurs inshore and targets juveniles and sub-adults (Wenner, 2000; Vaughn and Carmichael, 2000), this study also demonstrates that adult fish are targeted by the fishery. In previous stock assessments, adult red drum release mortality was assumed to be zero because they were outside the slot limits. Recent hooking mortality studies of adult red drum (Vecchio and Wenner, 2007) have shown that adult release mortality can range from 2-15% depending on hook type. This information coupled with the size and age distributions from this study will enable better estimates of mortality rates for both sub-adult and adult B-2 red drum. As with the red drum, the same data availability for spotted seatrout will provide important data for B-2 mortality estimates when this species undergoes it's next stock assessment.

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Table 1. Number of trips by estuarine system for recreational fishing guides participating in the South Carolina B-2 cooperative research program August 2007 to December 2008.

Month	Port Royal	St. Helena	Charleston Harbor	Cape Romain	Winyah Bay	Total
January					8	8
February					9	9
March				4	24	28
April				10	29	39
May			13	21	32	66
June			14	17	60	91
July			3	14	54	71
August	5	8	12	20	50	95
September	4	2	15	15	81	117
October	14	1	14	49	77	155
November	1	2	10	32	65	110
December			3	14	49	66
Total	24	13	84	196	538	855

Table 2. Species composition by estuarine system from reported log book data of recreational fishing guides participating in South Carolina's B-2 study for the cooperative research program from August 2007 to December 2008.

Common_Name	Total	Port Royal	St Helana	Charleston H	Cape Romain	Winyah Bay
Spotted Seatrout	5983	61	171	456	297	4998
Red Drum	5003	274	165	483	485	3596
Southern Flounder	465	3	7	26	62	367
Black Drum	281	3		3	66	209
Bluefish	102	4			2	96
Ladyfish	101	11		3	6	81
Black seabass	74					74
Bonnethead Shark	46	4	17	5	4	16
Blacktip Shark	40				10	30
Weakfish	32				2	30
Smooth Dogfish	27					27
Atlantic Sharpnose Shark	24		1		8	15
Atlantic Croaker	18				68	1
Sheepshead	15				8	7
Gag Grouper	12	3		1		8
Southern Whiting	12				5	7
Longnose Gar	11				2	9
Spanish Mackerel	4					4
Nurse Shark	3					3
Sandbar Shark	2				2	
Tripletail	2				2	
Spadefish	2		1			1
Brown Bullhead	2					2
Gafftop Catfish	1	0			1	
Oyster toadfish	1	1				
Striped Bass	1				1	
Cobia	1					1
Bowfin	1					1
Total	12266	364	362	977	1031	9583

Table 3. Age length distribution of red drum in South Carolina from recreational B-2 study from the cooperative research program. Age distribution was determined using an age-length key from the current stock assessment effort (SEDAR 18) for red drum in South Carolina. The percent frequency of each age-class within each length category was multiplied by the total number of B-2 red drum in that category in order to determine the number of fish in each age class. All fish 10 years of age and older were combined into a single age group due to multiple overlapping size ranges among older fish which follows the same protocol used for the current stock assessment.

			Age										
TL_mm	TL_inch	Total	0	1	2	3	4	5	6	7	8	9	10+
0-25	1												
26-50	2												
51-75	3												
76-100	4												
101-125	5												
126-150	6												
151-175	7												
176-200	8	2	2										
201-225	9												
226-250	10	28	28										
251-275	11	22	22										
276-300	12	116	116										
301-325	13	106	109										
326-350	14	187	185	2									
351-375	15	261	249	12									
376-400	16	308	270	38									
401-425	17	399	283	116									
426-450	18	260	114	146									
451-475	19	413	83	330									
476-500	20	164	2	162									
501-525	21	226		215	11								
526-550	22	194		180	14								
551-575	23	202		179	23								
576-600	24	203		146	55	2							
601-625	25	121		59	60	2							
626-650	26	323		74	196	51	2						
651-675	27	304		18	173	111	2						
676-700	28	215			93	111	9						
701-725	29	209			41	149	19						
726-750	30	134			11	109	14						
751-775	31	114			4	83	22	4					
776-800	32	58				39	16	2					
801-825	33	28				15	9	3			1		
826-850	34	21				8	4	6	2				
851-875	35	16				3		5	6	6			
876-900	36	37				4	8		12	4		4	4
901-925	37	15						2	3			6	5
926-950	38	26							3				23
951-975	39	40									4		36
976-1000	40	42											42
1001-1025	41	42											42
1026-1050	42	58											58
1051-1075	43	32											32
1076-1100	44	15											15
1126-1150	45	22											22
1151-1175	46	20											20
1176-1200	47	2											2
1201-1225	48	3											3
1226-1250	49	2											2
1251-1275	50	1											1
1276-1300	51	1											1
Total		4992	1463	1677	681	687	105	24	26	10	5	10	308

