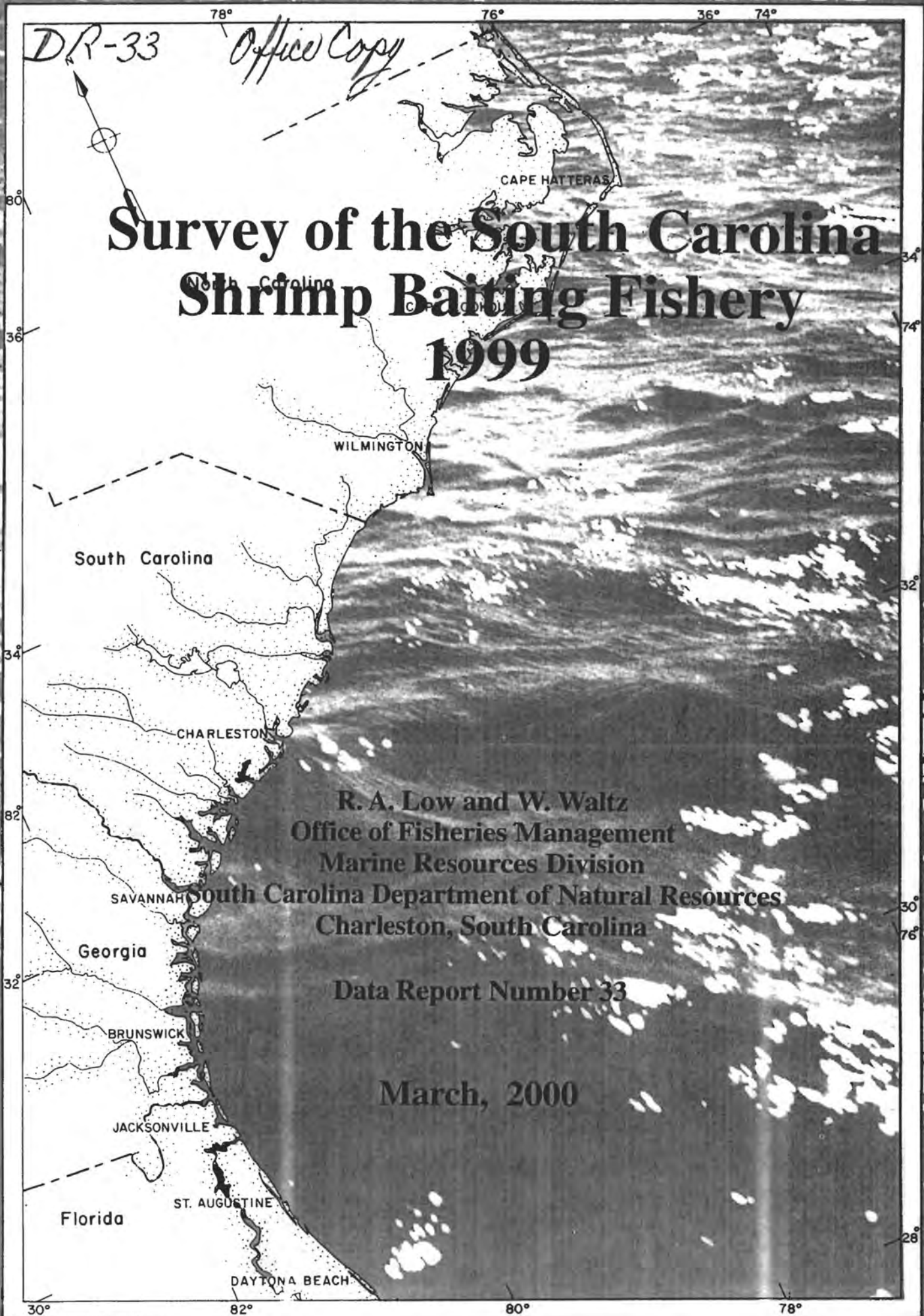


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Survey of the South Carolina Shrimp Baiting Fishery 1999



R. A. Low and W. Waltz
Office of Fisheries Management
Marine Resources Division
South Carolina Department of Natural Resources
Charleston, South Carolina

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INTRODUCTION

Theiling (1988) described the history of shrimp baiting in South Carolina. Surveys have been conducted annually since 1987, using various approaches to address several objectives and issues (Theiling 1988, Waltz and Hens 1989, Liao 1993, Low 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, and 1999). These studies have obtained statistics on participation, effort, and catch for each season, in addition to information on demographics of participants and constituency opinions on management options, user group conflicts, and economic issues.

Data for the 1999 fishery were obtained from three activities. An in-season survey was conducted using card questionnaires placed on windshields of vehicle/trailer rigs at launching locations heavily used by shrimp baiters. Objectives were to determine traffic densities, waiting times for launching, and to document trip-specific characteristics, e.g. catch per unit of effort (CPUE). A creel census was also conducted during the season in order to evaluate the size composition of the shrimp being landed. A postseason mailout survey was employed to estimate 1) total participation (i.e., the numbers of active permit holders and their assistants), 2) total effort in numbers of trips, 3) total catch, 4) effort and catch by shrimping area, and 5) to obtain information on the mesh size of nets.

METHODS

Site selection for the in-season survey was based on usage rates recorded during previous surveys (Theiling 1988, Waltz and Hens 1989, Low 1990). The windshield card (pre-addressed business reply) is shown in Fig. 1. Initially, we attempted to visit each sampling site every other night in order to achieve a continuous, uniform coverage, but adverse weather quickly disrupted this schedule and the intended sampling design. Actual coverage is shown in Table 1. A weekend began at 1200 Friday and ended at 2400 Sunday. Except for Bulls Bay, site visits were usually made between 1900 and 2200 hours. During each visit, the observer recorded the number of vehicle/trailer rigs present and the number of nonresident (out of state) license plates. Usually, the specific states were also listed. A survey card was placed on the windshield of each vehicle/trailer rig present (on a few occasions, card distribution was limited to 30 per site) and the number of cards recorded. Weather conditions were also noted.

As part of the windshield survey, staff conducted limited on-site interviews on several nights throughout the season. Samplers examined catches, estimated the amount of shrimp retained by baiters, and measured (total length) a subsample of 30 randomly selected shrimp from each catch. Cast net length and mesh size were also recorded.

Site _____

Date _____

ATTENTION SHRIMP BAITING PERMIT HOLDER-PLEASE COMPLETE CARD FOR THIS NIGHT'S TRIP AND MAIL IMMEDIATELY - NO POSTAGE REQUIRED.

1. What county does the permit holder live in? _____
2. What time did this boat trip start? _____ and end _____
3. How long did you wait to launch your boat? _____
4. This refers to people in the boat on this trip - total number? _____
 How many adults with permit? _____ without permit? _____
 How many are members of the permit holder's household? _____
 How many nonmembers? _____ How many children? _____
5. How many persons have a valid SC Marine Fishing Stamp? _____
6. What was your catch this trip in quarts of whole shrimp? _____
7. How much dry fish meal did you use? _____ pounds or _____ quarts
8. What type of mud/clay did you use?
 _____ white clay _____ mud _____ red clay _____ other
9. Which of the following best describes your trip?
 _____ very disappointing _____ mildly disappointing
 _____ mildly satisfying _____ very satisfying

Fig. 1. In-season (windshield) card questionnaire.

1. What county do you live in? _____
2. How many trips did you make using your permit and gear?
 _____ SEP _____ OCT _____ NOV _____ All season
3. Please indicate the number of trips you made in each area:
 _____ BEAUFORT _____ CHARLESTON
 _____ ST. HELENA SD. _____ BULLS BAY
 _____ WADMALAW/EDISTO IS. _____ GEORGETOWN
4. How many **different** people assisted you on your trips? _____
5. What was your average catch of shrimp per trip in quarts of whole shrimp? _____
6. What was your total catch for the season? _____ quarts
7. Which cast net mesh size (inch) did you use most often?
 _____ 3/8 _____ 1/2 _____ 5/8 _____ other; which _____

Fig. 2. Postseason (mailout) card questionnaire.

Table 1. Sample distribution of the in-season survey.

