Validation of North Carolina Commercial Finfish and Shellfish Conversion Factors

North Carolina Department of
Environment and Natural Resource
Division of Marine Fisheries
Morehead City, NC 28557

Validation of North Carolina Commercial Finfish and Shellfish Conversion Factors

Prepared by

Alan Bianchi

for the

North Carolina Division of Marine Fisheries

March 2013

Final Performance Report for
National Marine Fisheries Service
Atlantic Coastal Cooperative Statistics Program
Grant Award NA11NMF4740036
Grant Period: July 2011 to December 2012

North Carolina Division of Marine Fisheries
License and Statistics Section
P.O. Box 769
3441 Arendell Street
Morehead City, NC 28557

ABSTRACT

In 2010, a pilot study was conducted by the North Carolina Division of Marine Fisheries Trip Ticket Program (NCTTP) to evaluate and validate the conversion factors used by the program. Conversion factors are typically used to convert landings of finfish and shellfish into whole pounds or pounds of meat when the commercial harvest is landed in processed form or in differing marketing units (such as bushels). Preliminary results indicated that the conversion factors employed needed to be further evaluated and updated. In 2011, the NCTTP received funding from the Atlantic Coastal Cooperative Statistics Program (ACCSP) to continue its conversion factor project. The data gathered from this study were combined with those from the pilot study and analyzed with simple and multiple regression analyses. During this study, 6,113 samples were obtained from 55 different species. Species sampled were mainly from the snapper-grouper complex, coastal pelagics and shellfish. The results of this study indicate that some of the conversion factors used by the NCTTP need to be updated and may not be reflecting the true relationship between whole pounds and landed pounds. More detailed work and an expansion in sampling will be needed to do a complete review of the conversion factors used by the NCTTP. The data gathered from this study also needs to be combined with those from other ACCSP partner states to determine trends on a regional basis.

ACKNOWLEDGEMENTS

The completion of this report could not have been accomplished without the dedication to gathering samples from the technicians hired for this project and pilot project. I wish to thank Bryan Pearson, Vicky Thayer, and Karen Sayles-Altman for their hard work! I also wish to thank Holly White and Lee Paramore, as well as all of the observers who participated in the blueline tilefish exempted fishing permit observer program, in obtaining blueline tilefish samples for this project. I wish to thank all of the North Carolina Division of Marine Fisheries Trip Ticket staff for their diligent and excellent work.

Many other individuals and sections within the Division of Marine Fisheries have contributed to the success of the Trip Ticket Program and the collection and dissemination of commercial fisheries statistics including Marine Patrol, Licenses, Fisheries Management, Resource Enhancement, and Information Technology. I would like to give special thanks to Randy Gregory, Kevin Aman, and Dan Zapf of NCDMF Aging Program for assisting in the collection of samples. I want to thank all of North Carolina's commercial and recreational fishermen, seafood dealers, and the Oregon Inlet Fishing center for helping us obtain samples. Special thanks go out to Kenny Fex, Tatum's Seafood, Motts Channel Seafood, Joe Hifko and the Crab Ranch for allowing us to sample their operations. I would like to thank the late Captain Bill Brown for assisting us in obtaining samples from the Oregon Inlet Fishing Center. Thanks also go out to the numerous governor's cup and king mackerel tournament organizers for allowing us to obtain samples.

I would also like to thank Dr. Fred Scharf and his lab (Steve Poland, Steve Vanderfleet, and Megan Davis), students and volunteers from the Cape Fear Community College Marine technology program, Ben Gahagan at the University of Maryland with help collecting bluefin tuna samples, and all other volunteers.

I would also like to thank those people who reviewed drafts of this report: Don Hesselman, Craig Hardy, Jim Francesconi, Dee Lupton, Stephen Taylor, Michelle Duval, Holly White, Mike Loeffler, Tina Moore, Lynn Henry, Kelly Price, Jason Rock, and Tom Wadsworth.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The North Carolina Division of Marine Fisheries Trip Ticket Program (NCTTP) began on 1 January 1994 (Lupton and Phalen 1996). Prior to the implementation of the NCTTP, commercial statistics and harvest data were collected under the National Marine Fisheries Service (NMFS)/North Carolina Cooperative Statistics Program (NCCSP) (Sabo 2001; Lupton and Phalen 1996). The NCTTP was initiated due to a decrease in cooperation in reporting under the voluntary NMFS/NCCSP in place prior to 1994, as well as an increase in demand for complete and accurate trip-level commercial harvest statistics by fisheries managers (Lupton and Phalen 1996; Watterson 1999; Sabo 2001). The detailed data obtained through the NCTTP allow for the calculation of effort (i.e. trips, licenses, fishermen, vessels) in a given fishery that was not available prior to 1994 and provide a more accurate record of North Carolina's commercial seafood harvest.

A large portion of the state's commercial fishery harvest is processed at sea (such as gutting or heading) or uses other units of measure (such as bushels, bags, or baskets) instead of reporting by poundage. Conversion factors are commonly applied to commercially landed units of finfish and shellfish to determine the whole weight of commercially harvested finfish or shellfish by poundage. The conversion factors the NCTTP currently employ were those historically provided by NMFS (Hesselman and Kemp 2006). It has also been noted that conversion factors vary across different states (Hesselman and Kemp 2006). However, these conversion factors have not been evaluated or validated since the early 1980s in North Carolina and only limited documentation can be found (NMFS 1990).