Table 4. Mean monthly catch per unit effort (mean number of fish per trip) by estuarine system for red drum from recreational fishing guides participating in the B-2 cooperative research program from August 2007 to December 2008. System means are for time period (August through November) when all the estuarine systems were sampled. CPUE = catch per unit effort, SD = standard deviation

Month	Port Royal		St. Helena		Charleston H.		Cape Romain		Winyah Bay			
	Bass_CPUE	Bass_SD	Bass_CPUE	Bass_SD	Bass_CPUE	Bass_SD	Bass_CPUE	Bass_SD	Bass_CPUE	Bass_SD	Total_CPUE	Total_SD
January									18.0	17.2	18.0	17.2
February									5.0	5.3	5.0	5.3
March							4.0	2.9	2.8	4.6	3.0	4.3
April							4.9	2.9	3.2	4.0	3.6	3.8
May					3.3	1.1	7.4	5.6	4.0	4.5	5.0	4.8
June					3.3	1.4	8.0	4.9	3.7	3.7	4.4	4.0
July					4.3	3.5	6.1	2.4	4.5	4.0	4.9	3.7
August	18.4	11.4	3.5	4.2	3.5	2.1	9.2	6.5	3.7	3.5	5.6	6.0
September	8.8	5.7	4.5	2.1	5.1	2.7	8.5	7.0	5.0	4.7	5.6	5.0
October	9.5	4.8	2.0		4.5	4.9	8.9	8.8	7.1	7.4	7.6	7.6
November	14.0		1.0	0.0	2.2	1.4	8.4	9.1	6.0	6.3	6.3	7.1
December					3.0	1.7	9.6	15.5	6.4	8.5	6.9	10.2
System Mean Aug. - Nov	12.7		2.8		3.8		8.7		5.4		6.3	

Table 5. Mean monthly catch per unit effort (mean number of fish per trip) by estuarine system for spotted seatrout from recreational fishing guides participating in the B-2 cooperative research program from August 2007 to December 2008. System means are for time period (August through November) when all the estuarine systems were sampled. CPUE = catch per unit effort, SD = standard deviation

Month	Port Royal		St. Helena		Charleston H.		Cape Romain		Winyah Bay			
	Trout_CPUE	Trout_SD	Trout_CPUE	Trout_SD	Trout_CPUE	Trout_SD	Trout_CPUE	Trout_SD	Trout_CPUE	Trout_SD	Total_CPUE	Total_SD
January									4.0	4.8	4.0	4.8
February									0.9	2.0	0.9	2.0
March							1.5	1.7	8.3	15.4	7.4	14.4
April							9.8	13.6	5.1	6.9	6.3	9.1
May					0.9	1.6	5.3	6.8	8.8	11.8	6.2	9.5
June					0.6	0.9	1.1	2.4	3.8	5.6	2.8	4.8
July					1.7	2.9	0.7	1.2	3.1	3.9	2.6	3.6
August	3.2	1.8	5.3	5.9	1.8	4.3	4.7	7.6	4.4	7.1	4.1	6.6
September	3.3	2.9	0.5	0.7	1.3	2.6	10.2	12.6	12.5	16.1	10.3	14.7
October	1.9	2.7	8.0		3.0	5.6	15.2	16.0	4.6	8.7	7.6	12.2
November	6.0		1.5	2.1	6.2	4.7	18.5	16.6	6.3	10.8	9.7	13.4
December					12.0	12.2	33.4	18.1	6.2	7.4	12.2	15.3
System Mean Aug. - Nov.	3.6		3.8		3.1		12.1		6.9		7.9	

Figure 1. Size frequency distribution for released red drum from recreational fishing guides participating in the B2 study as part of the cooperative research program, August 2007 to December 2008. n = 4992