Site	Visits		Cards	Returns	% return
	Weekend	Weekday			
Bulls Bay			1014	258	25.4
Buck Hall	12	9	473	118	24.9
Moore's (day)	7	8	187	36	19.3
McClellanville	12	9	354	104	29.4
Charleston			1548	393	25.4
Remley Point	11	12	584	166	28.4
Shem Creek	11	12	398	80	20.1
Wappoo Cut	11	9	454	116	25.6
Folly River	11	9	112	31	27.7
Beaufort			2262	404	17.9
Grays Hill	9	13	522	94	18.0
Trask	10	16	528	120	22.7
Lemon Island	9	13	433	48	11.0
Broad River	10	13	227	30	13.2
Pinckney Island	10	16	323	58	18.0
All Joy	10	16	229	54	23.6
Total			4824	1055	21.9

The postseason mailout survey was virtually identical to those of the previous five years. The survey package consisted of an introductory statement and a pre-addressed business reply postcard questionnaire (Fig. 2). The package was sent by first class mail to 25% of those individuals who purchased a 1999 permit. The sample was randomly selected and stratified in direct proportion to the percentage of permit holders residing in each county. A two-week return period was specified in order to minimize problems associated with recall and responses received after that were not included in the analysis.

RESULTS

In-season Windshield Survey

This activity required 191 manhours and 4,024 miles of travel. Vehicle/trailer counts are listed in Table 2. Information on nonresident incidence is contained in Table 3. Nonresident permit sales were 23, most to Georgia residents. As would be expected, the highest incidence of nonresident plates was in the Beaufort area, in closest proximity to Georgia. It should be recognized that there was no way to identify rigs being used for baiting as opposed to those carrying fishing boats or otherwise employed by nonbaiters. It is therefore logical to assume that most of the nonresident rigs other than those with Georgia plates were so employed.

The average waiting periods are indicated in Table 4. Day trips (Bulls Bay only) were defined as those with launching between 0500 and 1500 hours, night trips as those with launching during the interval from 1500-0500. The percentages of respondents indicating that they had no waiting time exceeded 50% at nine of the thirteen sites routinely visited. Very few respondents reported waiting periods exceeding 15 minutes. At most locations, average waiting periods were slightly longer during weekends.

County-of-residence composition of the sample population is shown in Table 5. Obviously, the location of sampling sites influenced this aspect with residents of Berkeley, Charleston, and Dorchester Counties being a larger component of the population than in a statewide survey.

Participation figures were not necessarily additive between categories due to reporting discrepancies. Data are summarized in Table 6. Of the total number of people on the trips, the vast majority (96%) were adults. Sixty percent of those were permit holders and 77% also had a marine recreational fishing stamp. More than one permit holder was aboard during 23% of all trips. About 74% of the trips consisted of two people.

The average trip ranged from 4.9 hours in the Charleston area to 6.5 hours at Bulls Bay (5.9 hours in the Beaufort area). Night trips averaged about an hour shorter than day trips in Bulls Bay.

Table 2. Trailer counts. Weekend includes Friday night through Sunday night. OOS indicates out of state (nonresident).

Site	Total			Average		Total Average
	SC	OOS	% OOS	Weekend	Weekday	
Bulls Bay	1371	20	1.4			
Buck Hall	698	11	1.6	49.2	13.2	33.8
Moore's (day)	211	2	0.9	19.4	9.6	14.2
McClellanville	462	7	1.5	31.5	10.1	22.3
Charleston	1713	41	2.3			
Remley Pt.	699	14	2.0	38.9	23.8	31.0
Shem Creek	418	10	2.3	21.4	16.1	18.6
Wappoo Cut	463	12	2.3	24.9	22.3	23.8
Folly River	100	5	4.8	6.8	3.3	5.3
Beaufort	2666	129	4.6			
Grays Hill	623	8	1.3	26.3	30.3	28.7
Trask	713	40	5.3	37.3	23.8	29.0
Lemon Island	489	45	8.4	23.0	25.2	24.3
Broad River	278	8	2.8	6.9	16.7	12.4
Pinckney Is.	328	16	4.7	19.7	9.2	13.2
All Joy	235	12	4.9	12.0	7.9	9.5

Table 3. Nonresident trailer counts.

State	Bulls Bay	Charleston	Beaufort	Total
Unidentified	3	1	65	69
Georgia	-	6	58	64
North Carolina	8	8	3	19
Florida	2	8	-	10
Texas	2	3	-	5
Louisiana	1	3	-	4
Tennessee	2	-	-	2
Virginia	1	-	1	2
Delaware	-	2	-	2
Illinois	-	1	1	2
Michigan	-	2	-	2
Alaska	1	-	-	1
Idaho	-	1	-	1
W. Virginia	-	1	-	1
New York	-	1	-	1
Alabama	-	1	-	1
Massachusetts	-	1	-	1
California	-	1	-	1
Colorado	-	-	1	1
Maine	-	1	-	1
Total	20	41	129	190

Table 4. Average waiting period (minutes) to launch.

Location/site	Weekend	Weekday	Day	Night	% no wait
Bulls Bay	5.6	3.0	5.1	4.4	48
Buck Hall	4.9	2.9	4.5	3.2	54
Moores	4.7	1.7	3.9	NA	53
McClellanville	6.6	4.0	6.5	5.2	40
Charleston	3.8	2.3			63
Remley Point	4.3	2.3	NA	NA	63
Shem Creek	4.7	2.5	NA	NA	53
Wappoo Cut	3.9	2.2	NA	NA	61
Folly River	< 1	1.7	NA	NA	90
Beaufort	5.7	5.2			42
Grays Hill	8.4	6.7	NA	NA	31
Lemon Island	3.6	5.0	NA	NA	30
Broad River	2.0	1.9	NA	NA	69
Trask	6.3	6.2	NA	NA	35
Pinckney Island	3.9	2.6	NA	NA	60
All Joy	6.0	4.3	NA	NA	53

Table 5. Residence of respondents to the in-season survey by shrimping area.

County	Bulls Bay	Charleston	Beaufort	Total
Abbeville	-	-	4	4
Aiken	-	-	44	44
Allendale	-	-	3	3
Anderson	3	1	2	6
Bamberg	-	-	25	25
Barnwell	-	-	24	24
Beaufort	-	-	80	80
Berkeley	69	74	1	144
Calhoun	-	1	14	15
Charleston	30	213	1	244
Chesterfield	1	-	-	1
Clarendon	12	-	1	13
Colleton	-	1	43	44
Darlington	12	1	-	13
Dillon	4	-	-	4
Dorchester	14	68	13	95
Edgefield	-	-	5	5
Fairfield	-	1	3	4
Florence	15	-	-	15
Georgetown	22	1	-	23
Greenville	2	1	3	6
Greenwood	-	1	-	1
Hampton	-	-	22	22
Horry	30	2	-	32
Jasper	-	-	14	14
Kershaw	1	-	1	2
Lancaster	1	-	-	1
Laurens	-	-	1	1
Lee	1	-	-	1
Lexington	7	9	33	49
Marion	1	-	-	1
Newberry	3	2	6	11
Oconee	1	-	1	2
Orangeburg	6	12	41	59
Pickens	1	-	1	2
Richland	5	6	5	16
Saluda	-	1	-	1
Spartanburg	2	2	-	4
Sumter	2	4	4	10
Williamsburg	10	-	-	10
York	2	-	-	2
Nonresident	-	-	8	8
Total	257	401	403	1061

Table 6. Participation parameters from the in-season windshield survey. Household members are those of the permit holder whose tags were used. Number of trips = 1,026.

Category	Bulls Bay	Charleston	Beaufort	Total
Total persons	550	849	871	2270
Persons/trip ...1	23	36	24	83
...2	175	273	311	759
...3	37	63	48	148
...4	9	9	14	32
...5	1	0	3	4
Adults with permit	316	484	515	1315
...without permit	215	345	316	876
Children	20	27	40	87
Household members	301	462	502	1265
Marine fishing stampholders	443	633	613	1689
Trips with >1 permit holder	56	80	109	245

Bait usage was similar in all areas, averaging 8.8 pounds of dry fish meal per trip with white clay used as the binder on 72% of the trips.

Catch rates were highly variable both within and between areas, as well as during the season. Bulls Bay was the only area in which there was appreciable daytime baiting (at least as recorded during the in-season survey). There, the nighttime catch rate (4.66 quarts of whole shrimp per hour) was considerably higher than the daytime CPUE (3.57 quarts per hour). Trends in CPUE by area during the season are shown in Fig. 3.