Commercial landings data are extremely valuable to help describe the trends in a commercial fishery and for use in state and regional stock assessments. Accurate conversion factors are needed to determine the total amount of fish and shellfish landed so that the fishery can be described and assessed as accurately as possible. Conversion factors likely vary over time as the health of fish and shellfish stock changes. Likewise, conversion factors may vary seasonally (spawning seasons, months of high food abundance, etc.) and between sexes. Currently, no documentation exists to help describe the changes or differences in conversion factors over time, seasonally, between sexes, or regionally.

In July 2008, the NCTTP used funds received through a Atlantic Coastal Fisheries Cooperative Management Act grant (NOAA grant award NA05NMF4741103) for a pilot study to evaluate the conversion factors that are currently used by the program. The pilot study had two primary objectives: 1) evaluate and validate the conversion factors currently employed by the NCTTP, and 2) update current documentation on conversion factors used by the NCTTP. Results of the pilot study indicated that the conversion factors currently used by the NCTTP need to be further evaluated. The results of the pilot study showed updates are needed for some species while those for other species were validated (Bianchi 2010).

The Atlantic Coastal Cooperative Statistics Program (ACCSP) Commercial Technical Committee (Com Tech) recognized the need for validating and updating conversion factors across the Atlantic states. The ACCSP Com Tech submitted a proposal in 2010 to the ACCSP and received funds in fiscal year 2011 to conduct a regional conversion factor validation study. The funds were granted to Rhode Island, North Carolina, South Carolina, Georgia, Florida, NMFS Southeast Fisheries Science Center, and NMFS Northeast Fisheries Science Center to conduct their own independent analysis on the species and fisheries where validation was needed the most.

This study focused on obtaining samples from two primary groups: finfish that are typically processed at sea before being landed (including species from the snapper-grouper complex, coastal migratory pelagics, swordfish (*Xiphias gladius*), tunas and sharks, and shellfish species that are typically marketed in bags, bushels, or numbers such as hard clams (*Mercenaria mercenaria*), oysters (*Crassostrea virginica*), blue crabs (*Callinectes sapidus*) and sea urchins (*Arbacia punctulata*).

The North Carolina study had three primary goals:

1) Expand on the NC pilot conversion factor study;

2) Determine what factors significantly affect conversion factors; and

3) Continue to evaluate the current conversion factors used by the NCTTP.

METHODS

SAMPLING

In December 2011, a technician was hired to collect samples of fish and shellfish for this project and was responsible for coordinating sampling efforts with commercial fishermen and seafood dealers. To help the technician coordinate these activities, trip ticket data were analyzed by species and area to determine when selected species were typically harvested and in what counties they were landed. Trip ticket data were also analyzed on a seafood dealer and commercial fisherman basis to assist the technician in coordinating sampling efforts. From these data, the technician contacted commercial fishermen and seafood dealers to schedule dates and times for sampling. The technician would then meet the commercial fishermen at the docks to obtain as many whole samples of fish as possible which were then weighed and measured, processed according to industry standards, and weighed and measured again by the technician.

Samples were also obtained from charter boats, tournaments, and private recreational fisheries sectors. The technician would make weekly calls to the Oregon Inlet Fishing Center to determine charter boat activity for that week. Tournament organizers were also contacted to help coordinate sampling efforts as well as recreational fishermen who were targeting the species of interest for this study. Samples collected from these fisheries were also processed and recorded in the same manner as those collected from commercial fishermen.

Samples of blueline tilefish (*Caulolatilus microps*) and snowy grouper (*Epinephelus niveatus*) were also obtained by DMF staff in the northern district office in Manteo, NC through observer trips as part of an exempted fishing permit issued by the South Atlantic Fisheries Management Council that allowed a limited number of commercial fishing vessels to operate within the proposed deep water closure area in 2012.

Other staff from the NCTTP and other sections of North Carolina Division of Marine Fisheries (DMF), students from Cape Fear Technical College, and students from the University of North Carolina at Wilmington also assisted in data collection efforts.

Finfish were weighed whole to the nearest 0.01 kg on a digital scale, gutted according to industry standards, and then weighed again. Each weight was recorded along with the sex of the specimen. The total length (measured from the tip of the snout to the tip of the tail, mm), fork length (measured from the tip of the snout to the fork of the tail, mm), and standard length (measured from the tip of the snout to the peduncle of the tail, mm) for all fish were measured to the nearest mm whenever possible (some fish do not have forked tails).

For shellfish species, bushels or bags of oysters/clams were purchased from various dealers located throughout the state and brought back to DMF to determine pounds of meat per bushel/bag. Bags of hard clams were separated by size/market grade, individuals counted, shell length measured with digital calipers to the nearest mm. Bushels of oysters were counted and shell length measured with digital calipers to the nearest mm. The individual whole weight (shell and meat weight) was measured for all hard clams and oysters. Hard clams and oysters were then "shocked" by being placed inside a freezer for approximately ten minutes, shucked, drained and then the meat weight measured to the nearest gram. Peeler blue crabs were sampled from blue crab shedding operations and were counted, carapace width measured, and weighed. Sea urchins were counted and weighed individually to the nearest kg.

