Characterization of the inshore commercial shrimp trawl fishery in Pamlico Sound and its tributaries, North Carolina

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Abstract

Observations were made of commercial shrimp trawl fisheries in Pamlico Sound and its tributaries, North Carolina from 1 July 2009 to 31 December 2009. These observations were used to characterize the fishery and determine relative effort and discards of weakfish (*Cynoscion regalis*), spotted sea trout (*Cynoscion nebulosus*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), bluefish (*Pomatomus saltatrix*), Atlantic menhaden (*Brevoortia tyrannus*), southern flounder (*Paralichthys lethostigma*), and striped mullet (*Mugil cephalus*) as well as other federally and state managed species of finfish. Observations were made on 66 trips, consisting of 191 tows. Three different net types were observed: double seamed nets, four seamed nets and tongue nets. The three commercially important species of shrimp (brown, white, pink) (*Farfantepenaeus aztecus*, *Litopenaeus setiferus*, *F. duorarum*) represented 23% of the total observed catch by weight. Atlantic croaker and spot were the most abundant finfish bycatch, representing 33% and 13% of the total observed catch by weight, respectively. Weakfish represented the largest regulatory discard by weight in all three net types. The results of this study offer insights for fishery managers developing fishery management plans and may assist in bycatch mortality estimates. Recommendations include expansion of the observer coverage in commercial shrimp trawl fisheries to encompass all seasons, establishing a long-term observer program throughout North Carolina commercial fisheries and requiring mandatory observer coverage in North Carolina commercial fisheries.

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INTRODUCTION

North Carolina's shrimp fishery targets three species of shrimp (brown, pink, and white) (*Farfantepenaeus aztecus*, *Litopenaeus setiferus*, *F. duorarum*), which are considered annual crops. Although all three commercially important shrimp in North Carolina are considered viable (NCDMF 2006 and 2008), a formal stock assessment has not been completed due to environmental conditions influencing population size more than fishery pressure. Low cost imported shrimp, regulatory changes, and increased fuel prices have strained the industry and are likely contributing factors to the gradual decline in shrimp trawling effort since the mid 1990s (NCDMF 2006).

Commercial shrimp trawling in North Carolina began in 1916 in the Southport area (NCDMF 2006). The practice spread throughout the rest of North Carolina over the next couple of decades. Following World War II, there was a considerable increase in effort. Technological advances in the shrimp industry have increased the catching efficiency of larger boats. In the 1940s and early 1950s, a 45-60 foot vessel pulled a single trawl with a head rope length of 60-65 feet. Due to improvements in engine design, the same sized vessel, using four-barreled rigs, can now pull four nets with a combined head rope length of 120-160 feet. Four-barreled rigs allow fishermen to pull two nets from each outrigger. In Pamlico Sound the commercial shrimp trawl fishery is conducted primarily on a multiple day trip basis and is conducted around the clock. The Pamlico Sound fishery accounted for 68% of the total harvest of shrimp in North Carolina in 2009 (NCDMF 2009).

Currently, the shrimp trawl fishery is allowed to operate in the estuarine and oceanic water of North Carolina, which is controversial because of its bycatch and discards, especially of commercial and recreationally valuable species such as flounder spp. (*Parlichthys lethostigma*, *P. dentatus*, and *P. albigutta*), gray trout (weakfish) (*Cynoscion regalis*), spot (*Leiostomus xanthurus*), and Atlantic croaker (*Micropogonias undulatus*). Bycatch is defined as "the portion of a catch taken incidentally to the targeted catch because of non-selectivity of the fishing gear to either species or size differences" (ASMFC 1994). Bycatch can be divided into two components: incidental catch and discarded catch. Incidental catch refers to retained or marketable catch of non-targeted species, while discarded catch is that portion of the catch returned to the sea as a result of regulatory, economic, or personal preference. Scientists, natural resource managers, and the general public agree that bycatch is an important issue that needs to be addressed; however characterizing the nature and extent of bycatch has proven difficult. The amount of bycatch can vary greatly from fisherman to fisherman, trip to trip and tow to tow. Factors that may affect bycatch include water temperature, water clarity, fishing location, tow time, and gear configuration (NCDMF 2006). Fishery managers continually face the issue of bycatch and discards in commercial and recreational fisheries. Discards impact fishery yields and fishery managers' ability to accurately assess fishery stocks (Fennessy 1994; Hall 1999).

Fishery managers understand the importance of obtaining accurate and timely bycatch and discard data from commercial fisheries. Scientists can obtain estimates through fishery-independent research projects, which can provide accurate size selectivity information, however, components of effort, catch, and discards in relation to commercial fisheries cannot be obtained. One way to obtain accurate estimates of effort, catch, and discards is through scientific observations made aboard commercial fishing vessels. Commercial fishery (fishery-dependent) observations allow the collection of real time catch and discard information, while simultaneously using the knowledge and expertise of commercial fishermen (Price and Rulifson 2004). Observer programs at both the state and federal level have proven to be valuable tools

for fishery managers to characterize directed catch and bycatch, document endangered or threatened species interactions, and provide information that can be used for stock assessments. All will assist in sustaining economically important populations of finfish species (French et al. 1982).

This project quantified bycatch of federally and state managed species of finfish including but not limited to: weakfish, spotted sea trout, spot, Atlantic croaker, bluefish (*Pomatomus saltatrix*), Atlantic menhaden (*Brevoortia tyrannus*), southern flounder, and striped mullet (*Mugil cephalus*). These data will assist managers in sustaining coastal stocks, which are an important resource for both commercial and recreational fishermen. There were no interactions with protected species.

METHODS

This study was conducted from 1 July 2009 to 31 December 2009 in Pamlico Sound and its tributaries, North Carolina (Figure 1). The National Marine Fisheries Service (NMFS) and the North Carolina Division of Marine Fisheries (NCDMF) trained observers to conduct weekly observer trips aboard commercial vessels operating in the inshore shrimp trawl fishery. Commercial fishermen were randomly selected, and observer effort was weighted by region using the NCDMF Trip Ticket Program to ensure that observers obtained proportional effort and catch data.

Each observer was trained to collect data under NCDMF protocols. NMFS staff provided training on protected species identification, handling, and tagging protocols. Observers sampled every tow, randomly taking approximately one fish basket (32 kg) sample to determine species composition. Total weight (kg) of shrimp of each tow was collected, and used to extrapolate total weights of all species. Data collections included: enumerating, measuring, weighing, and recording disposition of target and bycatch species; noting date, time, location, and net characteristics (head rope length, mesh size of wing and tail bag, turtle excluder device (TED) type, bycatch reduction device (BRD) type, etc.) of all sets and retrievals; and recording all protected species interactions, including tagging.

The results were stratified by net type (double seamed, four seamed and tongue nets) and season (Summer: July – September, Fall: October - December). The results were analyzed to determine trends, to look for any key areas where management improvements are needed; and characterize currently unknown fishery parameters in these areas.

RESULTS

The results provided varying trends among the two strata of season and net type. Observations were made in two seasons (summer, and fall) and on three different net types of otter trawls (double seamed, four seamed and tongue nets). Otter trawls are cone shaped nets constructed of twine webbing of various types (nylon, spectra, and polypropylene). The net is opened horizontally by water pressure forcing the doors (planers), on either side of the net to spread apart. The bottoms of the doors are typically rounded along the leading edge, with a metal runner protecting the typically wooden door and providing weight. Typically a single float in the center of the top line, and weights (lengths of chain) run along the bottom line and are used to vertically open the mouth of the trawl. The nets are equipped with tickler chains, which

are attached to the doors and drag along the bottom just in front of the footrope. The nets terminate in a tail bag (or cod end) where the catch is concentrated and retained during the tow. Double seamed nets typically fish lower in the water column and are used to target brown shrimp, four seamed nets also are used to target brown shrimp but fish higher in the water column, while tongue nets also fish higher in the water column and are used to target white shrimp. The following sections will discuss findings ranging from observed net sets to discard estimates and provide an overall characterization of effort, catch, and bycatch in the commercial shrimp trawl fishery in Pamlico Sound and its tributaries, North Carolina from 1 July 2009 to 31 December 2009.

COVERAGE

According to preliminary trip ticket data, there were 5,462 commercial shrimp trawl fishing days in the observed areas between 1 July 2009 and 31 December 2009. Observers were present on 66 commercial shrimp trawl fishing days, consisting of 191 tows, and achieving 1.21% coverage (Figure 1). Observers obtained trips with 9 fishermen throughout the study. Observers obtained 1.29 % coverage during the summer (July, August, and September), and 0.79% in the fall (October, November, and December) (Table 1).