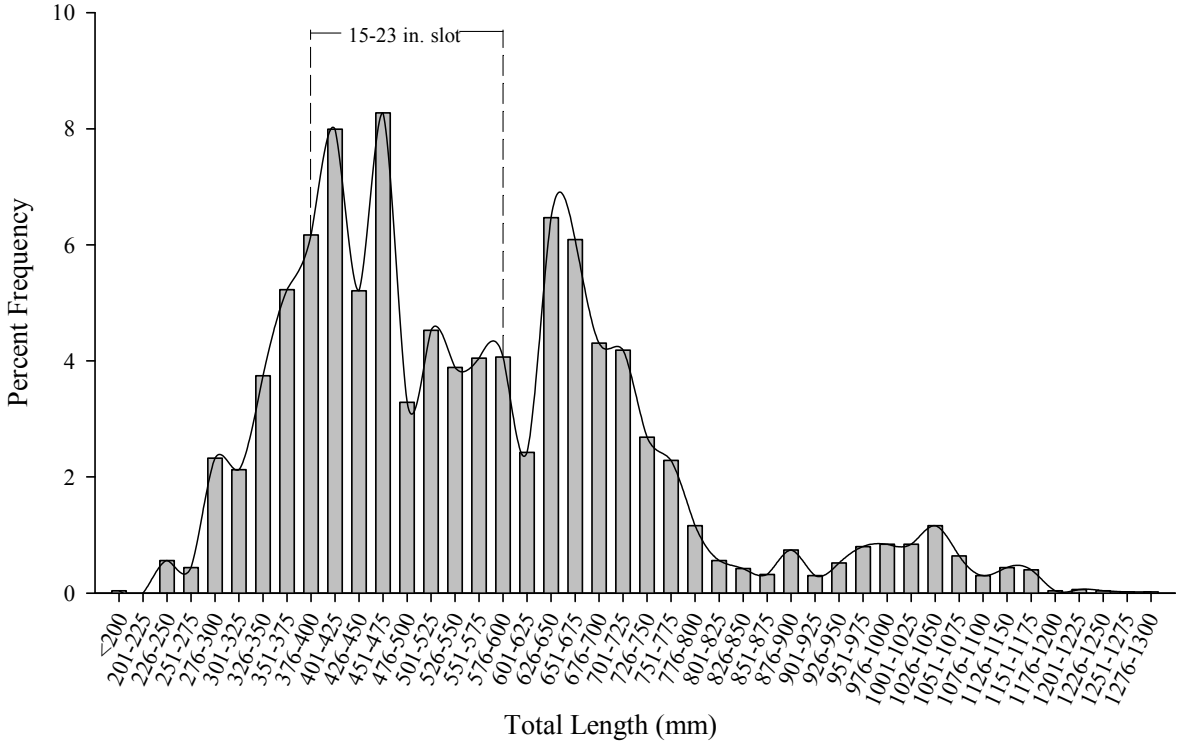

Figure 2. Monthly size frequency distribution for released red drum from recreational fishing guides participating in the B-2 study as part of the cooperative research program, August 2007 to December 2008