All data were recorded on customized field data sheets and then transferred to standardized coding sheets to be entered into the DMF biological database for analysis.

STATISTICAL ANALYSIS

The target sample size for all finfish species was set at 200, which was based on the results from the pilot study in 2010. The target sample size for shellfish species varied based on the species (molluscan shellfish was set at six bushels/bags per size category, 200 blue crabs per condition, five gallons of shucked shellfish meat, and 500 scallops). SAS® data management and analysis software was used to access and analyze these data (SAS® 2004). Proc GLM was used to run simple linear regressions on these data to determine the relationships between gutted weight and whole weight and other biological parameters. Multiple linear regression analysis and contrast statements in Proc GLM was also used to test for significant differences between the slopes of different levels of interaction effects of gutted weight and other parameters (gender, size, species, etc.). Microsoft Excel© was used to organize and summarize these data and to generate the graphics presented in this report.

Finfish Analysis

The sampling target of 200 was only reached for a few species due to variability in availability [Table 1; (fishery closures, holidays, decreased fishing effort, etc.] Therefore, all species that had a sample size of at least 30 across the pilot study and the current study were analyzed with a simple regression to determine the relationship between whole weight and gutted weight of finfish. The gutted weight to whole weight relationship was expressed with the following equation:

$$WW = x\,(GW) + b$$

where WW is the whole weight, x is the slope of the regression, GW gutted weight, and b is the intercept.

Gutted weight to whole weight conversions were determined by using the equations that were calculated from the simple regression analyses and by forcing the regression analysis to pass through the origin. By forcing the regression analysis to go through the origin, it is assumed that when the whole weight of an animal is zero that the gutted weight of the animal is also zero and the gutted weight to whole weight conversion is then the slope of the regression, (x).

Simple linear regression analyses were also used to determine the relationship between other biological parameters, including the following: fork length to total length ($TL = x (FL) + b$), standard length to total length ($TL = x (SL) + b$), and standard length to fork length ($FL = x (SL) + b$), where TL equals total length, FL equals fork length, and SL equals standard length and L equals primary length (length measurement typically used to describe the species). For these relationships, the intercepts were maintained (i.e., regressions were not forced through the origin).

The relationship between length and whole weight was also analyzed. To determine the relationship between length and whole weight, the data were log transformed. Simple linear regression was used to determine the relationship between ln(WW) and ln(L) with the following equation:

$$\ln(WW) = (\ln(a) + (b(\ln(L))$$

where ln(WW) equals natural log of whole weight, ln(L) equals natural log of the primary length (length measurement typically used to describe the species), a is the intercept, and b is the slope of the regression, and L equals the primary length.

The resulting equation was then recalculated to determine the non-linear relationship between length and weight ($WW=a*L^b$).

A multiple linear regression was used to determine the effects of season, location (county was used as a proxy for area of harvest), species, and gender on whole weight. Season was defined as Winter (Jan-March), Spring (April-June), Summer (July-September), and Fall (October-December). A separate multiple linear regression was conducted for each of these effects with the following equation:

$$WW=x(GW) + y(Effect)+ z(GW*Effect) + b$$

where WW is the whole weight, x is slope/regression coefficient for gutted weight, GW is the gutted weight, y is the slope/regression coefficient for the other main effect being analyzed, z is the slope/regression coefficient of the interaction of the gutted weight and other main effect and b is the intercept.

A Proc GLM contrast statement was then used to determine if there are significant differences in the slope for the different levels of the interaction term.

Shellfish Analysis

Conversions were then calculated for average meat weight of hard clams by size/market grade and meat weight of oysters per bushel and then compared to conversions currently used by the NCTTP. The total number of crabs per pound, for both soft and peeler crabs was then calculated and compared to the current conversion factor used by the NCTTP. Similar to the finfish analysis, the relationship between carapace width and weight was analyzed by log transforming the data. A simple regression analysis was used to determine the relationship between ln(CW) and ln(W) for soft and peeler crabs using the equation $\ln(W) = a + b(\ln(CW))$ where W equals weight, b equals the slope of the regression, CW equals carapace width, and a equals the intercept. The resulting equation was then recalculated to determine the non-linear relationship between carapace width and weight ($W = a * CW^b$).

DEVIATIONS

The sampling targets for many of the species in the highly migratory complex (swordfish, large tunas, coastal sharks) and those rare species in the snapper grouper complex were not obtained because of difficulties in accessibility to those fish species and in difficulties in coordinating sampling times with participants who operate in those fisheries. We also weren't able to collect samples of horseshoe crabs, whelks, and other shellfish that all have conversion factors that need to be evaluated and validated.

RESULTS

Fifty different species were sampled from December 2011 through November 2012 (n=2,811). Over 89% of the total number of samples collected were from: oysters vermilion snapper (*Rhomboplites aurorubens*), gag grouper (*Mycteroperca microlepis*), red grouper (*Epinephelus morio*), king mackerel (*Scomberomorus cavalla*), scamp (*M. phenax*), dolphin (*Coryphaena hippurus*), yellowfin tuna (*Thunnus albacores*), blueline tilefish wahoo (*Acanthocybium solandri*), rock hind (*E. adscensionis*), peeler blue crabs and squirrelfish (*Holocentrus adscensionis*). These samples were combined with those collected prior to December 2011for a total 6,113 samples across 55 different species (Table 1).