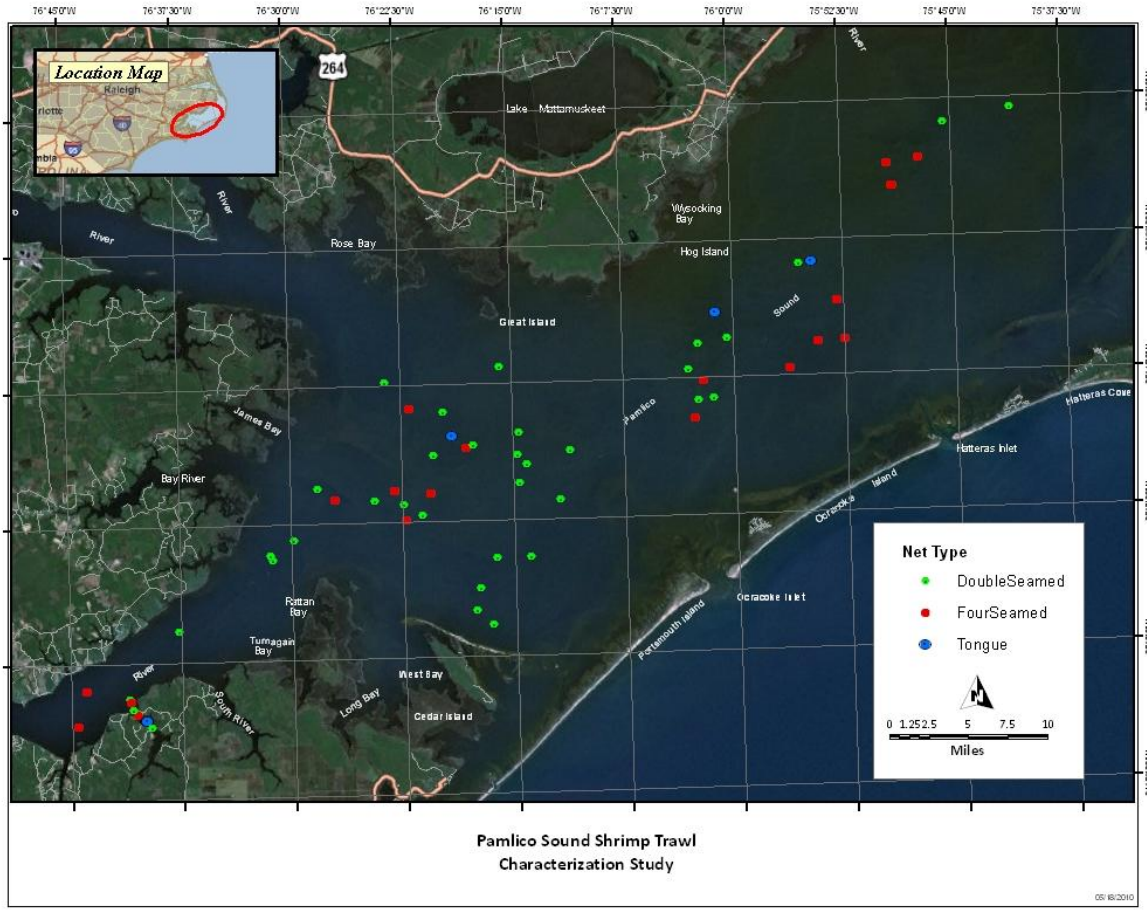

Figure 1. Study areas for commercial shrimp trawl observations made in North Carolina from 1 July 2009 through 31 December 2009.

Table 1. Total reported trips, total trips observed and percent coverage by month for commercial shrimp trawl observations made from in Pamlico Sound and its tributaries, North Carolina, 1 July 2009 to 31 December 2009.

Month	Total Days Fished	Total Days Observed	% Observed
July	1,896	38	2.00
August	1,825	21	1.15
September	855	0	0.00
October	637	5	0.78
November	240	0	0.00
December	9	2	22.22
Totals	5,462	66	1.21

GEAR PARAMETERS

Observers sampled commercial shrimp trawls consisting of three different net types: double seamed, four seamed and tongue nets. Varying trends were observed in the three fisheries.

Double seamed net fishery

There were 37 trips consisting of 121 tows observed in the double seamed net commercial shrimp trawl fishery. The majority (65%) of these trips were with four barrel rigs, while the remaining trips (35%) were with double rigged vessels (two barrel rigs). The head rope length ranged from 26 to 65 feet with the median being 35 ft. The observed tow speed ranged from 2.00 to 2.80 knots with the mean being 2.43 knots. Vessel length observed ranged from 34 to 65 feet with the mean being 54 feet. Tow time ranged from 50 to 275 minutes with the mean being 138 minutes. Polypropylene represented 54% of the type of webbing observed in this fishery and nylon represented the remaining 46%. The vast majority (81%) of observed trips used Straight Bar TEDs, while Super Shooter TEDs accounted for the remaining 19%. All of the observed BRD types were the Florida Fish Excluder (Table 2).

Table 2. Summary statistics for the double seamed trawl net gear parameters from observations made in Pamlico Sound and its tributaries, North Carolina, 1 July 2009 to 31 December 2009.

Net Type	Gear Parameter	N	Min	Mean	Median	Max
Double Seamed	Head Rope Length (ft)	37	26.00	*	35.00	65.00
	Wing Net Mesh (in)	37	0.75	*	0.88	0.88
	Tailbag Mesh (in)	37	0.75	*	0.75	0.88
	Depth (m)	37	4.00	5.86	*	6.50
	Tow Speed (kt)	37	2.00	2.43	*	2.80
	Placement of BRD/TT	37	60.00	*	64.00	65.00
	Placement of BRD/CL	37	1.00	*	10.00	15.00
	Vessel Length (ft)	37	34.00	53.73	*	65.00
	Tow Time (min)	37	50.00	138.11	*	275.00
	TED Type					
	Inshore Hooped Hard TED		*	*	*	*
	Super Shooter TED	7	*	*	*	*
	Straight Bar TED	30	*	*	*	*
	None		*	*	*	*
	Rig Type					
	Single rigged		*	*	*	*
	Two barrel/Double Rigged	13	*	*	*	*
	Four barrel	24	*	*	*	*
	Type of webbing					
	Nylon	17	*	*	*	*
	Poly	20	*	*	*	*
	Spectra		*	*	*	*
	BRD Type					
	Florida Fish Excluder	37	*	*	*	*

*Not applicable

Four seamed net fishery

There were 22 trips consisting of 59 tows observed in the four seamed net commercial shrimp trawl fishery. The majority (68%) of these trips were with four barrel rigs, while the remaining trips (32%) were with double rigged vessels (two barrel rigs). The head rope length ranged from 40 to 50 feet with the median being 50 ft. The observed tow speed ranged from 2.00 to 3.00 knots with the mean being 2.62 knots. Vessel length observed ranged from 44 to 80 feet with the mean being 68 feet. Tow time ranged from 50 to 260 minutes with the mean being 162 minutes. Nylon webbing was on 68% of the observed trips in this fishery and polypropylene webbing represented the remaining 32%. All of the observed TED types were Super Shooter TEDs. All of the observed BRD types were the Florida Fish Excluder (Table 3).

Table 3. Summary statistics for the four seamed trawl net gear parameters from observations made in Pamlico Sound and its tributaries, North Carolina, 1 July 2009 to 31 December 2009.

Net Type	Gear Parameter	N	Min	Mean	Median	Max
Four Seamed	Head Rope Length (ft)	22	40.00	*	50.00	50.00
	Wing Net Mesh (in)	22	0.75	*	0.88	0.94
	Tailbag Mesh (in)	22	0.75	*	0.88	0.94
	Depth (m)	22	4.90	6.04	*	7.20
	Tow Speed (kt)	22	2.00	2.62	*	3.00
	Placement of BRD/TT	22	65.00	*	65.00	65.00
	Placement of BRD/CL	22	10.00	*	15.00	15.00
	Vessel Length (ft)	22	44.00	67.86	*	80.00
	Tow Time (min)	22	50.00	162.05	*	260.00
	TED Type					
	Inshore Hooped Hard TED		*	*	*	*
	Super Shooter TED	22	*	*	*	*
	Straight Bar TED		*	*	*	*
	None		*	*	*	*
	Rig Type					
	Single rigged		*	*	*	*
	Two barrel/Double Rigged	7	*	*	*	*
	Four barrel	15	*	*	*	*
	Type of webbing					
	Nylon	15	*	*	*	*
	Poly	7	*	*	*	*
	Spectra		*	*	*	*
	BRD Type					
	Florida Fish Excluder	22	*	*	*	*

*Not applicable

Tongue net fishery

There were 7 trips consisting of 11 tows observed in the tongue net commercial shrimp trawl fishery. Double rigged vessels (two barrel rigs) represented 58% of the observed and four barrel rigs accounted for the remaining 42%. Head rope length ranged from 45 to 50 feet with a median of 45 feet. The observed tow speeds in this fishery ranged from 2.5 to 3.2 knots with the mean being 2.74 knots. Vessel length observed ranged from 34 to 80 feet with the mean being 54 feet. Tow times ranged from 60 to 240 minutes, with the mean being 120 minutes. All observed trips used Super Shooter TEDs. Nylon webbing was observed on 71% of trips and polypropylene accounted for the remaining 29%. All observed trips used the Florida Fish Excluder (Table 4).

Table 4. Summary statistics for the tongue trawl net gear parameters from observations made in Pamlico Sound and its tributaries, North Carolina, 1 July 2009 to 31 December 2009.

Net Type	Gear Parameter	N	Min	Mean	Median	Max
Tongue Net	Head Rope Length (ft)	7	45.00	*	45.00	50.00
	Wing Net Mesh (in)	7	0.88	*	0.88	0.88
	Tailbag Mesh (in)	7	0.75	*	0.88	0.88
	Depth (m)	7	5.60	6.28	*	7.00
	Tow Speed (kt)	7	2.50	2.74	*	3.20
	Placement of BRD/TT	7	65.00	*	65.00	65.00
	Placement of BRD/CL	7	10.00	*	15.00	15.00
	Vessel Length (ft)	7	34.00	53.71	*	80.00
	Tow Time (min)	7	60.00	120.00	*	240.00
	TED Type					
	Inshore Hooped Hard TED		*	*	*	*
	Super Shooter TED	7	*	*	*	*
	Straight Bar TED		*	*	*	*
	None		*	*	*	*
	Rig Type					
	Single rigged		*	*	*	*
	Two barrel/Double Rigged	4	*	*	*	*
	Four barrel	3	*	*	*	*
	Type of webbing					
	Nylon	5	*	*	*	*
	Poly	2	*	*	*	*
	Spectra		*	*	*	*
	BRD Type					
	Florida Fish Excluder	7	*	*	*	*

*Not applicable

SPECIES COMPOSITION

The composition of species caught varied by net type. The net type corresponded to the time of year and the target species. Miscellaneous includes invertebrates not identified to genus level.

All nets

There were 69 species observed throughout the study in all net types. The three commercially important species of shrimp (brown, white, pink) combined represented 22.76% of the catch by weight (Table 5). Atlantic croaker accounted for 32.97% of the catch by weight. Spot represented 12.62% of the catch by weight. The three commercially important flounder species combined to represent 0.97% of the catch by weight. Other commercially important species of note include weakfish, kingfishes (*Menticirrhus* spp.), and spotted sea trout which represented 6.34, 0.79, and 0.02% of the catch by weight, respectively (Table 5).

Table 5. Relative biomass (kg) observed in all net types combined in the commercial shrimp trawl fisheries in Pamlico Sound and its tributaries, North Carolina, 1 July 2009 to 31 December 2009.