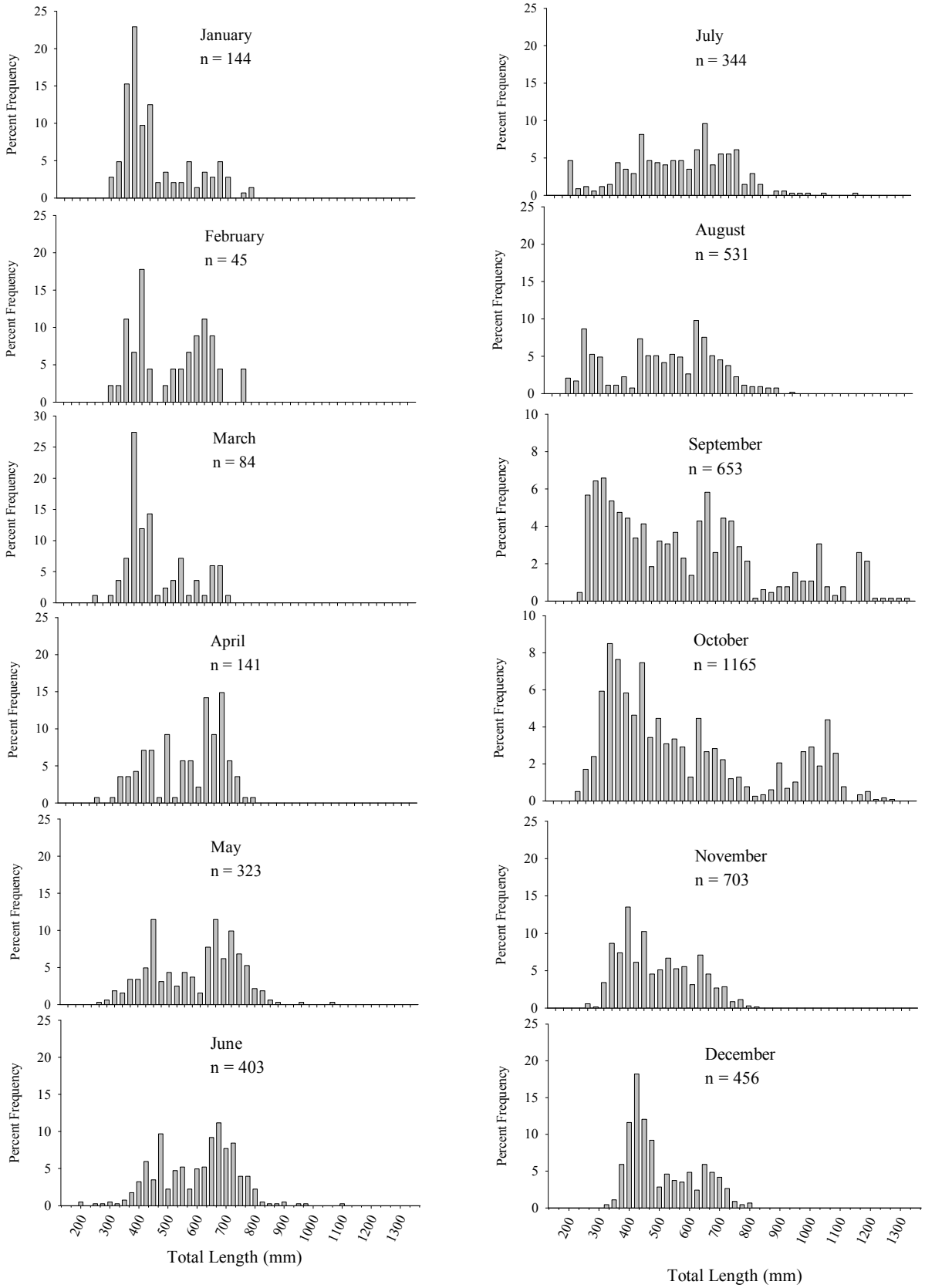

Figure 3. Age frequency distribution of red drum in South Carolina estuaries that were caught and released by recreational fishing guides participating in the cooperative research program B2 study. n = 4992

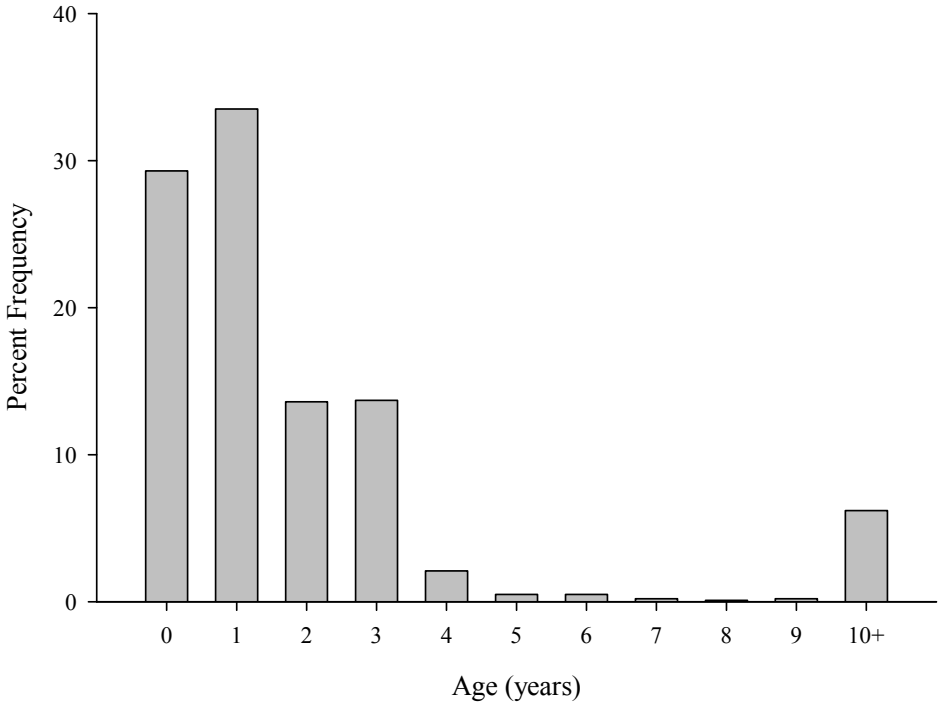

Figure 4. Mean monthly number of red drum per trip by estuarine system released by recreational fishing guides in South Carolina from 2007 to 2008.