Sampling occurred in the coastal fishing counties of North Carolina which are grouped into three districts (Figure 1). During the project period, samples were collected from all three districts, with the majority of samples from the southern district. The southern district accounted for 76% of the total number of samples. Samples were collected across seven counties: Beaufort, Brunswick, Carteret, Dare, New Hanover, Pender, and Onslow. The majority of the samples were obtained from New Hanover and Brunswick counties, which accounted for 66% of the total samples. Samples collected prior to December 2011 were mostly from the Central and Southern districts and mostly from Carteret and Brunswick counties (Tables 2 and 3).

Samples were collected from six primary gear types: hand harvest gears (rakes, tongs, etc.), handline gears (trolling, rod-n-reel, bandit, etc.), peeler pot, oyster dredge, spear guns, and longlines. Hand harvest gears and handline (bandit, rod-n-reel) gears comprised 87% of the samples (Table 4).

Table 1. Total number of fish and shellfish sampled by year, 2008-2012.

Species Common Name	Scientific Name	2008	2009	2010	2011	2012	Total
Eastern oyster	*Crassostrea virginica*	0	1,258	0	0	839	2,097
Vermilion snapper	*Rhomboplites aurorubens*	0	399	2	0	393	794
Bay scallop	*Argopecten irradians*	0	445	0	0	0	445
Gag	*Mycteroperca microlepis*	11	83	0	6	292	392
Hard clams	*Mercenaria mercenaria*	0	357	0	0	5	362
Blue crab, soft	*Callinectes sapidus*	0	308	0	0	0	308
Red grouper	*Epinephelus morio*	0	150	0	11	129	290
King mackerel	*Scomberomorus cavalla*	4	57	0	7	215	283
Scamp	*Mycteroperca phenax*	0	32	0	8	114	154
Dolphin	*Coryphaena hippurus*	0	12	0	0	121	133
Yellowfin tuna	*Thunnus albacares*	0	1	0	0	123	124
Rock hind	*Epinephelus adscensionis*	0	31	0	1	60	92
Blueline tilefish	*Caulolatilus microps*	0	0	0	0	92	92
Blue crab, peeler	*Callinectes sapidus*	0	45	0	0	32	77
Wahoo	*Acanthocybium solandri*	0	0	0	0	63	63
Squirrelfish	*Holocentrus adscensionis*	0	0	0	0	38	38
Red hind	*Epinephelus guttatus*	0	5	0	0	29	34
Spanish mackerel	*Scomberomorus maculatus*	0	0	0	0	33	33
Atlantic purple sea urchin	*Arbacia punctulata*	0	0	0	0	31	31
Hogfish	*Lachnolaimus maximus*	0	3	0	2	26	31
Almaco jack	*Seriola rivoliana*	0	3	0	0	23	26
Red porgy	*Pagrus pagrus*	0	0	7	8	11	26
Graysby	*Epinephelus cruentatus*	0	4	0	0	18	22
Cobia	*Rachycentron canadum*	0	6	0	2	13	21
Blackfin tuna	*Thunnus atlanticus*	0	2	0	0	18	20
Little tunny	*Euthynnus alletteratus*	0	1	0	1	13	15
Creole-fish	*Paranthias furcifer*	0	0	0	0	12	12
Coney	*Epinephelus fulvus*	0	2	0	0	8	10
Greater amberjack	*Seriola dumerili*	2	5	0	1	2	10
Snowy grouper	*Epinephelus niveatus*	0	1	0	0	6	7
Black grouper	*Mycteroperca bonaci*	0	7	0	0	0	7
Spotfin hogfish	*Bodianus pulchellus*	0	0	0	0	7	7
Red snapper	*Lutjanus campechanus*	0	4	1	0	1	6
Grunts	Haemulidae	0	0	0	5	0	5
Black sea bass	*Centropristis striata*	0	0	4	0	0	4
Yellowfin grouper	*Mycteroperca venenosa*	0	0	0	0	4	4
Blackfin snapper	*Lutjanus buccanella*	0	0	0	0	4	4
Silk snapper	*Lutjanus vivanus*	0	0	0	0	4	4

Table 1 (continued). Total number of fish and shellfish sampled by year, 2008 -2012.

Species	Scientific Name	2008	2009	2010	2011	2012	Total
Unclassified tuna	*Thunnus* spp.	0	0	0	0	4	4
Gray triggerfish	*Balistes capriscus*	0	0	0	0	4	4
Yellowmouth grouper	*Mycteroperca interstitialis*	0	0	0	0	3	3
Swordfish	*Xiphias gladius*	0	2	0	0	1	3
African pompano	*Alectis ciliaris*	0	0	0	0	2	2
Bluefin tuna	*Thunnus thynnus*	0	0	0	0	2	2
Bigeye tuna	*Thunnus obesus*	0	0	0	0	2	2
Bigeye	*Priacanthus arenatus*	0	0	0	0	1	1
Glasseye snapper	*Priacanthus cruentatus*	0	1	0	0	0	1
Bluefish	*Pomatomus saltatrix*	0	0	0	0	1	1
Gray snapper	*Lutjanus griseus*	0	0	0	0	1	1
Mutton snapper	*Lutjanus analis*	0	0	0	0	1	1
Knobbed porgy	*Calamus nodosus*	0	0	0	1	0	1
Atlantic pomfret	*Brama brama*	0	0	0	0	1	1
Yellowcheek wrasse	*Halichoeres cyanocephalus*	0	0	0	0	1	1
Escolar	*Lepidocybium flavobrunneum*	0	0	0	0	1	1
Albacore	*Thunnus alalunga*	0	0	0	0	1	1
Total		55	3,224	14	53	2,805	6,113