Scientific Name	Common Name	Total Number	% Number	Total Weight	% Biomass
Micropogonias undulatus	Atlantic Croaker	787,633	30.64	18,367.21	32.97
Penaeus aztecus	Brown Shrimp	511,395	19.89	11,607.66	20.84
Leiostomus xanthurus	Spot	404,076	15.72	7,028.64	12.62
Cynoscion regalis	Weakfish	213,578	8.31	3,530.18	6.34
Miscellaneous	Miscellaneous	*	*	2,695.76	4.84
Squilla empusa	Mantis Shrimp	185,545	7.22	2,283.12	4.10
Lolliguncula brevis	Atlantic Brief Squid	148,065	5.76	1,463.08	2.63
Callinectes sapidus	Blue Crab	14,585	0.57	909.88	1.63
Portunus spp.	Portunus Crabs	86,450	3.36	842.11	1.51
Penaeus duorarum	Pink Shrimp	50,884	1.98	727.85	1.31
Brevoortia tyrannus	Atlantic Menhaden	10,532	0.41	644.35	1.16
Synodus foetens	Inshore Lizardfish	8,316	0.32	517.62	0.93
Cnidaria	Jellyfish	100	0.00	452.51	0.81
Menticirrhus americanus	Southern Kingfish	6,314	0.25	434.30	0.78
Lagodon rhomboides	Pinfish	10,058	0.39	405.70	0.73
Paralichthys dentatus	Summer Flounder	5,275	0.21	398.01	0.71
Penaeus setiferus	White Shrimp	16,274	0.63	341.57	0.61
Trichiurus lepturus	Atlantic Cutlassfish	1,862	0.07	324.99	0.58
Chaetodipterus faber	Atlantic Spadefish	16,620	0.65	269.35	0.48
Purgamentum	Rubbish	*	*	268.94	0.48
Opisthonema oglinum	Atlantic Thread Herring	8,305	0.32	243.77	0.44
Peprilus paru	Harvestfish	24,219	0.94	214.64	0.39
Trinectes maculatus	Hogchoker	5,247	0.20	188.91	0.34
Citharichthys spilopterus	Bay Whiff	6,320	0.25	151.54	0.27
Paralichthys lethostigma	Southern Flounder	940	0.04	146.99	0.26
Dasyatis sabina	Atlantic Stingray	245	0.01	136.91	0.25
Peprilus triacanthus	Butterfish	2,145	0.08	120.64	0.22
Anchoa spp.	Anchovies	15,743	0.61	111.40	0.20
Symphurus spp.	Tonguefishes	4,121	0.16	90.51	0.16
Scomberomorus maculatus	Spanish Mackerel	676	0.03	89.18	0.16
Bairdiella chrysoura	Silver Perch	2,129	0.08	86.98	0.16
Cynoscion nothus	Silver Seatrout	7,349	0.29	65.55	0.12
Portunidae	Swimming Crabs	5,991	0.23	63.25	0.11
Pomatomus saltatrix	Bluefish	496	0.02	62.16	0.11
Gymnura micrura	Smooth Butterfly Ray	96	0.00	51.77	0.09
Chilomycterus schoepfii	Striped Burrfish	144	0.01	43.33	0.08
Dorosoma petenense	Threadfin Shad	653	0.03	41.83	0.08
Triglidae	Searobins	1,861	0.07	38.43	0.07
Aluterus spp.	Aluterus Filefishes	2,580	0.10	37.72	0.07
Orthopristis chrysoptera	Pigfish	1,094	0.04	30.62	0.05
Larimus fasciatus	Banded Drum	153	0.01	25.10	0.05
Gymnura spp.	Butterfly Rays	22	0.00	21.99	0.04
Selene vomer	Lookdown	1,103	0.04	19.30	0.03
Rhinoptera bonasus	Cownose Ray	13	0.00	14.45	0.03
Rhizoprionodon terraenovae	Atlantic Sharpnose Shark	19	0.00	13.88	0.02
Anadara ovalis	Blood Ark	276	0.01	13.40	0.02
Callinectes similis	Lesser Blue Crab	134	0.01	12.98	0.02
Cynoscion nebulosus	Spotted Seatrout	127	0.00	9.57	0.02
Anguilla rostrata	American Eel	45	0.00	8.95	0.02
Libinia spp.	Libinia Spider Crabs	71	0.00	7.10	0.01
Elopmorpha ang. anguilloidea	Eels	12	0.00	6.40	0.01
Citharichthys cornutus	Horned Whiff	157	0.01	4.72	0.01
Ancylopsetta quadrocellata	Ocellated Flounder	63	0.00	4.58	0.01
Opsanus tau	Oyster Toadfish	16	0.00	3.21	0.01
Menticirrhus saxatilis	Northern Kingfish	45	0.00	2.80	0.01
Scomberomorus regalis	Cero	128	0.00	2.56	0.00
Sphoeroides maculatus	Northern Puffer	51	0.00	2.45	0.00
Chloroscombrus chrysurus	Atlantic Bumper	180	0.01	1.65	0.00
Blenniidae	Combtooth Blennies	51	0.00	1.01	0.00
Anomura paguridea	Hermit Crabs	39	0.00	0.78	0.00
Lagocephalus laevigatus	Smooth Puffer	26	0.00	0.77	0.00
Paralichthys albigutta	Gulf Flounder	5	0.00	0.66	0.00
Anchoa mitchilli	Bay Anchovy	246	0.01	0.44	0.00
Xiphopenaeus kroyeri	Atlantic Seabob	44	0.00	0.44	0.00
Alectis ciliaris	African Pompano	19	0.00	0.38	0.00
Scophthalmus aquosus	Windowpane	13	0.00	0.25	0.00
Clupeidae	Herrings	13	0.00	0.17	0.00
Caranx hippos	Crevalle Jack	5	0.00	0.05	0.00
Trachinotus carolinus	Florida Pompano	5	0.00	0.05	0.00
Totals		2,570,995	100.00	55,709.04	100.00

Double Seamed sets

There were 56 species observed in the double seamed shrimp trawl nets. Atlantic croaker was the most abundant species by weight, representing 38.96% of the catch. All three commercially important species of shrimp combined to represent 22.74% of the catch by weight. Brown shrimp accounted for most of the shrimp catch in these nets, representing 21.77% of the catch by weight. Spot represented 14.54% of the catch by weight. The three commercially important species of flounder combined to represent 0.97% of the catch by weight. Weakfish represented 3.40% of the catch by weight (Table 6).

Table 6. Relative biomass (kg) observed in the double seamed commercial shrimp trawl fisheries in Pamlico Sound and its tributaries, North Carolina, 1 July 2009 to 31 December 2009.

Scientific Name	Common Name	Total Number	% Number	Total Weight	% Biomass
Micropogonias undulatus	Atlantic Croaker	517,144	34.27	11,707	38.96
Penaeus aztecus	Brown Shrimp	301,234	19.96	6,361	21.17
Leiostomus xanthurus	Spot	291,247	19.30	4,360	14.51
Squilla empusa	Mantis Shrimp	106,285	7.04	1,394	4.64
Cynoscion regalis	Weakfish	55,364	3.67	1,022	3.40
Miscellaneous	Miscellaneous	*	*	846	2.82
Lolliguncula brevis	Atlantic Brief Squid	75,703	5.02	806	2.68
Portunus spp.	Portunus Crabs	60,123	3.98	558	1.86
Callinectes sapidus	Blue Crab	6,841	0.45	388	1.29
Penaeus duorarum	Pink Shrimp	20,454	1.36	285	0.95
Lagodon rhomboides	Pinfish	5,925	0.39	244	0.81
Paralichthys dentatus	Summer Flounder	3,611	0.24	225	0.75
Brevoortia tyrannus	Atlantic Menhaden	3,107	0.21	169	0.56
Peprilus paru	Harvestfish	20,024	1.33	150	0.50
Synodus foetens	Inshore Lizardfish	3,373	0.22	148	0.49
Trinectes maculatus	Hogchoker	3,868	0.26	147	0.49
Purgamentum	Rubbish	*	*	138	0.46
Dasyatis sabina	Atlantic Stingray	192	0.01	119	0.40
Chaetodipterus faber	Atlantic Spadefish	2,895	0.19	115	0.38
Citharichthys spilopterus	Bay Whiff	4,092	0.27	105	0.35
Menticirrhus americanus	Southern Kingfish	796	0.05	97	0.32
Opisthonema oglinum	Atlantic Thread Herring	1,725	0.11	67	0.22
Paralichthys lethostigma	Southern Flounder	689	0.05	66	0.22
Cynoscion nothus	Silver Seatrout	7,349	0.49	66	0.22
Gymnura micrura	Smooth Butterfly Ray	96	0.01	52	0.17
Trichiurus lepturus	Atlantic Cutlassfish	311	0.02	51	0.17
Anchoa spp.	Anchovies	6,988	0.46	45	0.15
Peprilus triacanthus	Butterfish	915	0.06	44	0.15
Bairdiella chrysoura	Silver Perch	1,011	0.07	44	0.15
Chilomycterus schoepfii	Striped Burrfish	144	0.01	43	0.14
Symphurus spp.	Tonguefishes	1,807	0.12	35	0.12
Triglidae	Searobins	1,530	0.10	28	0.09
Larimus fasciatus	Banded Drum	91	0.01	21	0.07
Aluterus spp.	Aluterus Filefishes	1,787	0.12	21	0.07
Pomatomus saltatrix	Bluefish	308	0.02	21	0.07
Rhizoprionodon terraenovae	Atlantic Sharpnose Shark	19	0.00	14	0.05
Rhinoptera bonasus	Cownose Ray	8	0.00	8	0.03
Selene vomer	Lookdown	552	0.04	7	0.02
Scomberomorus maculatus	Spanish Mackerel	198	0.01	6	0.02
Orthopristis chrysoptera	Pigfish	246	0.02	6	0.02
Penaeus setiferus	White Shrimp	343	0.02	5	0.02
Ancylopsetta quadrocellata	Ocellated Flounder	63	0.00	5	0.02
Libinia spp.	Libinia Spider Crabs	36	0.00	3	0.01
Menticirrhus saxatilis	Northern Kingfish	45	0.00	3	0.01
Cnidaria	Jellyfish	56	0.00	2	0.01
Opsanus tau	Oyster Toadfish	11	0.00	2	0.01
Blenniidae	Combtooth Blennies	51	0.00	1	0.00
Lagocephalus laevigatus	Smooth Puffer	26	0.00	1	0.00
Paralichthys albigutta	Gulf Flounder	5	0.00	1	0.00
Scomberomorus regalis	Cero	30	0.00	1	0.00
Anchoa mitchilli	Bay Anchovy	246	0.02	0	0.00
Xiphopenaeus kroyeri	Atlantic Seabob	44	0.00	0	0.00
Alectis ciliaris	African Pompano	19	0.00	0	0.00
Clupeidae	Herrings	13	0.00	0	0.00
Sphoeroides maculatus	Northern Puffer	12	0.00	0	0.00
Chloroscombrus chrysurus	Atlantic Bumper	7	0.00	0	0.00
Totals		1,509,057	100.00	30,052	100.00

Four seamed nets

There were 51 species observed in the commercial four seamed net shrimp trawls (Table 7). The three commercially important shrimp species combined to represent 24.54% of the catch by weight. Brown shrimp accounted for 22.74% of the catch by weight. Atlantic croaker was the most abundant species by weight, accounting for 26.71% of the catch by weight. Spot represented 10.55% of the catch by weight. Weakfish represented 9.89% of the catch by weight. The three commercially important flounder species combined to represent 1.00% of the catch by weight. Southern kingfish (*M. americanus*) represented 1.33% of the catch by weight (Table 7).