Respondents were finally asked to evaluate their trip in terms of satisfaction. Overall ratings were generally similar, as indicated below (figures are percentages of responses):

Category	Bulls Bay	Charleston	Beaufort	All
Very disappointing	11	21	18	17
Mildly disappointing	16	14	18	16
Mildly satisfying	36	37	28	34
Very satisfying	37	28	36	33

A reasonable assumption is that the satisfaction level was largely dependent on the catch rate for the trip. The averages (in quarts per trip) are shown below (a correlation coefficient is rather meaningless given only four dependent variables):

Category	Bulls Bay	Charleston	Beaufort	All
Very disappointing	3.6	6.7	7.0	6.4
Mildly disappointing	13.4	14.5	19.6	16.5
Mildly satisfying	25.0	25.7	27.5	26.3
Very satisfying	36.3	35.7	40.7	38.0

Clearly, there was a consistent tendency for perceived satisfaction to closely parallel the level of catch obtained.

Creel Census

Staff conducted on-site interviews as follows.

Date	Site	Number of interviews
9/13	Wappoo Cut	8
9/24	McClellanville	8
	Buck Hall	5
10/3	Remley Point	10
10/6	All Joy	1
	Trask	8
10/22	McClellanville	3
	Buck Hall	3
10/29	Cherry Point	6

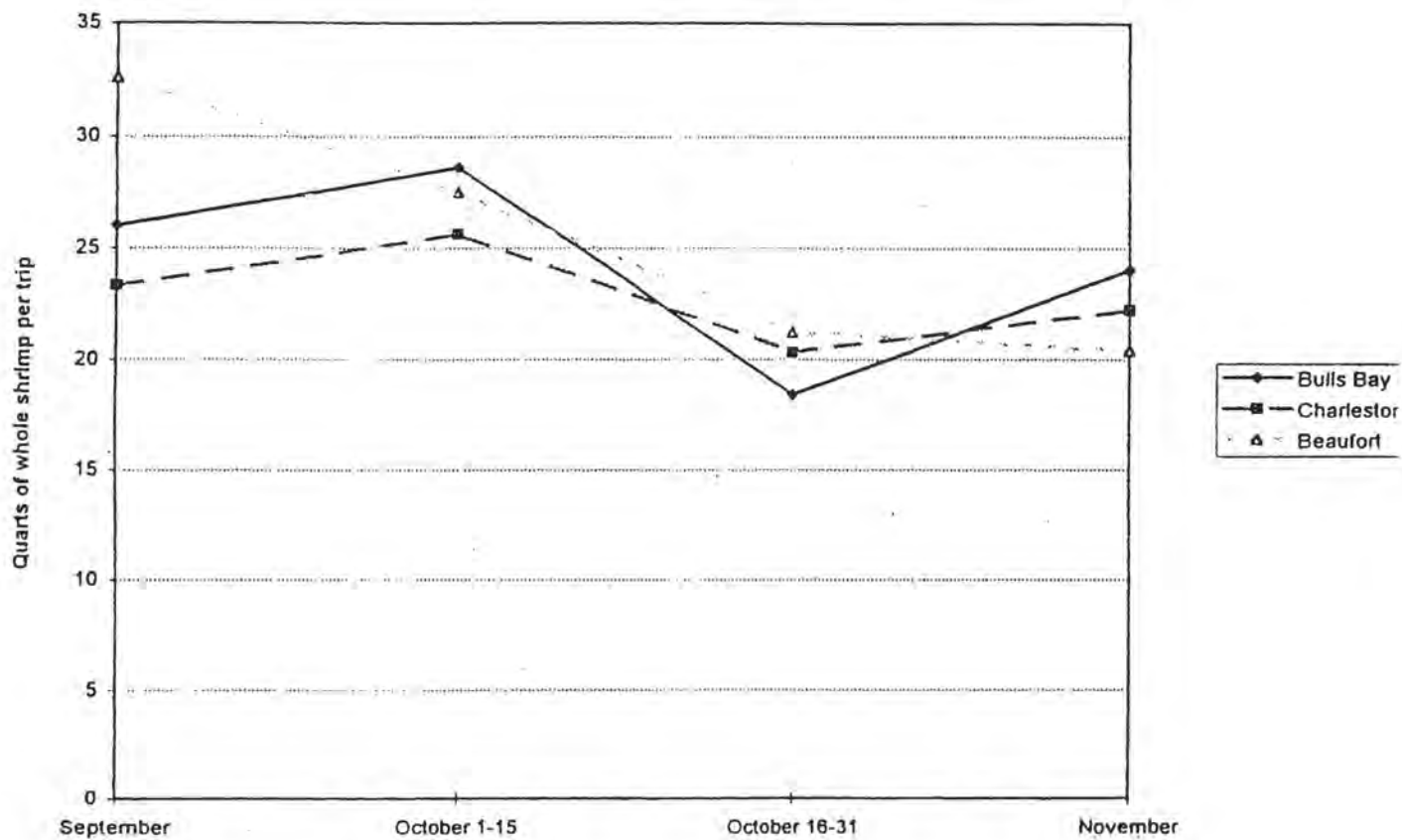


Fig. 3. Catch rates by area as reported during the in-season survey.

Of the 51 baiters interviewed, 49 provided catch information. Their average catch was 22.25 quarts of whole shrimp. Seven baiters (14%) had the limit (48 quarts). Thirty seven percent had 12 quarts or less, 23% had 13-24 quarts, and 25% had 37-47 quarts.

A total of 1427 shrimp were measured. The length frequency distribution (in percent) vs cast net mesh size was as follows.

Total length (mm)	Mesh size (inches)		
	3/8	1/2	5/8
60-69	0.2	-	-
70-79	0.6	0.5	-
80-89	2.5	2.2	-
90-99	13.2	9.8	1.1
100-109	20.4	16.3	3.3
110-119	28.9	22.3	21.1
120-129	18.7	21.9	21.1
130-139	12.3	14.9	28.9
140-149	2.3	8.1	18.6
150-159	1.1	3.3	5.6
160-169	-	-	-
170-179	-	0.1	-
Mean length (mm)	114	120	130

Modal lengths of shrimp taken in 3/8 and 1/2 inch mesh were very similar. Shrimp were substantially larger in the southern area (130 mm) vs the central (122 mm) and northern (119 mm) areas. Some time differences may have been a factor, although these results conformed with anecdotal information received throughout the season.

Postseason Mailout Survey

The effective mailout (after subtraction of nondeliverables) for the postseason survey was 3,925 with a return rate (usable responses) of 36.8% (N = 1,445) postmarked by the cutoff date (December 15). The survey results were therefore based on information provided by 9.1% of the total population (N=15,895) of permit holders.

Distributions of the total permit holder populations by county of residence in the first year of permit sales, average of the last three years, and in the current year are shown in Table 7. The distributions of the 1999 permit holder population and survey populations are compared in Table 8. As has been generally the case, the postseason return rates from noncoastal residents were slightly higher, but the overall distribution of the postseason sample group was comparable to that of the total population.

Table 7. Distributions of permit holder populations, in percentages of permit holders by county.