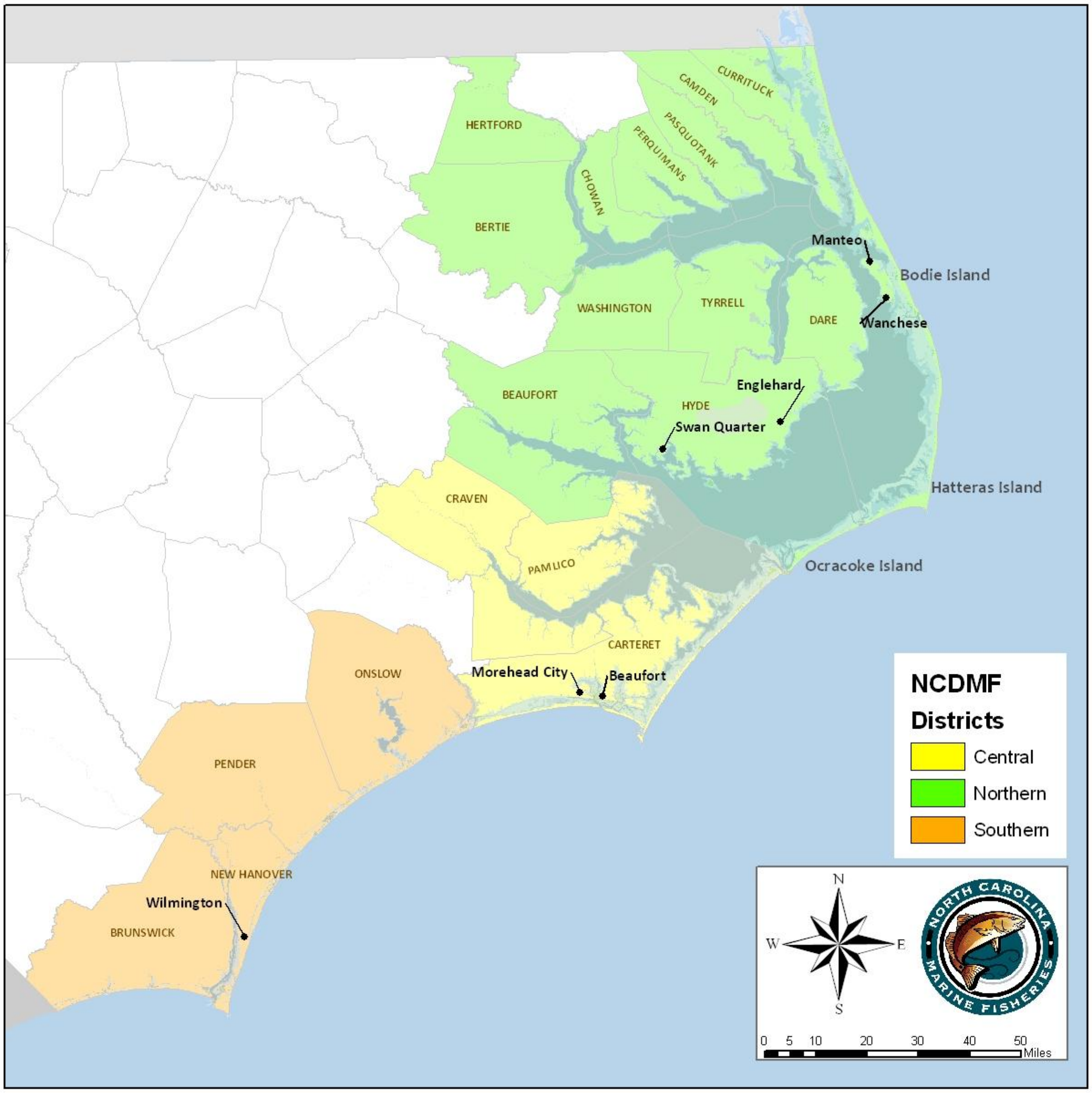

Figure 1. Map of the study area showing the North Carolina coastal fishing counties grouped into three districts.

Table 2. Total number of samples collected by district and county, 2008-2010 and 2011-2012.

2008-2010

District	Beaufort	Brunswick	Carteret	Dare	Hyde	New Hanover	Onslow	Pender	Total
Central	0	0	1,899	0	0	0	0	0	1,899
Northern	67	0	0	1	262	0	0	0	330
Southern	0	986	0	0	0	0	40	0	1,026
Total	67	986	1,899	1	262	0	40	0	3,255

2011-2012

District	Beaufort	Brunswick	Carteret	Dare	Hyde	New Hanover	Onslow	Pender	Total
Central	0	0	355	0	0	0	0	0	355
Northern	32	0	0	286	0	0	0	0	318
Southern	0	972	0	0	0	913	166	134	2,185
Total	32	972	355	286	0	913	166	134	2,858

Table 3. Total number of samples collected by county and species of analysis, 2008-2012.