Table 7. Relative biomass (kg) observed in the four seamed commercial shrimp trawl fisheries in Pamlico Sound and its tributaries, North Carolina, 1 July 2009 to 31 December 2009.

Scientific Name	Common Name	Total Number	% Number	Total Weight	% Biomass
Micropogonias undulatus	Atlantic Croaker	251,004	25.95	6,142.86	26.71
Penaeus aztecus	Brown Shrimp	209,211	21.63	5,228.71	22.74
Leiostomus xanthurus	Spot	101,468	10.49	2,426.66	10.55
Cynoscion regalis	Weakfish	147,784	15.28	2,273.52	9.89
Miscellaneous	Miscellaneous	*	*	1,513.35	6.58
Squilla empusa	Mantis Shrimp	66,554	6.88	761.19	3.31
Lolliguncula brevis	Atlantic Brief Squid	64,887	6.71	600.32	2.61
Callinectes sapidus	Blue Crab	7,614	0.79	513.48	2.23
Penaeus duorarum	Pink Shrimp	27,852	2.88	408.24	1.78
Brevoortia tyrannus	Atlantic Menhaden	6,064	0.63	391.05	1.70
Synodus foetens	Inshore Lizardfish	4,683	0.48	343.55	1.49
Menticirrhus americanus	Southern Kingfish	5,187	0.54	305.29	1.33
Portunus spp.	Portunus Crabs	24,996	2.58	274.38	1.19
Trichiurus lepturus	Atlantic Cutlassfish	1,552	0.16	273.83	1.19
Lagodon rhomboides	Pinfish	3,901	0.40	156.56	0.68
Paralichthys dentatus	Summer Flounder	1,495	0.15	151.64	0.66
Chaetodipterus faber	Atlantic Spadefish	13,042	1.35	146.67	0.64
Opisthonema oglinum	Atlantic Thread Herring	2,461	0.25	137.77	0.60
Purgamentum	Rubbish	*	*	108.00	0.47
Scomberomorus maculatus	Spanish Mackerel	443	0.05	80.16	0.35
Paralichthys lethostigma	Southern Flounder	212	0.02	78.29	0.34
Peprilus triacanthus	Butterfish	1,230	0.13	76.40	0.33
Portunidae	Swimming Crabs	5,991	0.62	63.25	0.28
Peprilus paru	Harvestfish	3,882	0.40	57.85	0.25
Symphurus spp.	Tonguefishes	2,202	0.23	53.26	0.23
Anchoa spp.	Anchovies	6,278	0.65	50.72	0.22
Trinectes maculatus	Hogchoker	1,379	0.14	42.10	0.18
Dorosoma petenense	Threadfin Shad	653	0.07	41.83	0.18
Pomatomus saltatrix	Bluefish	170	0.02	39.86	0.17
Citharichthys spilopterus	Bay Whiff	1,330	0.14	37.95	0.17
Bairdiella chrysoura	Silver Perch	621	0.06	31.28	0.14
Cnidaria	Jellyfish	44	0.00	23.71	0.10
Gymnura spp.	Butterfly Rays	22	0.00	21.99	0.10
Orthopristis chrysoptera	Pigfish	730	0.08	18.42	0.08
Dasyatis sabina	Atlantic Stingray	53	0.01	17.87	0.08
Aluterus spp.	Aluterus Filefishes	665	0.07	15.03	0.07
Anadara ovalis	Blood Ark	276	0.03	13.40	0.06
Callinectes similis	Lesser Blue Crab	134	0.01	12.98	0.06
Selene vomer	Lookdown	410	0.04	11.80	0.05
Triglidae	Searobins	273	0.03	9.51	0.04
Anguilla rostrata	American Eel	45	0.00	8.95	0.04
Rhinoptera bonasus	Cownose Ray	5	0.00	6.58	0.03
Elopmorpha ang. anguilloidea	Eels	12	0.00	6.40	0.03
Penaeus setiferus	White Shrimp	286	0.03	5.69	0.02
Citharichthys cornutus	Horned Whiff	157	0.02	4.72	0.02
Larimus fasciatus	Banded Drum	56	0.01	3.88	0.02
Scomberomorus regalis	Cero	98	0.01	1.97	0.01
Opsanus tau	Oyster Toadfish	5	0.00	1.09	0.00
Scophthalmus aquosus	Windowpane	13	0.00	0.25	0.00
Caranx hippos	Crevalle Jack	5	0.00	0.05	0.00
Trachinotus carolinus	Florida Pompano	5	0.00	0.05	0.00
Totals		967,439	100.00	22,994.40	100.00

Tongue nets

There were 38 species observed in the commercial tongue net shrimp trawls (Table 8). The three commercially important shrimp species combined to represent 14.40% of the catch by weight. White shrimp accounted for 12.42% of the catch by weight. Atlantic croaker was the most abundant species by weight, accounting for 19.43% of the catch by weight. Spot represented 9.08% of the catch by weight. Weakfish represented 8.82% of the catch by weight. The three commercially important flounder species combined to represent 0.91% of the catch by weight. Southern kingfish represented 1.22% of the catch by weight. Spotted sea trout accounted for 0.36% of the catch by weight (Table 8).

Table 8. Relative biomass (kg) observed in tongue nets in the commercial shrimp trawl fishery in Pamlico Sound and its tributaries, North Carolina, 1 July 2009 to 31 June 2009.

Scientific Name	Common Name	Total Number	% Number	Total Weight	% Biomass
Micropogonias undulatus	Atlantic Croaker	19,486	20.62	517.38	19.43
Cnidaria	Jellyfish	*	*	426.56	16.02
Miscellaneous	Miscellaneous	*	*	336.22	12.63
Penaeus setiferus	White Shrimp	15,644	16.55	330.70	12.42
Leiostomus xanthurus	Spot	11,360	12.02	241.88	9.08
Cynoscion regalis	Weakfish	10,430	11.04	234.83	8.82
Squilla empusa	Mantis Shrimp	12,705	13.44	127.53	4.79
Brevoortia tyrannus	Atlantic Menhaden	1,362	1.44	84.28	3.16
Lolliguncula brevis	Atlantic Brief Squid	7,474	7.91	57.16	2.15
Opisthonema oglinum	Atlantic Thread Herring	4,119	4.36	39.25	1.47
Penaeus duorarum	Pink Shrimp	2,578	2.73	34.54	1.30
Menticirrhus americanus	Southern Kingfish	331	0.35	32.38	1.22
Synodus foetens	Inshore Lizardfish	260	0.28	26.25	0.99
Purgamentum	Rubbish	*	*	23.23	0.87
Paralichthys dentatus	Summer Flounder	169	0.18	20.96	0.79
Penaeus aztecus	Brown Shrimp	950	1.00	18.22	0.68
Anchoa spp.	Anchovies	2,477	2.62	15.30	0.57
Bairdiella chrysoura	Silver Perch	497	0.53	12.08	0.45
Portunus spp.	Portunus Crabs	1,331	1.41	10.09	0.38
Cynoscion nebulosus	Spotted Seatrout	127	0.13	9.57	0.36
Citharichthys spilopterus	Bay Whiff	898	0.95	8.23	0.31
Callinectes sapidus	Blue Crab	131	0.14	8.18	0.31
Chaetodipterus faber	Atlantic Spadefish	684	0.72	8.13	0.31
Peprilus paru	Harvestfish	313	0.33	6.69	0.25
Orthopristis chrysoptera	Pigfish	117	0.12	6.18	0.23
Lagodon rhomboides	Pinfish	232	0.25	4.81	0.18
Libinia spp.	Libinia Spider Crabs	35	0.04	4.25	0.16
Paralichthys lethostigma	Southern Flounder	39	0.04	3.10	0.12
Scomberomorus maculatus	Spanish Mackerel	35	0.04	2.83	0.11
Sphoeroides maculatus	Northern Puffer	39	0.04	2.33	0.09
Symphurus spp.	Tonguefishes	112	0.12	2.25	0.08
Aluterus spp.	Aluterus Filefishes	127	0.13	1.84	0.07
Chloroscombrus chrysurus	Atlantic Bumper	173	0.18	1.58	0.06
Pomatomus saltatrix	Bluefish	18	0.02	1.45	0.05
Triglidae	Searobins	58	0.06	1.16	0.04
Anomura paguridea	Hermit Crabs	39	0.04	0.78	0.03
Selene vomer	Lookdown	142	0.15	0.71	0.03
Larimus fasciatus	Banded Drum	5	0.01	0.05	0.00
Totals		94,498	100.00	2,663.00	100.00

EFFORT

Effort was defined as headrope length multiplied by number of nets multiplied by tow time and was calculated per hour. Season was defined as summer (July, August, and September) and fall (October, November, and December). Observed effort varied by season and net type.

Observed effort was highest during the summer and was evenly split between double seamed and four seamed nets. The summer accounted for 93% of the total observed effort, while the fall accounted for the remaining 7% (Table 9 and Figure 2).