County	1988	1996-1998	1999
Abbeville	0.1	0.3	0.3
Aiken	2.0	3.7	3.9
Allendale	1.2	0.8	0.8
Anderson	0.2	0.5	0.6
Bamberg	1.5	1.3	1.2
Barnwell	1.3	1.9	2.0
Beaufort	10.3	9.9	10.0
Berkeley	9.4	9.6	8.7
Calhoun	0.4	0.9	1.1
Charleston	41.2	24.9	21.6
Cherokee	<0.1	<0.1	<0.1
Chester	<0.1	0.2	0.2
Chesterfield	<0.1	<0.1	<0.1
Clarendon	0.1	0.5	0.7
Colleton	5.0	4.8	4.6
Darlington	0.1	0.6	0.7
Dillon	0	0.2	0.3
Dorchester	6.9	5.3	4.8
Edgefield	<0.1	0.3	0.4
Fairfield	0.1	0.2	0.3
Florence	0.2	1.6	1.9
Georgetown	2.4	5.7	5.8
Greenville	0.2	0.8	1.1
Greenwood	0.1	0.6	0.6
Hampton	4.0	2.8	2.7
Horry	0.3	2.6	3.4
Jasper	3.4	1.9	1.8
Kershaw	0.1	0.6	0.7
Lancaster	0	0.2	0.2
Laurens	0.1	0.3	0.4
Lee	0	<0.1	<0.1
Lexington	2.5	5.3	6.0
McCormick	<0.1	<0.1	<0.1
Marion	0.1	0.2	0.3
Marlboro	<0.1	<0.1	<0.1
Newberry	0.2	0.5	0.6
Oconee	<0.1	0.2	0.3
Orangeburg	4.0	3.6	4.0
Pickens	<0.1	0.3	0.3
Richland	1.4	3.0	3.4
Saluda	<0.1	0.3	0.4
Spartanburg	0.1	0.5	0.7
Sumter	0.3	1.0	1.1
Union	0.1	<0.1	0.1
Williamsburg	0.4	0.8	1.0
York	0.1	0.5	0.6

Table 8. Distribution of permit holders and sample populations.

Residence	Total population		Postseason sample population		In-season sample population	
	N	%	N	%	N	%
North Coast						
Georgetown	914	5.8	94	6.5		2.2
Horry	545	3.4	65	4.5		3.0
Total	1459	9.2	159	11.0		5.2
Central Coast						
Berkeley	1381	8.7	114	7.9		13.6
Charleston	3425	21.5	296	20.5		23.0
Dorchester	768	4.8	72	5.0		8.9
Total	5574	35.1	482	33.4		45.5
South Coast						
Beaufort	1589	10.0	127	8.8		7.5
Colleton	735	4.6	69	4.8		4.1
Hampton	434	2.7	27	1.9		2.1
Jasper	285	1.8	12	0.8		1.3
Total	3043	19.1	235	16.3		15.1
Central Inland						
Aiken	622	3.9	64	4.4		4.1
Allendale	121	0.8	10	0.7		0.3
Bamberg	192	1.2	16	1.1		2.4
Barnwell	310	2.0	28	1.9		2.3
Lexington	947	6.0	85	5.9		4.6
Orangeburg	633	4.0	55	3.8		5.6
Richland	536	3.4	64	4.4		1.5
Total	3361	21.1	322	22.3		20.7
Other	2458	15.5	247	17.1		13.5
Total	15895				1445	

About 19.4% of the respondents indicated that they had made no trips using their gear tags. The estimated numbers of active permit holders (Table 9) were obtained by multiplying the number of permits issued in each residence category by the percentage of positive responses received per area. Assistants were the numbers of different individuals who accompanied the permit holders. Although some individuals probably were counted by more than one individual, the extent of such duplication was assumed to be negligible. The average numbers of assistants per permit holder in each residence category were multiplied by the estimated numbers of active permit holders to obtain the estimated total numbers of assistants. The total numbers of participants equalled the sums of the active permit holders and their assistants.

The average numbers of season trips per active permit holder were obtained by summing the numbers of trips reported in each residence category and dividing these figures by the numbers of respondents who reported trips. These means were then multiplied by the numbers of estimated active permit holders in the overall populations to obtain estimates of seasonal effort by residence category (Table 10). The estimated numbers of trips per month were calculated by multiplying these season totals by the appropriate percentages of trips in each month. These were determined from the data provided by respondents who broke their seasonal effort down into complete monthly components. The estimated effort figures in the Total column were generated by adding these categorical figures. The distribution of seasonal effort by residential category is shown in Table 11.

The coastal area was divided into six geographical components (Fig. 4). The relative distribution of estimated effort in each area is indicated in Table 12. These figures were obtained by multiplying the total numbers of trips in each residence category by the percentages of effort reported in each area. Percentages were determined by summing all trips reported by area within each residence category, then dividing by the numbers associated with each area.

Average seasonal catch rates are listed in Table 13. These were obtained by adding the reported catch per unit of effort (CPUE, in quarts of whole shrimp/trip) in each category and dividing by the numbers of observations. The CPUEs in Table 14 were calculated by summing the season CPUEs for each area and dividing these figures by the corresponding numbers of observations. Only the data from respondents who limited their activity to one area were included, since there was no way to separate catch and effort by area for respondents who shrimped in more than one area.

Because the residential stratification of the sample population was similar to that of the total permit holder population, an unbiased estimate of the average statewide CPUE can

Table 9. Estimated participation by residential category.

	North coast	Central coast	South coast	Central inland	Other	Total
Permits issued	1459	5574	3043	3361	2458	15895
% active permits	79.9	78.0	80.0	85.1	80.6	80.6
Number active	1166	4348	2434	2860	1981	12789
Aver. assistants	1.87	2.12	2.04	2.03	2.30	2.09
Total assistants	2180	9218	4965	5806	4556	26725
Participants	3346	13566	7399	8666	6537	39514
Percent of total	8.5	34.3	18.7	21.9	16.5	

Table 10. Estimated numbers of trips by residential category.

	North coast	Central coast	South coast	Central inland	Other	Total
Aver. trips/permit	4.80	5.55	6.22	4.57	4.27	5.12
% by month						
September	40	32	33	32	39	34
October	46	47	48	51	46	48
November	14	21	19	17	15	18
Estimated trips/month						
September	2239	7722	4996	4182	3299	22438
October	2575	11342	7267	6666	3891	31741
November	783	5067	2876	2222	1269	12217
Total	5597	24131	15139	13070	8459	66396
Percent of total	8.4	36.3	22.8	19.7	12.7	

Table 11. Distribution of seasonal effort in percentages of respondents by residential category.

Residential category	Trips/individual/season				
	1-4	5-10	11-15	16-20	>20
North Coast	67	22	7	2	2
Central Coast	57	34	5	3	< 1
South Coast	52	32	8	5	3
Central Inland	62	32	3	2	< 1
Other	65	31	2	2	1
Statewide	60	31	5	3	1

Table 12. Estimated number of trips by shrimping area.

Residence category	Beaufort	St. Helena	Wadmalaw/Edisto	Charleston	Bulls Bay	Georgetown
North Coast	0	20	0	268	3979	1330
Central Coast	766	450	3892	10436	8575	12
South Coast	12188	2459	396	41	55	0
Central Inland	6950	3240	1298	480	982	120
Other	1790	1918	618	309	3335	489
Total	21694	8087	6204	11534	16926	1951
% of total	32.7	12.2	9.3	17.4	25.5	2.9