Species	Beaufort	Brunswick	Carteret	Dare	Hyde	New Hanover	Onslow	Pender
Vermilion snapper	0	694	100	0	0	0	0	0
Gag grouper	0	52	86	0	0	50	91	113
Red grouper	0	135	116	0	0	23	0	16
King Mackerel	0	57	43	0	0	90	93	0
Scamp	0	144	3	0	0	7	0	0
Dolphin	0	11	64	16	0	42	0	0
Yellowfin Tuna	0	0	2	122	0	0	0	0
Rock hind	0	92	0	0	0	0	0	0
Blueline Tilefish	0	0	0	92	0	0	0	0
Wahoo	0	0	29	28	0	6	0	0
Squirrelfish	0	38	0	0	0	0	0	0
Red hind	0	32	2	0	0	0	0	0
Spanish mackerel	0	18	0	0	0	13	0	0
Hogfish	0	0	13	0	0	2	18	0
Peeler blue crab	77	0	0	0	0	0	0	0
Oysters	0	559	662	0	262	614	0	0
Hard Clams	0	0	357	0	0	5	0	0
Atlantic Purple Sea Urchin	0	0	0	0	0	31	0	0

Table 4. Total number of samples collected by gear type, 2008-2012.

Gear	2008	2009	2010	2011	2012	Total
Hand Harvest	0	1,789	0	0	875	2,673
Handline (bandit, rod-n-reel)	17	807	14	53	1,766	2,657
Long Lines	0	4	0	0	89	93
Oyster Dredge	0	262	0	0	0	262
Peeler Pot	0	353	0	0	32	385
Spear Gun	0	0	0	0	43	43
Total	17	3,224	14	53	2,805	6,113

FINFISH RESULTS

Vermilion Snapper

The number of vermilion snapper sampled was 794 with the majority of the samples coming from Brunswick County [Table 3 (n=694)]. Fifty samples that were gathered on the same day were excluded from the analysis because those data were anomalous, indicating that there was a sampling issue on that day (e.g. calibration of the scale). Vermilion snapper were sampled across five different market grades, with the 0.5 to 1 pound and 1 to 2 pound market grades accounting for the 81% of the samples (Table 5). Vermilion snapper ranged from 250 mm to 500 mm fork length (Figure 2). The conversion factor for vermilion snapper calculated from this study was estimated to be 1.07 (Table 6 and Figures 3 and 4). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A1.

Multiple regression analysis indicated that the interaction effects of season*gutted weight (p-value = 0.0764), gender*gutted weight (p-value = 0.1861), market grade*gutted weight (p-value = 0.3731), and county*gutted weight (p-value = 0.1437) were all insignificant factors on whole weight. Figure A2 contains a scatter plot of the gutted weight and whole weight relationship by season, gender, market grade, and county.

Table 5. Number of samples of vermilion snapper by market grade.

Market Grade (lb)	Number
0.5 to 1	216
1 to 2	429
2 to 4	144
>4	3
Mixed	2

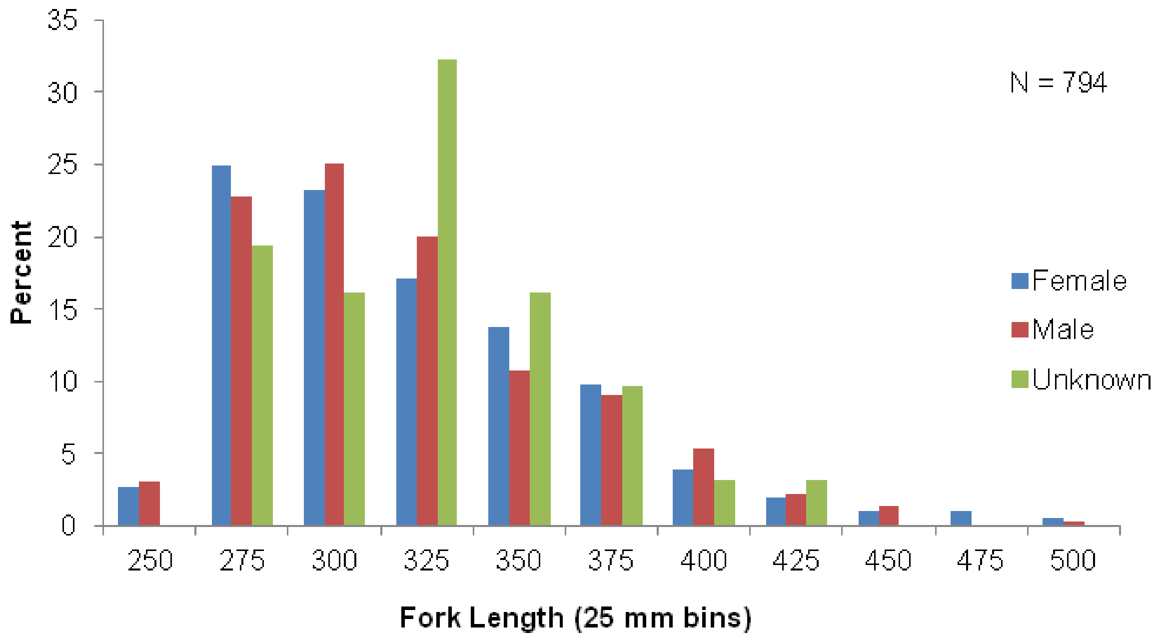

Figure 2. Length frequency (25 mm bins) for vermilion snapper.