Table 9. Total number of trips, total number of tows, and tow times observed in the commercial shrimp trawl fishery in Pamlico Sound and its tributaries, North Carolina, 1 July 2009 to 31 December 2009.

Net Type	# Trips		# Tows		Min Tow Time (min)		Max Tow Time (min)		Avg Tow Time (min)	
	Summer	Fall	Summer	Fall	Summer	Fall	Summer	Fall	Summer	Fall
Double Seamed	37	0	121	0	45	0	325	0	138	0
Four Seamed	22	0	59	0	59	0	260	0	182	0
Tongue	0	7	0	11	0	60	0	315	0	151

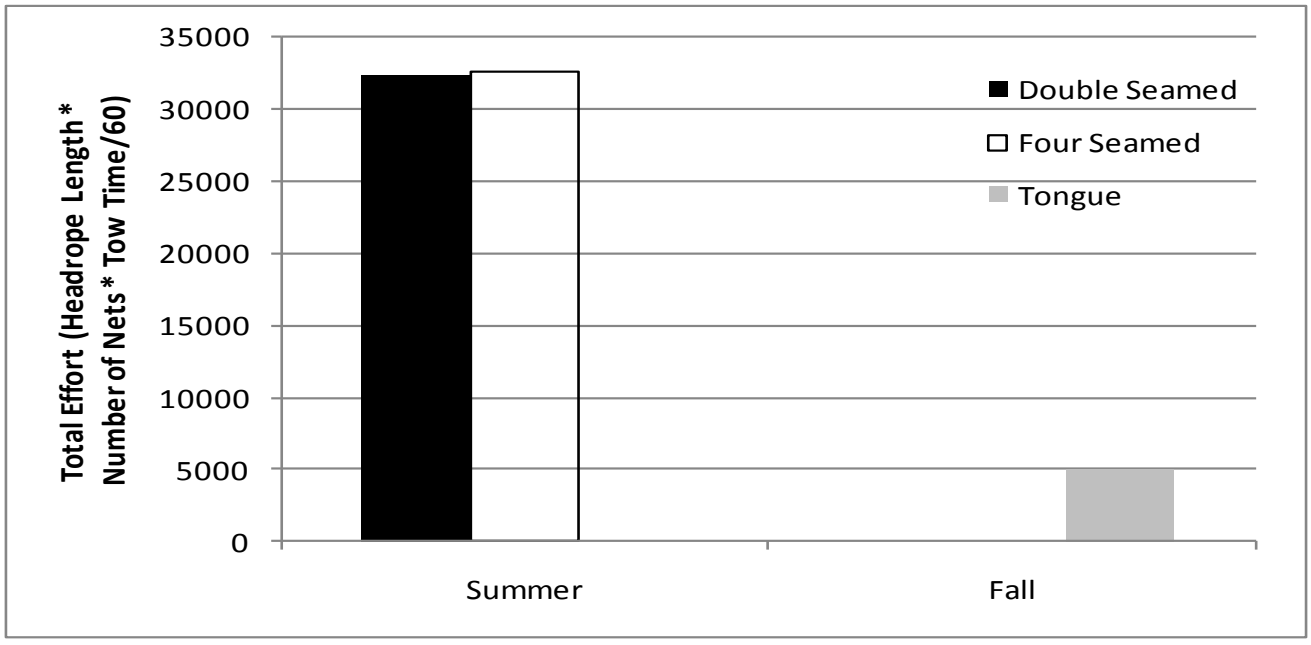

Figure 2. Total effort (headrope length*number of nets*tow time) per hour by net type observed in the commercial shrimp trawl fishery in Pamlico Sound and its tributaries, North Carolina from 1 July 2009 to 31 December 2009.

KEY SPECIES CATCHES

Total catch of key species was determined by calculating total weight (kg) by season and net type. Paralichthid species (flounder) and Menticirrhus species (kingfish) were combined to the genus level because of the relatively low numbers of individual species observed. Trends are discussed between double seamed, four seamed and tongue nets.

The double seamed and four seamed net fishery primarily targeted brown shrimp in the summer and the tongue net fishery targeted white and pink shrimp in the fall. Atlantic croaker represented the largest bycatch of commercially important species in all three net types, while spot was the second most abundant. The majority of both Atlantic croaker (78%) and spot (95%) were harvested during the summer months in the double seamed and four seamed net fishery (Figure 3).

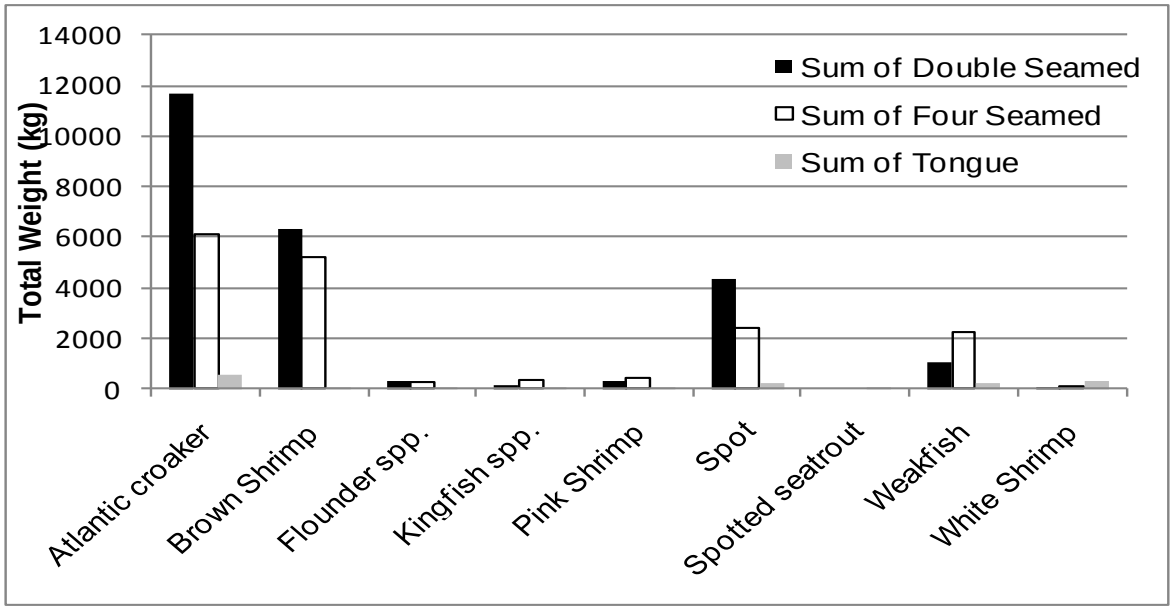

Figure 3. Total weight (kg) of commercially important species observed in the commercial shrimp trawl fishery by net type in Pamlico Sound and its tributaries, North Carolina from 1 July 2009 to 31 December 2009.

Length frequencies of key species

Length frequency data of a given population is important information used in the assessments of that population. Length frequency of commercially and recreationally important species in this study was stratified by season and categorized into 10 mm groups.

The length frequency distribution of brown shrimp show the expected growth patterns of individuals increasing in length from the spring through the fall. The vast majority of individuals measured were in the summer and the majority of those measured between 110 and 170 mm (Figure 4). The vast majority of pink shrimp were measured in the summer and the majority of those ranged between 90 and 140 mm (Figure 4). White shrimp length frequency distributions showed seasonal variation, with the majority of individuals measured in the summer ranging

between 80 and 110 mm. The majority of individuals measured in the fall ranged between 80 and 180 mm (Figure 4).

The vast majority of weakfish measured were in the summer with the majority of these ranging from 70 to 150 mm (Figure 5). Weakfish length frequency distributions showed no discernable trends, however 99.9% of those measured were under sized fish (less than 305 mm (12 in)) (Figure 5).

The vast majority of spot were measured in the summer and ranged from 80 to 120 mm (Figure 7). The vast majority of Atlantic croaker were measured in the summer and the majority of these ranged from 100 to 140 mm (Figure 6).

Southern kingfish length frequency distributions showed no discernable trends (Figure 7). The vast majority of flounder measured were in the summer and the majority of these ranged from 130 to 180 mm (Figure 8). The majority of individuals measured of both species were undersized fish (less than 355 mm (14 in)) (Figure 8).