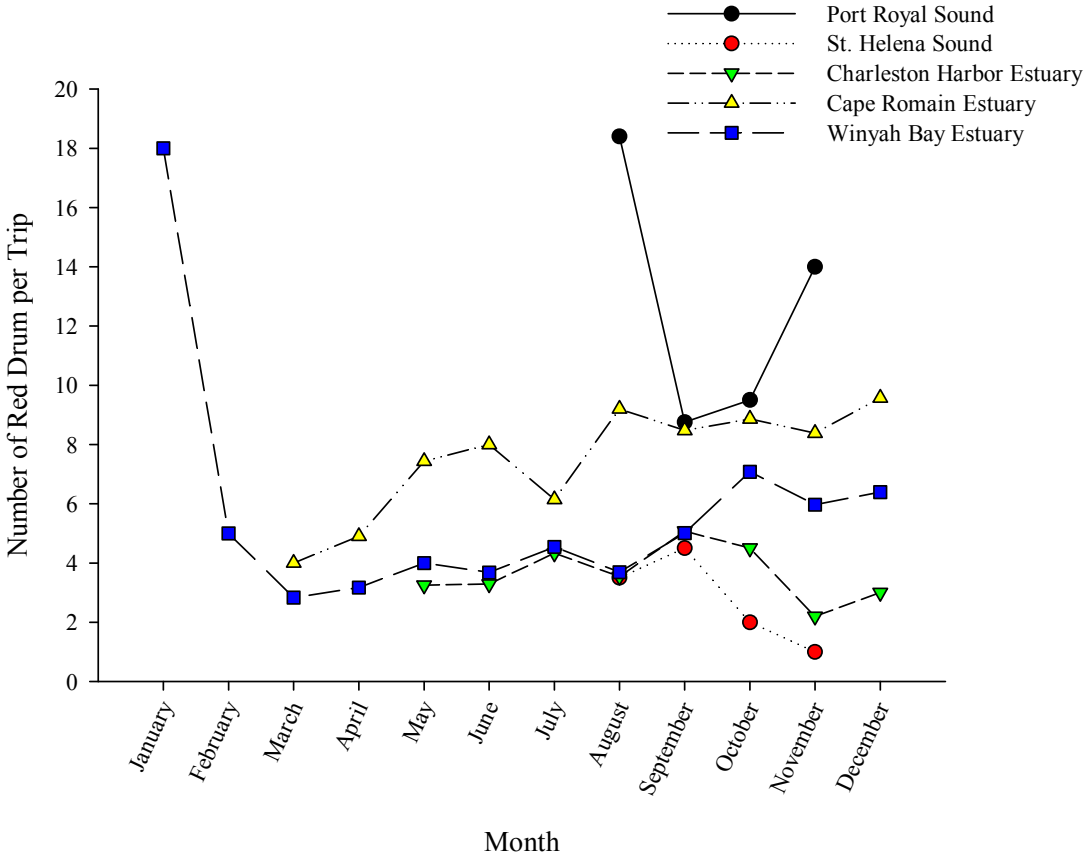

Figure 5. Size frequency distribution for spotted seatrout in South Carolina capturedby recreational fishing guides participating in the B2 cooperative research program from August 2007 to December 2008. N = 5988