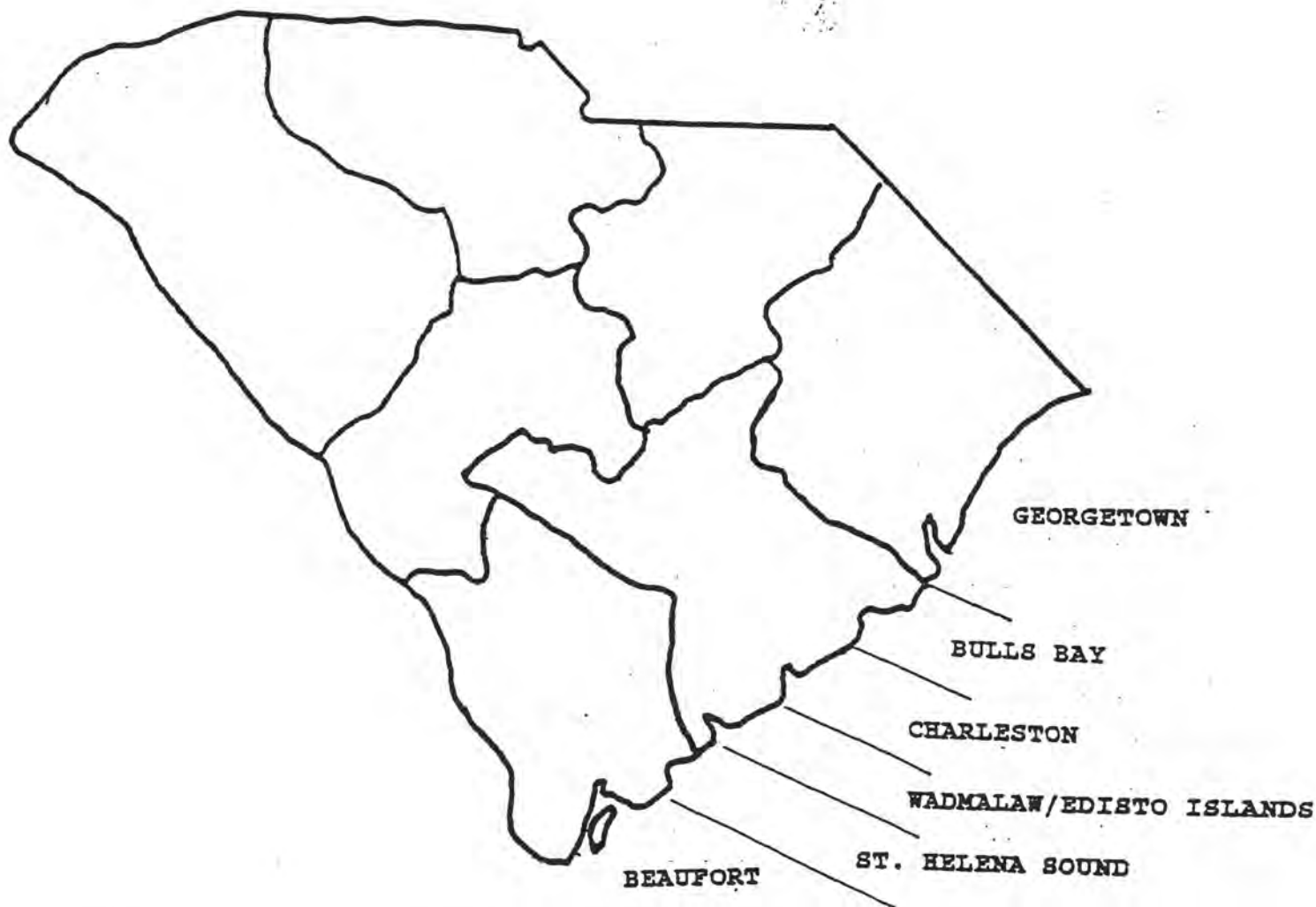


Fig. 4. Shrimp baiting areas.

- BEAUFORT-** from the Savannah River to the south end of St. Helena Island, including the Beaufort River
- ST. HELENA SOUND-** from the south end of St. Helena Island to the South Edisto River and southern end of Edisto Island
- WADMALAW/EDISTO ISLANDS-** from the South Edisto River to the Stono River (Edisto, Wadmalaw, Seabrook, Kiawah, and Johns Islands)
- CHARLESTON-** from the Stono River to the north end of the Isle of Palms
- BULLS BAY-** from the north end of the Isle of Palms to the southern boundary of Georgetown County (near the Santee River)
- GEORGETOWN-** Georgetown and Horry Counties, including Winyah Bay

Table 13. CPUE (quarts of whole shrimp/trip) by residential category.

Residential category	CPUE							
	1992	1993	1994	1995	1996	1997	1998	1999
North Coast	15.0	26.5	17.9	29.0	13.3	25.4	21.4	20.0
Central Coast	24.3	22.3	21.7	27.0	18.7	23.3	19.2	19.5
South Coast	26.3	24.0	12.1	28.9	14.8	28.7	23.8	21.2
Central Inland	30.3	24.0	16.7	32.3	16.7	29.2	25.3	22.1
Other	25.2	24.4	19.9	29.0	16.3	28.5	20.9	23.7

Table 14. CPUE (quarts of whole shrimp/trip) by shrimping area.

Area	1992	1993	1994	1995	1996	1997	1998	1999
Beaufort	28.7	22.2	13.2	30.6	15.5	30.7	25.7	23.7
St. Helena	29.7	23.8	16.4	27.7	18.8	26.2	21.5	19.5
Wad./Edisto	30.0	22.5	16.1	25.6	17.1	22.4	21.5	17.6
Charleston	23.4	20.4	21.6	26.1	18.2	23.7	17.7	18.2
Bulls Bay	20.3	26.4	23.1	28.7	15.2	25.2	19.6	22.3
Georgetown	14.4	26.9	13.2	19.9	9.6	23.3	21.5	25.4

be obtained by calculating the mean of the CPUEs reported by the respondents. This value was 21.1 quarts of whole shrimp/trip.

The average season catches (quarts of whole shrimp) reported by respondents were as follows for various residence categories:

North Coast	Central Coast	South Coast	Central Inland	Other
90.5	89.8	115.7	97.3	93.4

There are numerous ways to estimate the total catch, depending on the interest in its relative components. The simplest method is to multiply the statewide average CPUE (21.1 quarts/trip) by the estimated total number of trips (66,396). This figure is 1,400,956 quarts.

An estimate can be derived from the average catch data above by multiplying them by the appropriate numbers of active shrimpers. This method produced the following estimates:

Residence category	Estimated catch (quarts)
North Coast	105,523
Central Coast	390,450
South Coast	281,614
Central Inland	278,278
Other	185,025
Total	1,240,890

Catches by residence category were also estimated by multiplying the estimated effort for each by the appropriate CPUE:

Residence category	Trips	CPUE	Catch (quarts)
North Coast	5,597	20.0	111,940
Central Coast	24,131	19.5	470,555
South Coast	15,139	21.2	320,947
Central Inland	13,070	22.1	288,847
Other	8,459	23.7	200,478
Total			1,392,767

This approach produced somewhat higher values than the method using average season catch.

Catches by shrimping area were obtained by multiplying the estimated effort in each by the corresponding average CPUE:

Shrimping area	Trips	CPUE	Catch (quarts)
Beaufort	21,694	23.7	514,148
St. Helena	8,087	19.5	157,697
Wadmalaw/Edisto	6,204	17.6	109,190
Charleston	11,534	18.2	209,919
Bulls Bay	16,926	22.3	377,450
Georgetown	1,951	25.4	49,555
Total	66,396		1,417,959

There are trade-offs in probable accuracy and lack of bias associated with each approach and an intermediate value is a reasonable overall estimate. The average of the four estimates shown above is **1,363,143 quarts**. The conversion factor from quarts to pounds (whole weight) is 1.48. The weight equivalent of heads-on shrimp is **2,017,452 pounds**. The conversion factor to heads-off weight is 0.649, giving an estimate of **1,309,326 pounds heads-off**.

The distribution of season catches by residential category is shown in Table 15. A conservative estimate of the statewide average catch per active permit holder, based on reported season catches, was 96.4 quarts (143 pounds) of whole shrimp. Assuming that this was evenly divided between the permit holders and their assistants, the typical participant obtained about 46 pounds of whole shrimp. A higher value, 51 pounds, can be obtained by dividing the estimated total catch by the estimated number of participants.

The relative distribution of the fall white shrimp harvest is perceived as an allocation issue. Since 1992, a monitoring system for commercial landings has been in place that permits comparison of recreational and commercial landings for comparable area/time units. The baiting areas and corresponding commercial statistical zones are as follows:

Baiting area	Commercial zone
Beaufort (rivers, sound)	Hilton Head to Bay Point
St. Helena Sound	Bay Point to South Edisto River
Wadmalaw/Edisto Islands	South Edisto River to Stono Inlet
Charleston (rivers, harbor)	Stono Inlet to Dewees Inlet
Bulls Bay	Dewees Inlet to Cape Romain
Georgetown (rivers, bay)	Cape Romain to N.C. line, Winyah and Santee Bays

The comparison of baiting and commercial landings is shown in Table 16. In-season commercial landings were defined as those during week 3 of September through week 2 of November. Total commercial landings included those from week one of August through the closure of the 1999 season. Combined total recreational and commercial landings are the baiting catch plus the total commercial landings as so defined.

DISCUSSION

Documentation of seasonal statistics began in 1987. Table 17 summarizes the data for each year's fishery. The number of permits sold declined from that in the previous year for only the second time and 1999's total was second only to the record set in 1998. The principal difference in the distribution of the current permit holder population vs the original one is that Charleston County residents now account for an appreciably lower percentage, 21.6% in 1999 vs 41.2% in 1988 (Table 7). The percentage distribution of the permit holders by county has remained essentially unchanged

Table 15. Distribution of season catches (quarts of whole shrimp) in percentages of respondents by residential category.