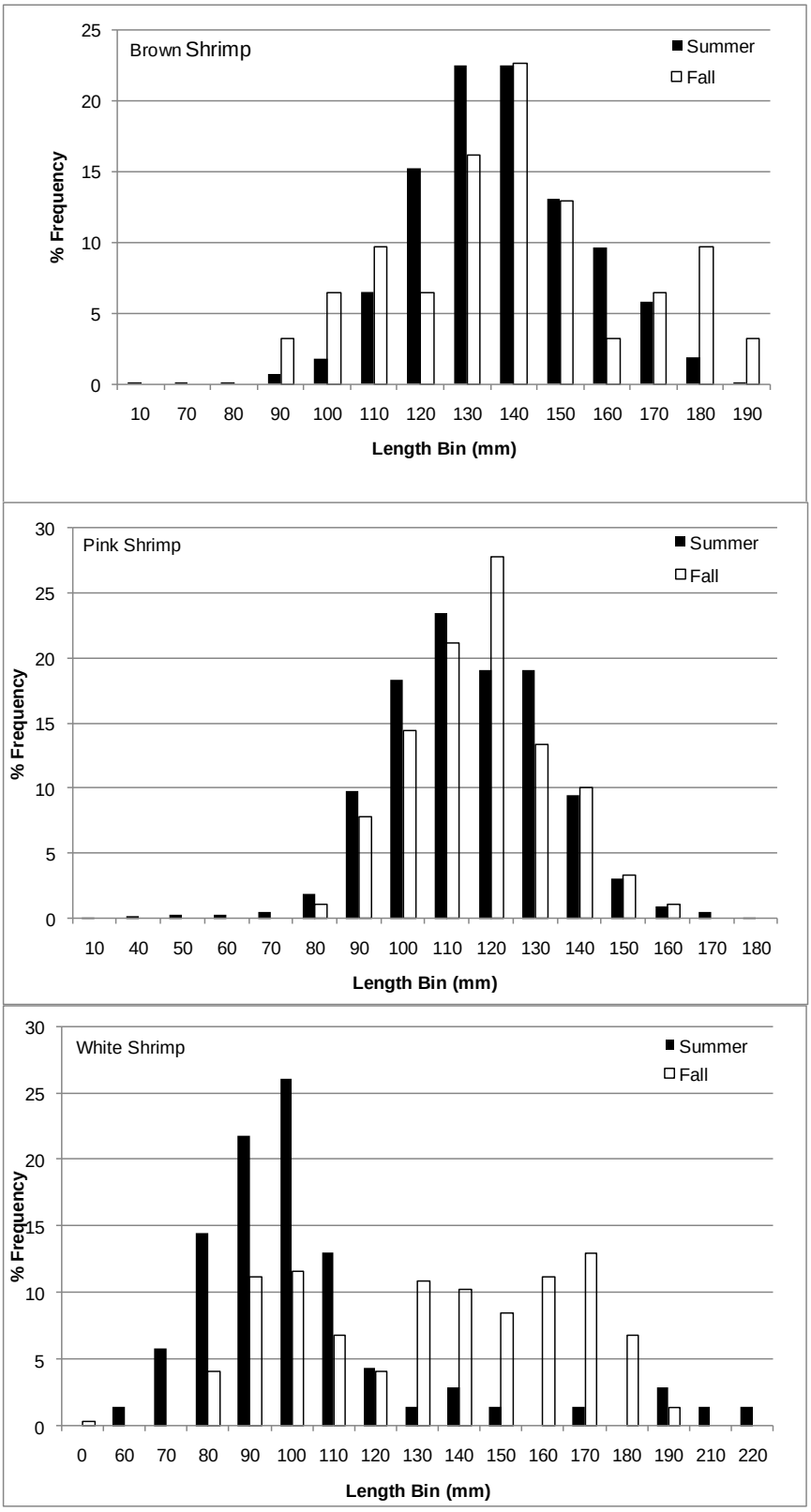

Figure 4. Length frequency of the three commercially important species of shrimp (brown, pink, white) observed in the commercial shrimp trawl fishery in Pamlico Sound and its tributaries, North Carolina from 1 July 2009 to 31 December 2009.

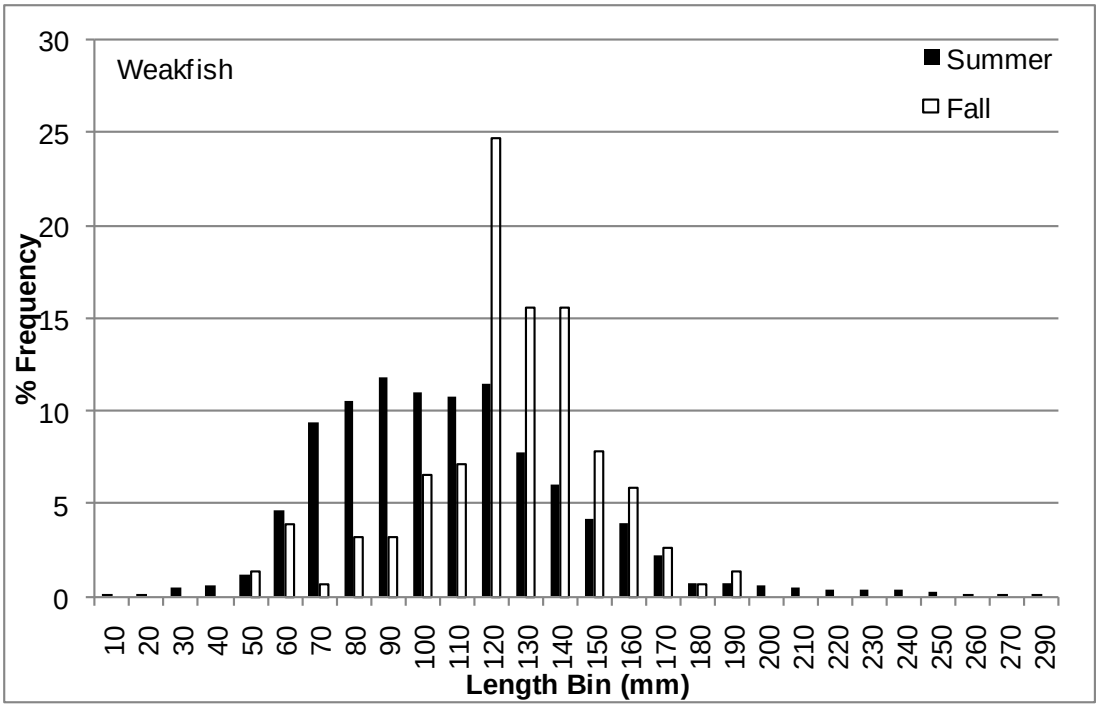

Figure 5. Length frequency of weakfish observed in the commercial shrimp trawl fishery from Pamlico Sound and its tributaries, North Carolina from 1 July 2009 to 31 December 2009.

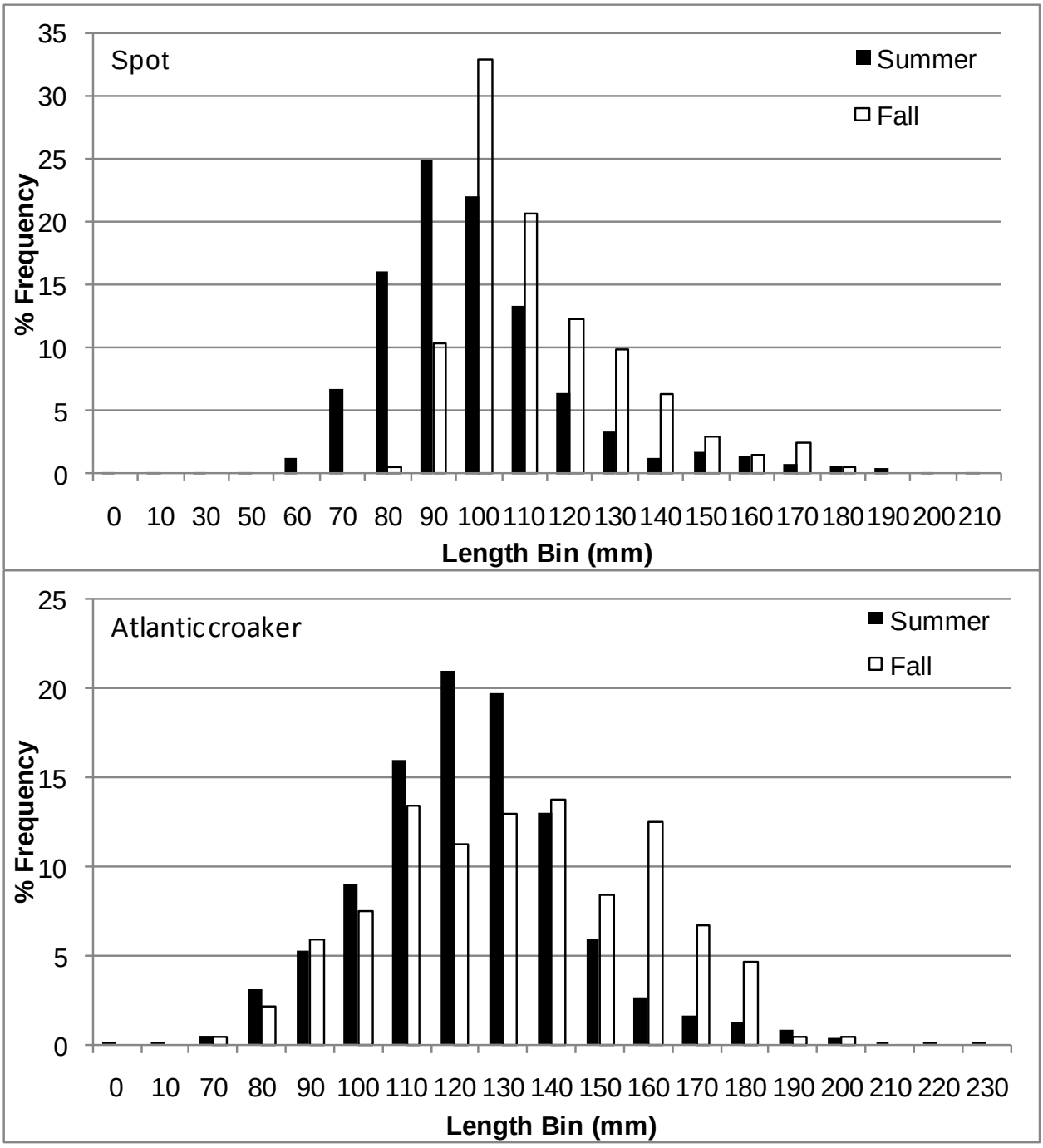

Figure 6. Length frequency of spot and Atlantic croaker observed in the commercial shrimp trawl fishery in Pamlico Sound and its tributaries, North Carolina from 1 July 2009 to 31 December 2009.

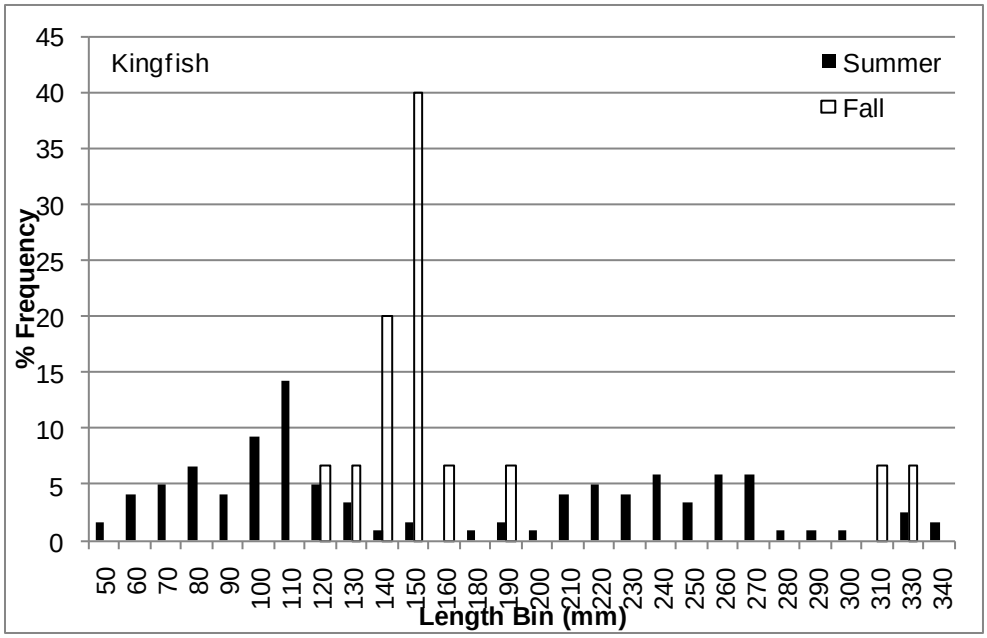

Figure 7. Length frequency of Southern kingfish observed in the commercial shrimp trawl fishery in Pamlico Sound and its tributaries, North Carolina from 1 July 2009 to 31 December 2009.