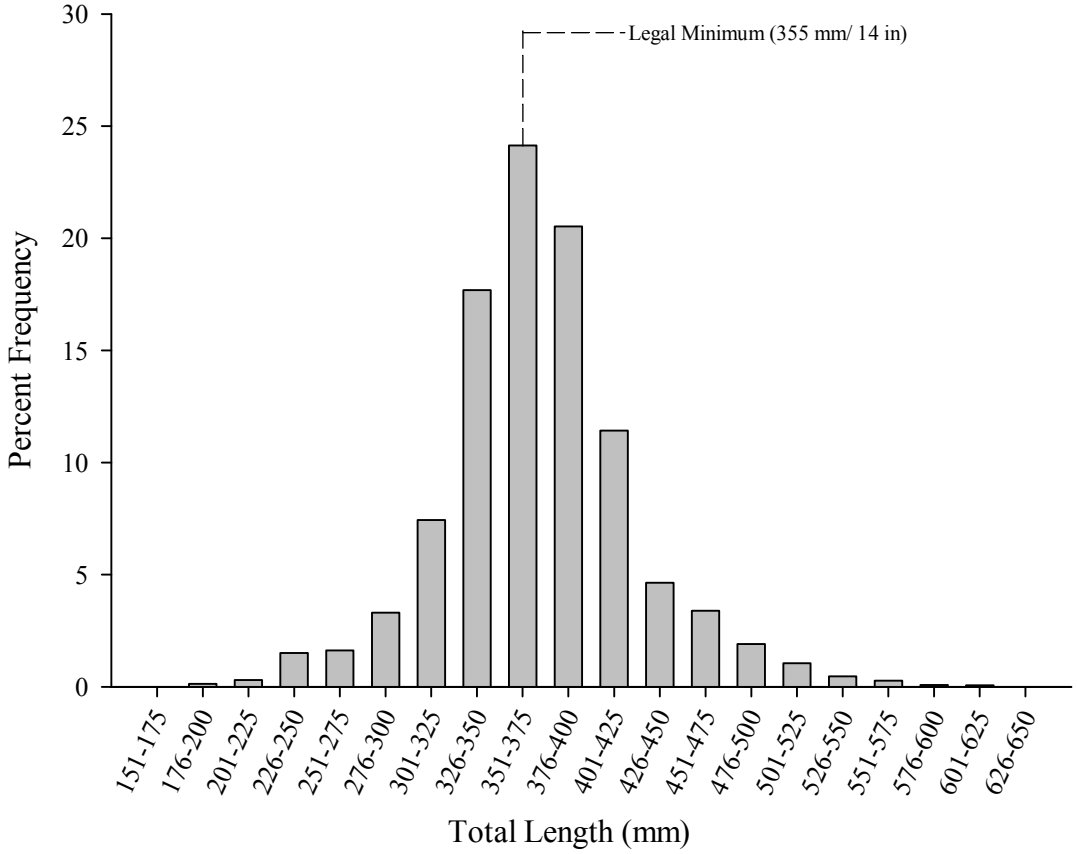

Figure 6. Monthly size frequency distribution for released spotted seatrout from recreational fishing guides participating in the B-2 study as part of the cooperative research program, August 2007 to December 2008