Residential category	Catch/permit holder					
	<99	100-199	200-299	300-399	400-499	>500
North Coast	68	23	7	-	-	2
Central Coast	70	19	7	3	< 1	1
South Coast	56	24	11	2	2	5
Central Inland	64	23	8	4	-	< 1
Other	71	15	8	3	1	< 1
Statewide	66	20	8	3	< 1	2

Table 16. Estimated shrimp baiting catches and reported commercial landings (all gears) by area, in thousands of pounds of whole shrimp.

Area	Baiting	Commercial		Percent baiting	
		In-season	Total	In-season	Total
Beaufort	761	141	249	84	75
St. Helena	233	691	1,275	25	15
Wad./Edisto	162	336	560	33	22
Charleston	311	340	595	48	34
Bulls Bay	559	610	1,065	48	34
Georgetown	73	643	953	10	7
Total	2,099	2,760	4,697	43	31

Table 17. Season comparisons of participation, effort, and catch parameters. 1987-1999.

	1987	1988	1989	1990	1991	1992
Permits issued	NA	5509	6644	9703	12005	11571
% active permits	NA	92	82	94	89	87
Assts./permit	NA	2.50	2.14	2.79	2.24	2.15
Participants	21735	17749	17171	34662	34821	31812
Trips/permit holder	NA	7.0	5.7	7.8	6.6	6.1
Total trips	40101	35609	31624	71153	71034	62459
Average qts./trip	28.5	22.1	26.5	25.6	21.3	25.4
Million lbs heads-on	1.80	1.16	1.25	2.75	2.14	2.35
Lbs/participant	83	65	73	79	62	74
	1993	1994	1995	1996	1997	1998
Permits issued	12984	13366	13919	14156	15488	17497
% active permits	91	86	89	85	91	87
Assts./permit	2.43	2.32	2.39	2.25	2.44	2.31
Participants	40620	38081	41971	38932	48544	50436
Trips/permit holder	6.8	6.0	6.5	5.7	6.6	6.0
Total trips	80709	70429	81632	68927	94154	92484
Average qts./trip	23.5	18.5	28.9	16.9	26.4	21.7
Million lbs heads-on	2.72	1.91	3.40	1.73	3.63	2.91
Lbs/participant	67	50	81	44	72	58
	1999					
Permits issued	15895					
% active permits	81					
Assts./permit	2.09					
Participants	39514					
Trips/permit holder	5.1					
Total trips	66396					
Average qts./trip	21.1					
Million lbs heads-on	2.02					
Lbs/participant	46					

since 1994.

The percentage of active permit holders was the lowest since 1989, when Hurricane Hugo struck Charleston in late September. Another year of relatively high inactivity was 1996, when two hurricanes (Fran and Josephine) passed close to the South Carolina coast. A coastwide mandatory evacuation was ordered on September 14, 1999 as Hurricane Floyd neared Charleston. Swells from distant Hurricane Gert produced small craft warnings on September 19. As in 1996, a mid-October hurricane, Irene, caused heavy rains. Such events obviously detracted from the ability of many permit holders to participate.

In addition to the hurricanes, the weather during the 1999 season was unusually wet with strong northeast winds associated with the passage of cold fronts around September 21, October 7, October 19, and November 2. There seldom were more than three consecutive days of good weather and these periods occurred mainly near the end of the season. A daily weather log indicated that windy and/or heavy rain conditions prevailed during at least 29 days (nights) of the 60-day season. As a result, the overall participation in 1999 was about 8% below the average of the previous six years.

Such conditions also contributed to reduced shrimping activity with the average number of trips per active permit holder being the lowest recorded to date. The impact was most obvious in the Charleston area, accentuating a generally downward trend (Fig. 5). Effort in the two other major shrimping areas has shown different trends, tending to increase in Bulls Bay and fluctuate around a relatively level long-term line in the Beaufort area.

The disproportionate decline in effort in the Charleston area appeared to be related to several factors besides the weather, which tended to have a statewide effect. The shrimp there were relatively small and apparently not as abundant as in most other areas. CPUE in the Charleston area was the lowest statewide with the exception of the adjacent Wadmalaw-Edisto area and Central Coastal residents reported the lowest average catch/trip.

The reliability of the effort estimates generated from the postseason survey has been a longstanding concern, since it depends on recall over a fairly lengthy period (the season lasts 60 days). Research done for the National Marine Fisheries Service in conjunction with the design of the Marine Recreational Fisheries Statistics Survey (the primary source of marine recreational fisheries data for the federal government) indicated that participants could accurately recall the location and number of trips they made within a 60-day recall period. Given the time frame associated with survey distribution, most of the season's activity tends to fall within that limit or close to it.

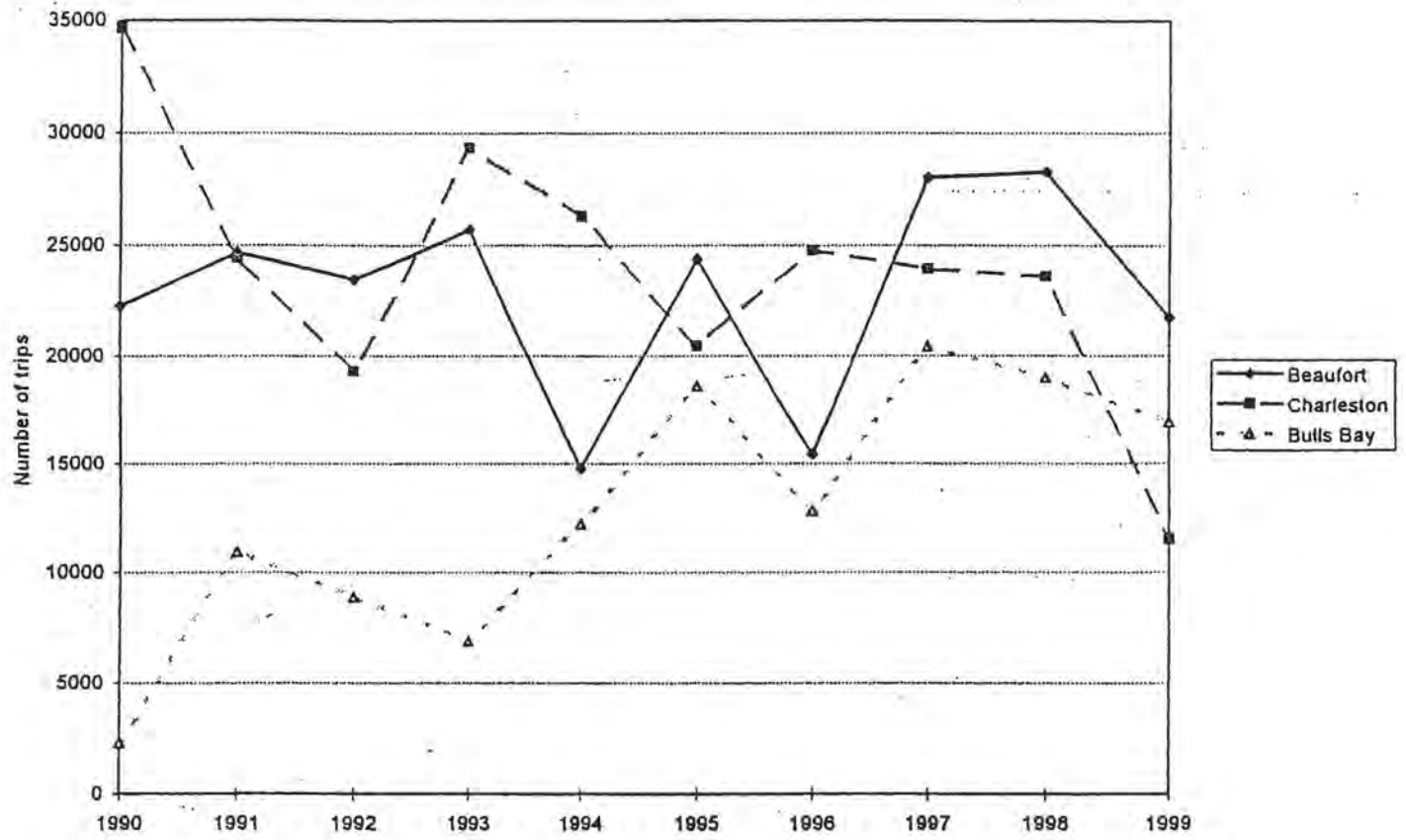


Fig. 5. Trends in effort by shrimping area.