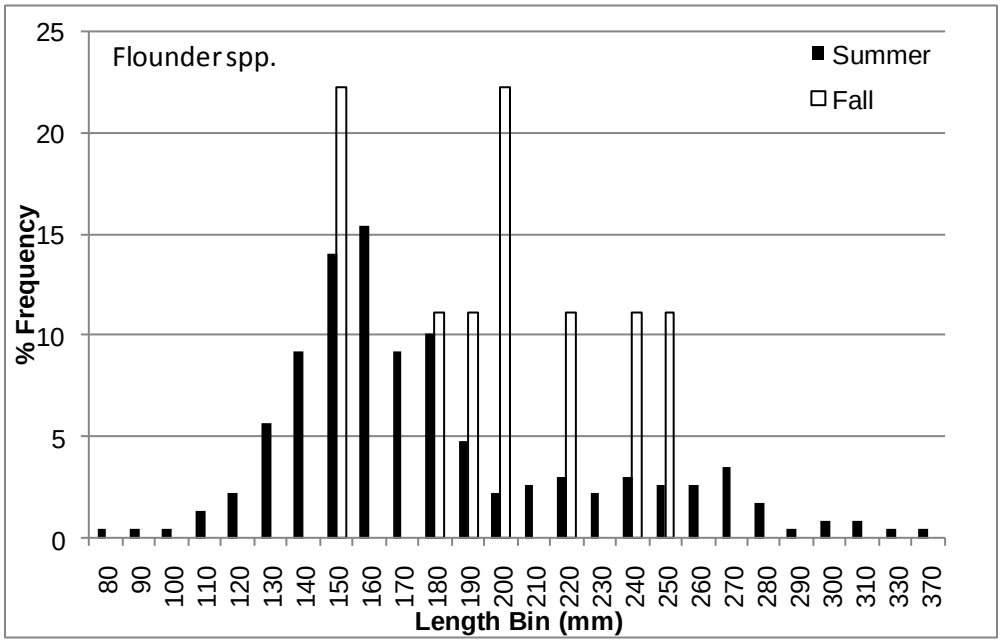

Figure 8. Length frequency of flounder species observed in the commercial shrimp trawl fishery in Pamlico Sound and its tributaries, North Carolina from 1 July 2009 to 31 December 2009.

CATCH PER UNIT EFFORT (CPUE) – KEY SPECIES

Catch per unit effort was determined by dividing total weight (kg) by total effort, and was calculated per 60 minutes of tow time. Differences were observed based on net type and season.

Double seamed fishery

The CPUE for brown shrimp (the target species of the fishery) in this fishery was the highest observed for all shrimp species across all net types and seasons. The CPUEs of Atlantic croaker and spot were significantly higher than other commercially important bycatch in this fishery (Table 10).

Four seamed fishery

The CPUE of brown shrimp in this fishery was similar to that seen in the double seamed fishery. The CPUE of Atlantic croaker was significantly higher than other commercially important bycatch in this fishery (Table 10).

Tongue net fishery

The highest CPUE observed for white shrimp was in this fishery. Atlantic croaker had the highest CPUE of all bycatch in this fishery. The CPUE of spot, flounder, Atlantic croaker, and brown shrimp in this fishery was the lowest observed during this study. The CPUE of weakfish in this fishery was the highest observed during this study (Table 10).

Table 10. Catch per unit effort (CPUE) defined as: total weight (kg) / (head rope length*number of nets*tow time) per hour by net type in the commercial shrimp trawl fisheries in Pamlico Sound and its tributaries, North Carolina, 1 July 2009 to 31 December 2009.

Species	Double Seamed		Four Seamed		Tongue	
	Summer	Fall	Summer	Fall	Summer	Fall
Brown Shrimp	0.20	*	0.16	*	*	0.00
Pink Shrimp	0.01	*	0.01	*	*	0.01
White Shrimp	0.00	*	0.00	*	*	0.07
Atlantic Croaker	0.36	*	0.19	*	*	0.10
Spot	0.13	*	0.07	*	*	0.05
Weakfish	0.03	*	0.07	*	*	0.05
Kingfish spp.	0.00	*	0.01	*	*	0.00
Flounder spp.	0.01	*	0.01	*	*	0.00

*No nets observed

FINFISH BYCATCH

There were two classifications of discards: regulatory and unmarketable. Regulatory discards were defined as any fish that must be discarded due to size, season, or quota restrictions. Unmarketable discards accounted for all other discards, including discretionary discards.

Atlantic croaker accounted for the largest percentage of the unmarketable discards in all net types by weight. All Atlantic croaker were classified as unmarketable discards. Spot was the second most abundant unmarketable finfish discard in all fisheries. Over 99% of all spot by weight were classified as unmarketable in all three net types. (Table 11, 12, and 13).

Weakfish represented the largest regulatory discard in all three net types. In the double seamed nets 98% of weakfish were classified as regulatory discards and comprised 78% of all regulatory discards by weight. Spanish mackerel (*Scomberomorus maculatus*), southern flounder, and summer flounder represented 0.48%, 5%, and 17% of regulatory discards in the double seamed nets, respectively. In the four seamed nets 100% of weakfish were regulatory discards and represented 89% of all regulatory discards by weight. Spanish mackerel, southern flounder, and summer flounder represented 2%, 3%, and 6% of regulatory discards in the four seamed nets, respectively. In the tongue net fishery, 86% of weakfish were regulatory discards and represented 84% of all regulatory discards by weight. Spotted seatrout, Spanish mackerel, southern flounder, and summer flounder represented 4%, 1%, 1%, and 9% of the regulatory discards in the tongue net fishery, respectively (Table 11, 12 and 13).

Table 11. Tabulation of sampled catch and discards by weight (kg) and species status (kept, unmarketable, regulatory discards) in double seamed nets in the commercial shrimp trawl fishery in Pamlico Sound and its tributaries, North Carolina, 1 July 2009 to 31 December 2009.

Species	Fish Kept	Unmarketable	Regulatory Discard	Total
Rubbish	0.00	137.71	0.00	137.71
Miscellaneous	0.00	846.19	0.00	846.19
Jellyfish	0.00	2.24	0.00	2.24
Atlantic Brief Squid	111.46	694.14	0.00	805.60
Brown Shrimp	6,260.94	99.78	0.00	6,360.72
Pink Shrimp	250.28	34.78	0.00	285.06
White Shrimp	4.57	0.61	0.00	5.18
Atlantic Seabob	0.00	0.44	0.00	0.44
Libinia Spider Crabs	0.00	2.85	0.00	2.85
Blue Crab	0.00	388.22	0.00	388.22
Portunus Crabs	0.00	557.63	0.00	557.63
Mantis Shrimp	3.75	1,390.65	0.00	1,394.40
Atlantic Sharpnose Shark	0.00	13.88	0.00	13.88
Atlantic Stingray	0.00	119.04	0.00	119.04
Smooth Butterfly Ray	0.00	51.77	0.00	51.77
Cownose Ray	0.00	7.87	0.00	7.87
Herrings	0.00	0.17	0.00	0.17
Atlantic Menhaden	4.15	164.88	0.00	169.03
Atlantic Thread Herring	2.47	64.28	0.00	66.75
Anchovies	0.00	45.38	0.00	45.38
Bay Anchovy	0.00	0.44	0.00	0.44
Inshore Lizardfish	0.00	147.82	0.00	147.82
Oyster Toadfish	0.00	2.12	0.00	2.12
Searobins	0.00	27.75	0.00	27.75
Bluefish	0.00	20.84	0.00	20.84
African Pompano	0.00	0.38	0.00	0.38
Atlantic Bumper	0.00	0.07	0.00	0.07
Lookdown	0.00	6.80	0.00	6.80
Pigfish	0.00	6.01	0.00	6.01
Pinfish	0.00	244.34	0.00	244.34
Silver Seatrout	1.55	64.00	0.00	65.55
Weakfish	0.00	15.43	1,006.39	1,021.82
Silver Perch	0.00	43.62	0.00	43.62
Spot	0.00	4,360.09	0.00	4,360.09
Banded Drum	0.00	21.16	0.00	21.16
Southern Kingfish	53.16	43.46	0.00	96.62
Northern Kingfish	2.08	0.72	0.00	2.80
Atlantic Croaker	0.00	11,706.97	0.00	11,706.97
Atlantic Spadefish	37.83	76.72	0.00	114.55
Combtooth Blennies	0.00	1.01	0.00	1.01
Atlantic Cutlassfish	0.00	51.16	0.00	51.16
Spanish Mackerel	0.00	0.00	6.19	6.19
Cero	0.00	0.60	0.00	0.60
Butterfish	0.00	44.24	0.00	44.24
Harvestfish	0.17	149.94	0.00	150.10
Bay Whiff	0.00	105.36	0.00	105.36
Summer Flounder	8.96	0.00	216.45	225.41
Gulf Flounder	0.00	0.00	0.66	0.66
Southern Flounder	0.00	0.00	65.60	65.60
Ocellated Flounder	0.00	4.58	0.00	4.58
Hogchoker	0.00	146.82	0.00	146.82
Tonguefishes	0.00	35.00	0.00	35.00
Aluterus Filefishes	0.00	20.84	0.00	20.84
Smooth Puffer	0.00	0.77	0.00	0.77
Northern Puffer	0.00	0.12	0.00	0.12
Striped Burrfish	0.00	43.33	0.00	43.33

Table 12. Tabulation of sampled catch and discards by weight (kg) and species status (kept, unmarketable, regulatory discards) in four seamed nets in the commercial shrimp trawl fishery in Pamlico Sound and its tributaries, North Carolina, 1 July 2009 to 31 December 2009.