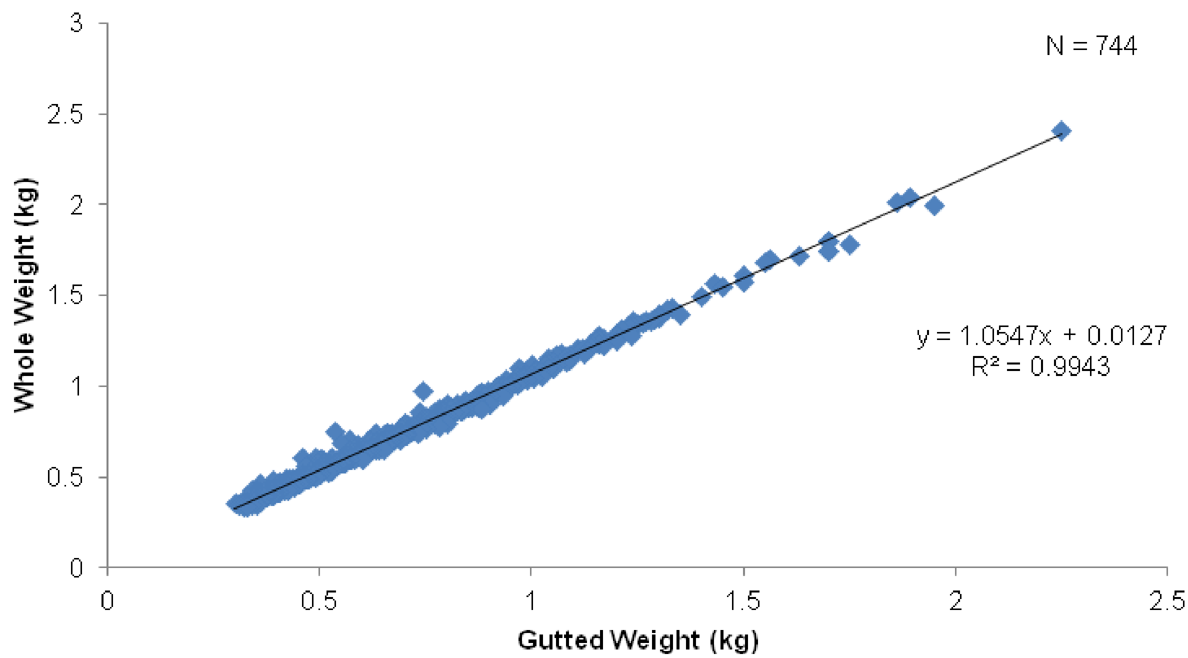

Figure 3. Gutted weight (kg) to whole weight (kg) relationship for vermilion snapper.

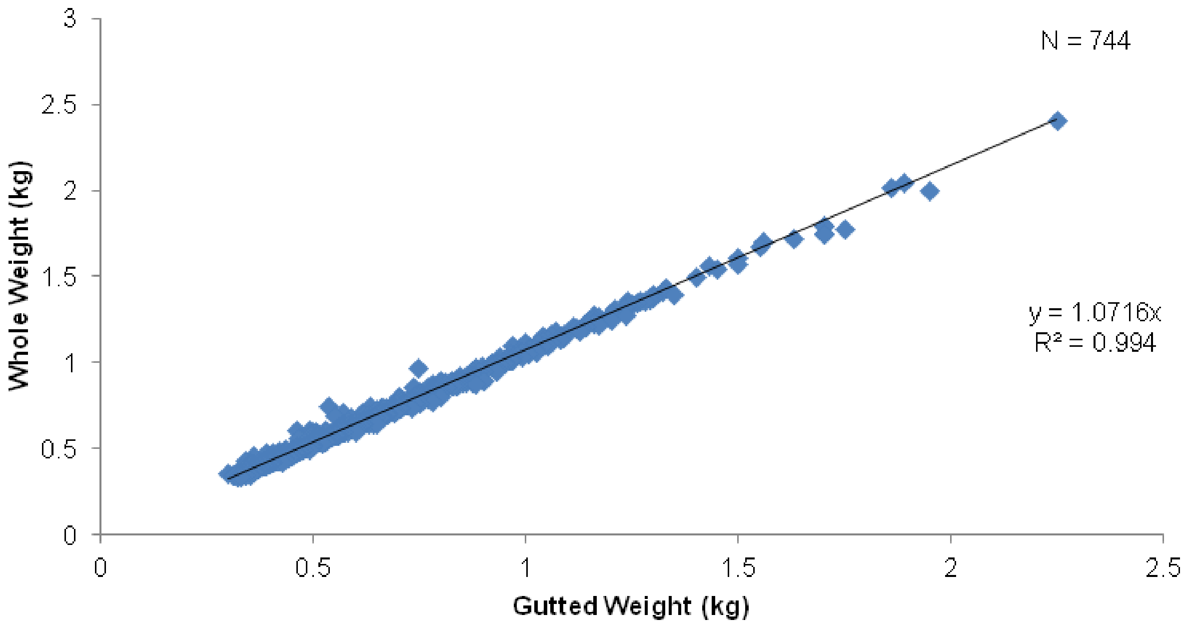

Figure 4. Gutted weight (kg) to whole weight (kg) relationship for vermilion snapper with intercept set at zero.