The use of a postseason survey such as that employed here is appropriate. Gotie et al. (1984) found that an after-the-fact survey is useful for short-term, special seasons, where one inquiry supplies the data, no written records are needed by the respondent, and the activity is discrete and well-remembered.

The in-season survey offered the opportunity for some insight into the probable validity of some of the postseason survey's findings. One category was the area effort estimates. The data in Table 18 are from the last comprehensive site-specific survey of shrimp baiters. The total sites were the number of locations listed by respondents as launch locations for their trips. Total trips included all trips reported for the indicated area. Trips at site were those made at sites included in the 1999 in-season survey. The percentages refer to the portion of total trips made at the survey sites.

The data used in the following exercise are from Table 2. As defined previously, the season included 24 weekend days and 36 weekdays. The figures shown were calculated by multiplying the appropriate number of days by the average trailer counts reported for the indicated sites. The results are listed in Table 19. The totals for each area were divided by the percentages from Table 18 in order to estimate the potential total trailer counts (equivalent to trips) originating at each site. These results can be summarized as follows:

Bulls Bay:	$3,588/0.38 = 9,442$
Charleston metro:	$4,568/0.57 = 8,014$
Beaufort:	$7,076/0.62 = 11,413$

In each instance, these hypothetical estimates are well below those generated from the postseason survey data; the closest agreement is for the Charleston metro area (8,014 vs 11,534). In considering this information, several factors need to be recognized. First, the weather was unusually bad during the 1999 season with nearly half of the days/nights considered at best marginally suitable for baiting, yet the hypothetical estimates include the entire 60 days/nights. The in-season survey was, at most locations, confined to a relatively short (and constant) time interval with usage patterns during the remainder of the available time largely unknown. Site usage patterns have changed considerably since 1988 with some additional locations and expansion of existing sites, e.g. Buck Hall, Remley Point, and Shem Creek: these changes undoubtedly have altered the usage percentages assumed here.

Perhaps the most reasonable impression that can be drawn is that there is a substantial likelihood that effort is being overestimated by using the data from the postseason survey. This interpretation assumes that permit holders who are most active (i.e., make the most trips) are more likely to respond than permit

Table 18. Distribution of trips reported by shrimp baiters.
(Source: Waltz and Hens 1988.)

Area	Total Sites	Total trips	Trips at survey sites	Percent of trips at survey sites
Beaufort Cty.	34	7214	4463	62
Jasper Cty.	4	335	0	0
Total	38	7549	4463	59
Chas. metro	24	11892	6777	57
Berkeley Cty.	2	35	0	0
Total	26	11927	6777	57
Bulls Bay	5	181	68	38

Table 19. Hypothetical trailer counts for sites included in the 1999 in-season survey.

Area/site	Weekend	Weekday	Total
Bulls Bay			
Buck Hall	1181	475	1656
Moore's	466	346	812
McClellanville	756	364	1120
Total			3588
Charleston metro			
Remley Point	934	857	1791
Shem Creek	514	580	1094
Wappoo Cut	598	803	1401
Folly River	163	119	282
Total			4568
Beaufort			
Grays Hill	631	1091	1722
Trask	895	857	1752
Lemon Island	552	907	1459
Broad River	166	601	767
Pinckney Island	473	331	804
All Joy	288	284	572
Total			7076

holders who make few or no trips. This would cause the average trips/season figures to be higher than is actually the case and thus result in effort overestimates when multiplied by the numbers of active permit holders.

There is evidence, however, that the opposite bias tends in fact to apply to surveys of the type used here. Thompson and Hubert (1990) found that the anglers who fished often were the most reluctant to participate in a survey, keep records, or spend much time responding to questions. It was the fishermen who fished less often that were most cooperative in participating and recalling trip information.

The second category where comparison of the in-season vs postseason survey estimates is of interest is the CPUE (quarts/trip) estimates. The results are summarized below:

	In-season	Postseason
Bulls Bay	25.2	22.3
Charleston metro	23.1	18.2
Beaufort	27.2	23.7

Although both surveys documented the same long-term pattern with CPUE being highest (among major shrimping areas) in Beaufort and Bulls Bay, respectively, the estimates derived from the postseason survey ranged from 12-21% lower than those calculated from in-season survey data.

The difference in length of recall period aside, there are several factors that could account for the apparent discrepancies. One is the above-mentioned tendency for less active (and presumably less successful) participants to respond to a postseason survey. Whether this trait also applies to an on-site survey is conjectural. The differences in distribution of effort (percentages indicated below) may also have been a contributing factor.

	In-season	Postseason
September	28	34
October	63	48
November	9	18

It appears that a higher proportion of the trips covered by the in-season survey likely occurred during the period when CPUE was highest.

Commercial shrimpers have continually argued that baiting in estuarine areas results in excessive harvests of small shrimp and associated wastage. They have been generally unopposed, however, to the taking of shrimp in such areas without the use of bait. Whitaker and Wenner (1988) found that the size composition of white shrimp was not significantly different between baited and unbaited

areas. The solution to the small shrimp problem is therefore independent of the use of bait.

Size composition of the shrimp caught with a cast net is a function of the mesh size of the net (Woodward 1989, Whitaker et al. 1991). Whitaker et al. (1991) compared the catches and size distribution of shrimp taken with three mesh sizes. This study was conducted in the Ashley River about 7-8 miles from Charleston Harbor, using bait balls similar to those used by shrimp baiters. They found that the smaller the mesh, the more shrimp (but of a smaller average size) were caught. The average count (tails per pound) was 71 for 3/8 inch mesh, 59 for 1/2 inch, and 41 for 5/8 inch. They designated a 90 mm shrimp as the smallest usable size, equivalent to 160 count. Over 54% of the shrimp retained by the 3/8 inch mesh were below this standard, compared to 25% for the 1/2 inch and 18% for the 5/8 inch.

These results indicate that 3/8 inch mesh nets, fished where (and when) large shrimp predominate, catch about the same amount of usable shrimp as larger-mesh nets. The small mesh catches far more unusable shrimp when small shrimp are abundant. Whitaker et al. (1991) therefore concluded that "... 3/8 inch mesh should be banned in the shrimp baiting fishery and a minimum mesh size of 1/2 inch be adopted."

In 1989, about 45% of the shrimpers in the Beaufort area reported using 1/2 inch or larger mesh nets, compared to about 20% of the Charleston area participants. In 1991, about 47% of the Central Coast residents reported using 1/2 mesh nets, as did 61% of the South Coast residents (statewide usage was 49% each for 3/8 and 1/2 inch). Reported mesh usage in 1999 was as follows:

Residential category	Percent using mesh		
	3/8	1/2	5/8
North Coast	26	43	30
Central Coast	32	55	13
South Coast	34	49	17
Central Inland	36	59	5
Other	41	48	11
Statewide	34	52	14

Based on direct observations during the creel census, 36% of the baiters used 3/8 inch, 58% used 1/2 inch, and the remaining 6% employed 5/8 inch mesh.

If the baiting fishery continues to grow, it is likely that an increasing number of shrimpers will be displaced from areas where larger shrimp predominate into nursery areas with high percentages of small shrimp. To minimize the catch and wastage of small shrimp, it would be prudent to restrict the fishery to use of nets with 1/2 inch or larger square (bar) mesh. In a year such as 1999, when climatic and hydrological conditions resulted in a large

percentage of small shrimp in customary baiting areas, use of 1/2 inch or larger mesh would appreciably reduce waste of the resource.

Commercial shrimpers have also routinely complained that the baiting fishery substantially reduces their landings, particularly during the baiting season. The trends in the baiting fishery's share of the fall white shrimp harvest are shown in Fig. 6. In 1999, the baiters' share was the lowest since detailed records have been kept. This appeared to be attributable to several factors, some of which were previously mentioned (e.g. the inclement weather during the baiting season and reduced effort). Historically, the baiting fishery's share has been largest during dry years (as in 1997 and 1998). Although the summer of 1999 was exceptionally dry, the fall weather was wet. The heavy rainfall associated with the passing hurricanes caused shrimp to move quickly through the baiting areas into the ocean, thus reducing their availability to the recreational sector.