Species	Fish Kept	Unmarketable	Regulatory Discard	Total
Rubbish	0.00	108.00	0.00	108.00
Miscellaneous	0.00	1,513.35	0.00	1,513.35
Jellyfish	0.00	23.71	0.00	23.71
Blood Ark	0.00	13.40	0.00	13.40
Atlantic Brief Squid	0.00	600.32	0.00	600.32
Brown Shrimp	5,092.50	136.21	0.00	5,228.71
Pink Shrimp	408.24	0.00	0.00	408.24
White Shrimp	5.69	0.00	0.00	5.69
Swimming Crabs	0.00	63.25	0.00	63.25
Blue Crab	0.00	513.48	0.00	513.48
Lesser Blue Crab	0.00	12.98	0.00	12.98
Portunus Crabs	9.61	264.77	0.00	274.38
Mantis Shrimp	0.00	761.19	0.00	761.19
Atlantic Stingray	0.00	17.87	0.00	17.87
Butterfly Rays	0.00	21.99	0.00	21.99
Cownose Ray	0.00	6.58	0.00	6.58
Eels	0.00	6.40	0.00	6.40
American Eel	0.00	8.95	0.00	8.95
Atlantic Menhaden	0.00	391.05	0.00	391.05
Threadfin Shad	0.00	41.83	0.00	41.83
Atlantic Thread Herring	0.00	137.77	0.00	137.77
Anchovies	0.00	50.72	0.00	50.72
Inshore Lizardfish	0.00	343.55	0.00	343.55
Oyster Toadfish	0.00	1.09	0.00	1.09
Searobins	0.00	9.51	0.00	9.51
Bluefish	0.00	39.86	0.00	39.86
Crevalle Jack	0.00	0.05	0.00	0.05
Lookdown	0.00	11.80	0.00	11.80
Florida Pompano	0.00	0.05	0.00	0.05
Pigfish	0.00	18.42	0.00	18.42
Pinfish	0.00	156.56	0.00	156.56
Weakfish	0.00	0.00	2,273.52	2,273.52
Silver Perch	0.00	31.28	0.00	31.28
Spot	61.72	2,364.95	0.00	2,426.67
Banded Drum	0.00	3.88	0.00	3.88
Southern Kingfish	167.90	137.39	0.00	305.29
Atlantic Croaker	0.00	6,142.86	0.00	6,142.86
Atlantic Spadefish	0.00	146.67	0.00	146.67
Atlantic Cutlassfish	0.00	273.83	0.00	273.83
Spanish Mackerel	28.58	0.00	51.59	80.16
Cero	0.00	1.97	0.00	1.97
Butterfish	0.00	76.40	0.00	76.40
Harvestfish	0.00	57.85	0.00	57.85
Horned Whiff	0.00	4.72	0.00	4.72
Bay Whiff	0.00	37.95	0.00	37.95
Summer Flounder	0.00	0.00	151.64	151.64
Southern Flounder	14.34	0.00	63.95	78.29
Windowpane	0.00	0.25	0.00	0.25
Hogchoker	0.00	42.10	0.00	42.10
Tonguefishes	0.00	53.26	0.00	53.26
Aluterus Filefishes	0.00	15.03	0.00	15.03

Table 13. Tabulation of sampled catch and discards by weight (kg) and species status (kept, unmarketable, regulatory discards) in tongue nets in the commercial shrimp trawl fishery in Pamlico Sound, North Carolina, 1 July 2009 to 31 December 2009.

Species	Unmarketable	Fish Kept	Regulatory Discard	Total
Rubbish	23.23	0.00	0.00	23.23
Miscellaneous	336.22	0.00	0.00	336.22
Jellyfish	426.56	0.00	0.00	426.56
Atlantic Brief Squid	57.16	0.00	0.00	57.16
Brown Shrimp	0.00	18.22	0.00	18.22
Pink Shrimp	0.00	34.54	0.00	34.54
White Shrimp	0.00	330.70	0.00	330.70
Hermit Crabs	0.78	0.00	0.00	0.78
Libinia Spider Crabs	4.25	0.00	0.00	4.25
Blue Crab	8.18	0.00	0.00	8.18
Portunus Crabs	10.09	0.00	0.00	10.09
Mantis Shrimp	127.16	0.38	0.00	127.53
Atlantic Menhaden	84.28	0.00	0.00	84.28
Atlantic Thread Herring	39.25	0.00	0.00	39.25
Anchovies	15.30	0.00	0.00	15.30
Inshore Lizardfish	26.25	0.00	0.00	26.25
Searobins	1.16	0.00	0.00	1.16
Bluefish	1.45	0.00	0.00	1.45
Atlantic Bumper	1.58	0.00	0.00	1.58
Lookdown	0.71	0.00	0.00	0.71
Pigfish	6.18	0.00	0.00	6.18
Pinfish	4.81	0.00	0.00	4.81
Spotted Seatrout	0.00	0.00	9.57	9.57
Weakfish	0.00	32.82	202.01	234.83
Silver Perch	12.08	0.00	0.00	12.08
Spot	241.88	0.00	0.00	241.88
Banded Drum	0.05	0.00	0.00	0.05
Southern Kingfish	7.61	23.96	0.81	32.38
Atlantic Croaker	517.38	0.00	0.00	517.38
Atlantic Spadefish	8.13	0.00	0.00	8.13
Spanish Mackerel	0.00	0.00	2.83	2.83
Harvestfish	6.69	0.00	0.00	6.69
Bay Whiff	8.23	0.00	0.00	8.23
Summer Flounder	0.00	0.00	20.96	20.96
Southern Flounder	0.00	0.00	3.10	3.10
Tonguefishes	2.25	0.00	0.00	2.25
Aluterus Filefishes	1.84	0.00	0.00	1.84
Northern Puffer	2.33	0.00	0.00	2.33

SEA BIRD AND PROTECTED SPECIES BYCATCH

There was no sea bird bycatch observed in the commercial shrimp trawl fishery throughout the study. However, there were always numerous sea birds of several unrecorded species present. Likewise, no marine mammal takes were observed in the commercial shrimp trawl fishery during the study. There were no observed sea turtle interactions observed during this study.

DISCUSSION

Worldwide fishery observers monitor and record catch data on commercial fishing activity. The data are used to supplement research and aid in the management of living marine resources. Observers may collect data on species composition of the catch, weights of fish caught, disposition of landed species and protected species interactions. Fishing locations and fishing effort are also important data for managing fisheries. In some fisheries, observers provide valuable assistance to researchers with tagging projects involving sharks, and even some species of sea turtles. Observer programs often are responsible for collecting the largest part of fisheries management data. The first hand information supplied by observers to fisheries managers on protected species interactions with fishing activities provides excellent information to help sustain and rebuild some populations of protected species (French et. al 1982).

The purpose of this project was to identify and characterize effort, catch, and bycatch in commercial shrimp trawl fisheries in Pamlico Sound and its tributaries of North Carolina. This project identified and observed three net types (double seamed, four seamed and tongue nets) and observed trips during the summer and fall. Double seamed and four seamed nets are used primarily to target brown shrimp in the spring and early summer. Tongue nets fish higher in the water column and are used primarily to target white shrimp in the late summer and fall.

Bycatch and discard mortality estimates are important issues in fisheries management. There were no discard mortality estimates obtained from this study, however due to tow times and predation from birds, sharks, and dolphins the discard mortality is assumed to be high for finfish.

The three commercially important species of shrimp represented 23% of the catch by weight for all net types combined, compared to 54% seen in a similar study conducted in the estuarine waters of North Carolina (Logothetis and McCuiston 2005) and 21% in a study conducted in the near shore waters of southeastern North Carolina (Brown 2009). Atlantic croaker accounted for approximately 33% of the catch by weight (Table 5) for all net types combined and represented the largest bycatch. The stock status of Atlantic croaker is considered viable and the population in the mid-Atlantic region is currently not overfished and overfishing is not occurring based on the Atlantic States Marine Fisheries Commission assessment (ASMFC 2009). Spot and weakfish were the second and third most abundant finfish bycatch by weight in the commercial shrimp trawl fishery, accounting for approximately 13% and 6% of the catch by weight for all net types combined, respectively. The bycatch of other commercially and recreationally important species was relatively low. Flounder (Gulf, southern, and summer flounders combined), kingfishes and spotted sea trout represented approximately 0.97%, 0.79% and 0.02% of the catch by weight for all net types combined (Table 5). Weakfish represented the largest regulatory discard in all three net types, accounting for approximately 85% of all regulatory discards by weight. Length frequency distributions of these species indicate that the majority of these fish are undersized.

The importance of characterization studies cannot be overstated. The results of this study provide effort, catch, and discard information that can be used in current and future stock assessments and management decisions in trawl fisheries throughout North Carolina.

CONCLUSION

This study characterized the commercial shrimp trawl fishery in Pamlico Sound and its tributaries of North Carolina. This fishery encompasses double seamed nets, four seamed nets and tongue nets. The observed targeted species varied seasonally based on the availability of the target species. Specifically, this program quantified species composition, effort, CPUE and bycatch of federally managed species of finfish. Further observations of commercial shrimp trawl effort and other fisheries are needed to accurately quantify effort, catch, and discards throughout commercial fisheries in North Carolina. This information will assist in the development of fishery management plans and maintaining sustainable stocks.

RECOMMENDATIONS

- Expand the scientific observer coverage in commercial shrimp trawl fisheries to encompass all seasons and areas.
- Establish a long-term scientific observer program throughout North Carolina commercial fisheries.
- Require mandatory observer coverage in North Carolina commercial fisheries.
- Generate better lines of communication between fishery managers and the commercial fishing industry. This will increase understanding and allow the increased incorporation of commercial knowledge into fishery management.
- Work with the commercial fishing industry and fishery managers to develop gear or trawling methods to reduce bycatch.

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