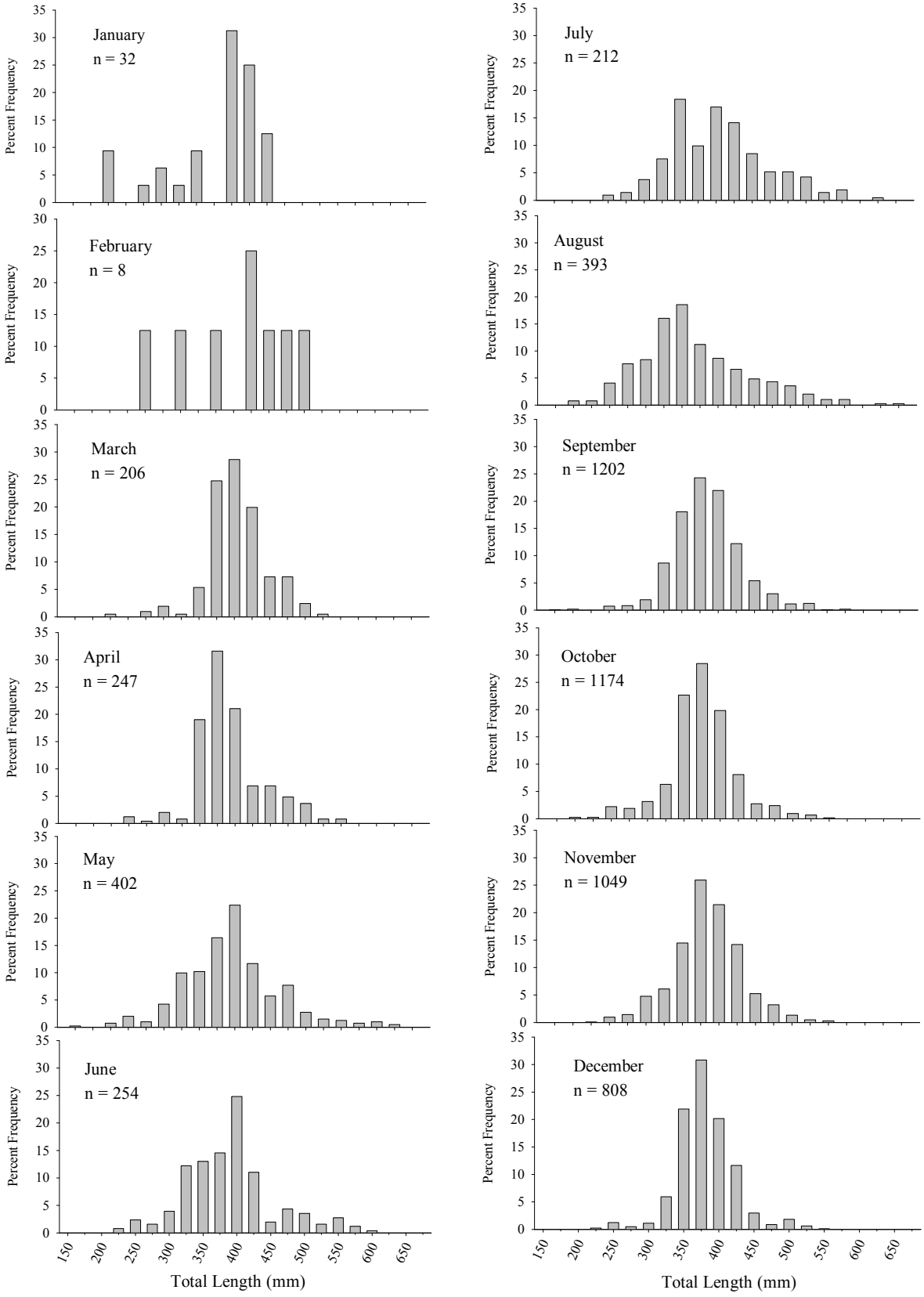

Figure 7. Age frequency distribution of B2 spotted seatrout from recreational fishing guides 2007 to 2008 in South Carolina. n = 5988

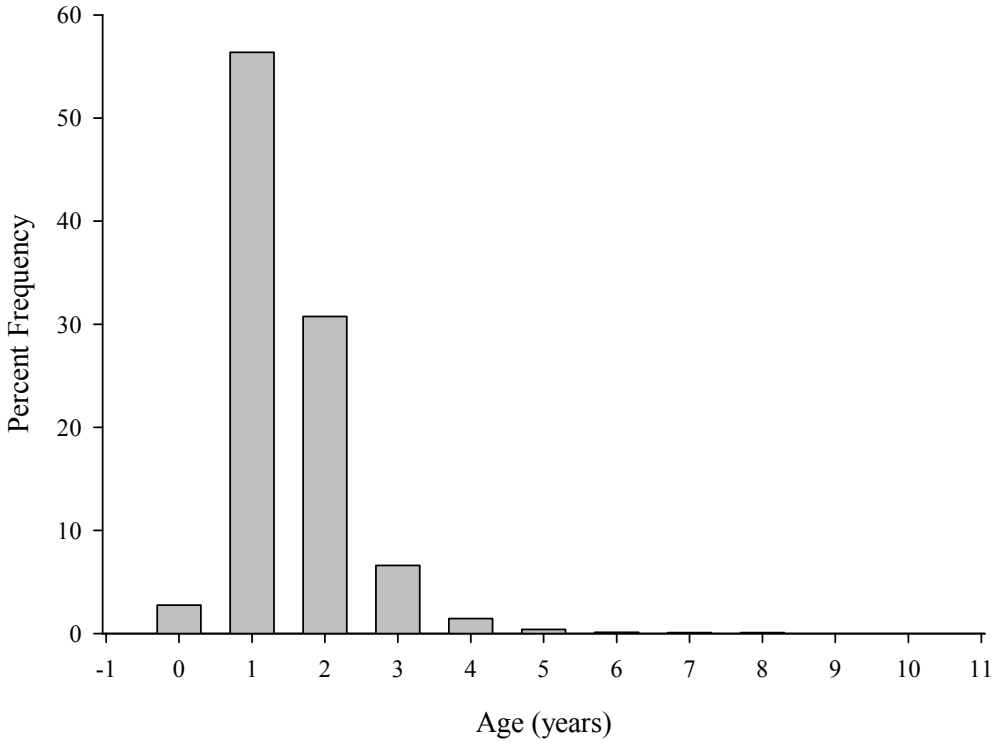

Figure 8. Mean monthly number of spotted seatrout per trip caught by recreational fishing guides in South Carolina by estuarine system from 2007 to 2008.