One option that has been suggested to reduce the baiters' share of the total fall catch is a lower limit. In previous surveys, respondents have been asked to comment on catch limits and there have been numerous revisions proposed. For example, in the first such survey (Waltz and Hens 1988), the catch limit was the second most frequently discussed issue by responding shrimp baiters (after season length). The most common suggestions were to change the limit to 48 quarts per permit holder or to 48 quarts per head of household with a maximum of two limits per boat. Similar comments were repeated in the 1989 survey (Low 1990).

In the 1990 survey (Low 1991), the only suggested management option that received statewide support from a majority of baiters was to allow a limit per permit holder. This would be logical in making the limit concept consistent with that for finfish fisheries. Support for this change was reiterated in the comments received in the 1991 survey (Low 1992).

The limit issue has therefore been both long-term and thoroughly explored in terms of constituent opinion. In the 1993 survey (the most recent to address specific management options), respondents were strongly opposed to a simple reduction in the present 48-quart limit per boat without compensatory measures (Low 1994).

Perhaps the most acceptable option would be to allow a limit per permit holder with a maximum of two limits per boat. This could be done by either allowing a 48-quart limit to each permit holder or a lower amount, perhaps 36 quarts, per permit holder. In these cases, the maximum allowable catch per trip would be 96 quarts and 72 quarts, respectively, assuming a cap of two limits.

The potential impact of these limit changes can be evaluated using data from the 1999 surveys. The initial input data are as

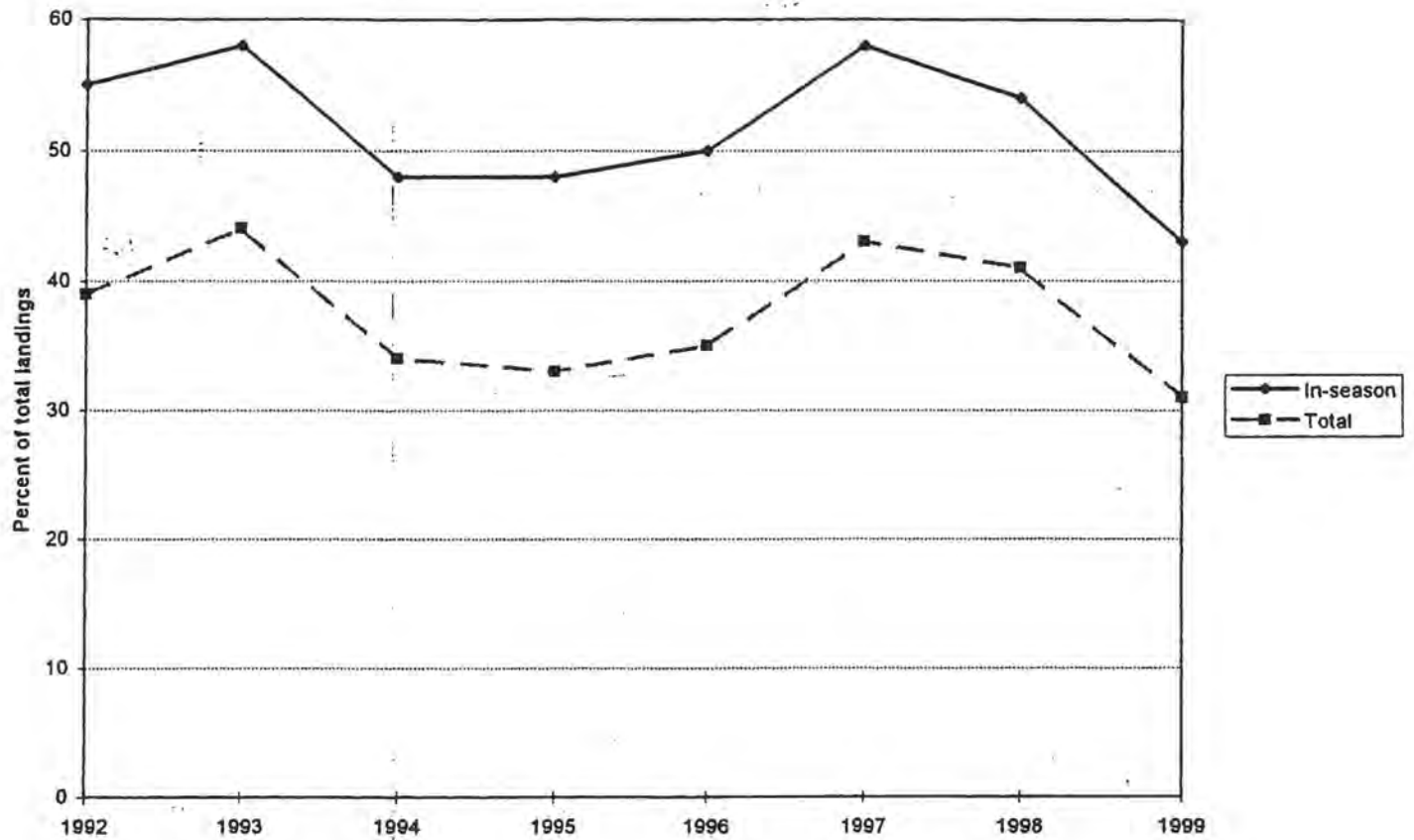


Fig. 6. Trends in baiters' share of the fall white shrimp harvest.

follows:

trips with >1 permit holder (23% of total)	15,271
with >40 quarts/trip (26% of above)	3,970
with 40 quarts or less	11,301
trips with one permit holder	51,125
total trips	66,396

total catch (based on statewide CPUE, 21.1 qts)	1,400,956
CPUE on trips with >1 permit holder, 26.6	
total catch on trips with >1 permit holder	
15,271 trips x 26.6 qts/trip	406,209
total catch on trips with one permit holder	
1,400,956 - 406,209	994,747

The CPUE for trips with one permit holder was 19.46 quarts/ trip (994,747 quarts/51,125 trips). The CPUE for trips with >1 permit holder and <41 quarts was 19.33 quarts/trip, calculated as follows. The in-season survey data for trips with >1 permit holder were 238 trips with 6323 quarts. Of these, there were 62 trips with >40 quarts, a total of 2970 quarts. Thus, the CPUE was

$$(6323 - 2970)/(238 - 62) \text{ or } 3403/176 = 19.33$$

Consider the two scenarios that follow. In each case, it is assumed that the maximum allowable catch is taken on each trip with more than one permit holder. Thus, the total catch estimates are the maximum obtainable values.

Limit is 48 quarts per permit holder:

51,125 trips x 19.46 qts/trip	994,747 qts
11,301 trips x 19.33 qts/trip	218,448 qts
3,970 trips x 96.00 qts/trip	381,120 qts
total catch	1,594,315 qts

Limit is 36 quarts per permit holder:

51,125 trips x 19.45 qts/trip	994,747 qts
11,301 trips x 19.33 qts/trip	218,448 qts
3,970 trips x 72.00 qts/trip	285,840 qts
total catch	1,499,035 qts

When compared to the estimated actual catch under the current limit (i.e., 1,400,956 quarts), the catch under the most liberal scenario (48-qt limit for each permit holder) could have increased a maximum of 13.8%. With a 36-qt limit, the maximum potential increase would have been 7.0 %.

These hypothetical values should be considered in the context of an "average" season. The 1999 season, as evaluated in terms of area-specific CPUE, came fairly close to "average" as shown below (based on reported CPUEs in postseason surveys):

Area	1992-1998 mean	1999
Beaufort	23.8	23.7
Charleston metro	21.6	18.2
Bulls Bay	22.6	22.3

Thus, over a period of years, it is reasonable to expect maximum percentage increases on an annual average on the order of those derived.

If the limit is changed to one for each permit holder, whether it remains at 48 quarts or is set lower is mainly a social issue. In this regard, it is relevant to consider what determines satisfaction with the shrimp baiting experience. In the Bulls Bay/Charleston area, a "very satisfying" rating corresponded to an average catch of 36 quarts with the amount being slightly higher in Beaufort. This suggests that a 36-quart limit would be the minimum acceptable to the majority of the shrimpers if a reduction was adopted.

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