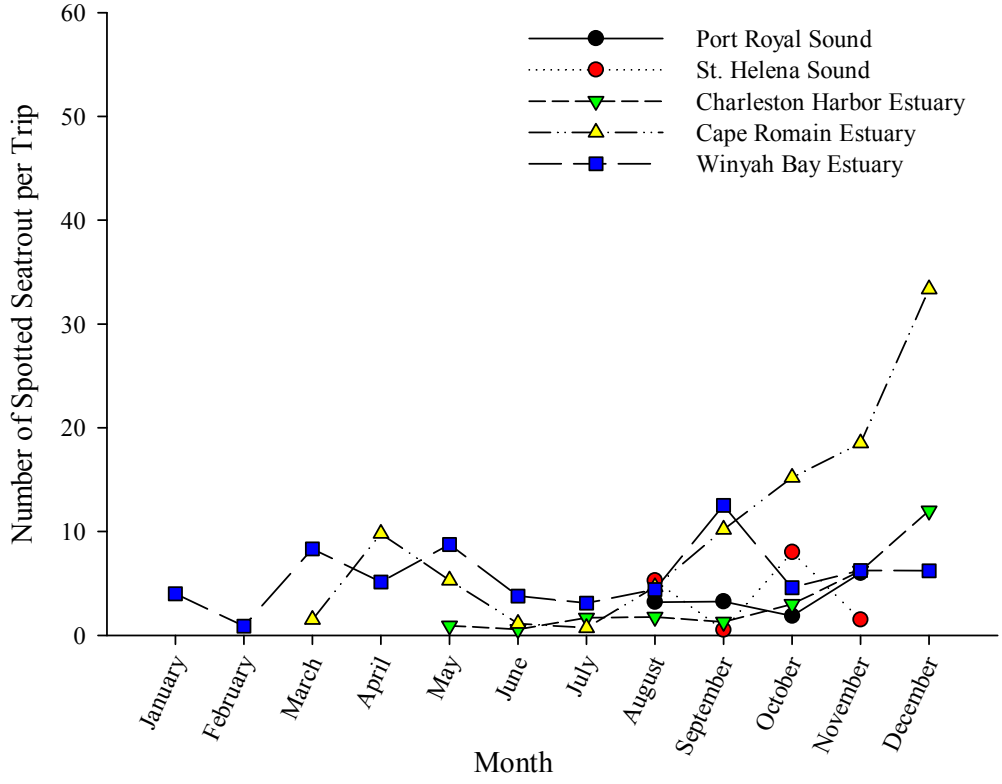

Figure 9. Size frequency distribution of southern flounder caught and released by recreational fishing guides from August 2007 to December 2008. N = 464

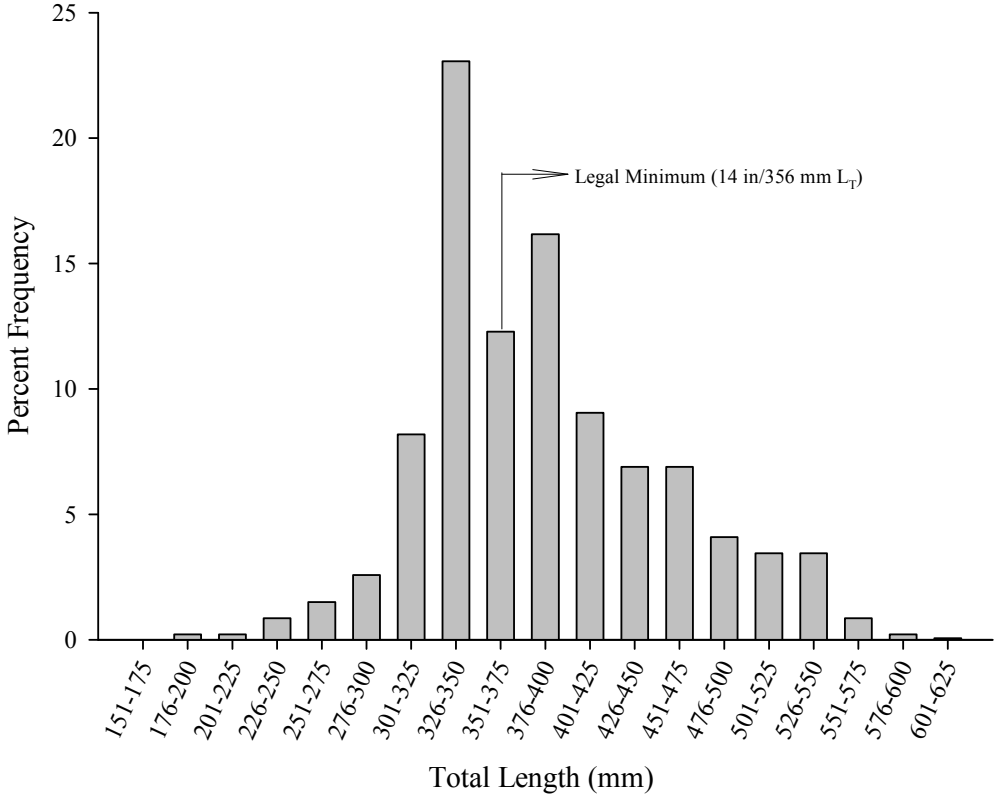

Figure 10. Size frequency distribution of Black Drum caught and released by recreational fishing guides from August 2007 to December 2008. N = 284