Table 6. Whole weight (kg) to gutted weight (kg) relationships for six main species of finfish, their calculated gutted to whole weight conversion (and the current conversion used by the NCTTP).

Species	WW= *x* (GW) + *b*	R^2	WW = x (GW)	Calculated conversion
Vermilion snapper	WW = 1.0491(GW) +0.0189	0.9881	WW = 1.077(GW)	1.08 (1.08)
Gag grouper	WW = 1.1031(GW) - 0.1514	0.9957	WW = 1.074(GW)	1.07 (1.25)
Red grouper	WW = 1.0436(GW) + 0.091	0.9962	WW = 1.0575(GW)	1.06 (1.25)
King mackerel	WW = 1.0693(GW) - 0.0378	0.9979	WW = 1.0657(GW)	1.07 (1.04)
Scamp	WW = 1.0395(GW) + 0.0388	0.9980	WW = 1.0499(GW)	1.05 (1.25)
Dolphin	WW = 1.0856(GW) + 0.1163	0.9950	WW = 1.1022(GW)	1.10 (1.04)
Yellowfin tuna	WW = 1.0654(GW) + 0.0914	0.9869	WW = 1.072(GW)	1.07 (1.25)
Rock hind	WW = 1.0583(GW) + 0.0003	0.9890	WW = 1.0586(GW)	1.06 (1.25)
Blueline tilefish	WW = 1.0368(GW) + 0.0785	0.9938	WW = 1.0686(GW)	1.07 (1.09)
Wahoo	WW = 1.0813(GW) - 0.1016	0.9958	WW = 1.0754(GW)	1.08 (1.04)
Squirrelfish	WW = 0.984(GW) + 0.0454	0.9623	WW = 1.0876(GW)	1.09 (1.08)
Red hind	WW = 1.0553(GW) + 0.0294	0.9978	WW = 1.0658(GW)	1.07 (1.25)
Spanish mackerel	WW = 1.1223(GW) - 0.0029	0.9995	WW = 1.1198(GW)	1.12 (1.15)
Hogfish	WW = 1.0094(GW) + 0.2076	0.9929	WW = 1.0435(GW)	1.04 (1.25)

Table 7. Measurement relationships for fourteen species of finfish.

Species	Total Length to Fork Length	Total Length to Standard Length	Fork Length to Standard Length	Whole Weight to Length
Vermilion snapper	TL = 1.1032(FL) + 2.0219	TL = 1.2787(SL) + 7.647	FL = 1.1595(SL) + 5.1551	$WW = 6^{-08}L^{2.7882}$
Gag Grouper	TL = 1.038(FL) - 3.4954	TL = 1.1439(SL) + 32.952	FL = 1.0967(SL) + 38.574	$WW = 8^{-10}L^{3.4323}$
Red Grouper	TL = 1.071(FL) - 18.303	TL = 1.154(SL) + 35.669	FL = 1.0641(SL) + 58.082	$WW = 2^{-08}L^{2.9725}$
King mackerel	TL = 1.0903(FL) + 29.374	TL = 1.2253(SL) + 33.652	FL = 1.1254(SL) + 4.9919	$WW = 1^{-08}L^{2.9541}$
Scamp	TL = 0.8774(FL) + 23.304	TL = 1.2474(SL) + 22.672	FL = 1.1125(SL) + 34.313	$WW = 3^{-08}L^{2.888}$
Dolphin	TL = 1.2022(FL) + 4.3175	TL = 1.3208(SL) + 4.3777	FL = 1.0974(SL) + 0.9403	$WW = 3^{-08}L^{2.8067}$
Yellowfin tuna	TL = 1.0631(FL) + 79.806	TL = 1.2587(SL) + 93.959	FL = 1.1726(SL) + 21.836	$WW = 5^{-08}L^{2.8593}$
Rock hind*	N/A	TL = 1.1249(SL) + 27.05	N/A	$WW = 2^{-09}L^{3.3848}$
Blueline tilefish**	TL = 1.0433(FL) + 5.5181	N/A	N/A	$WW = 3^{-08}L^{2.8504}$
Wahoo	TL = 0.9472(FL) + 168.47	TL = 1.0042(SL) + 263.15	FL = 1.0237(SL) + 137.29	$WW = 6^{-09}L^{3.0208}$
Squirrelfish	TL = 1.0784(FL) + 41.797	TL = 0.8974(SL) + 113.86	FL = 0.8585(SL) + 60.039	$WW = 8^{-07}L^{2.3456}$
Red hind	TL = 1.0881(FL) - 33.708	TL = 1.1002(SL) + 52.985	FL = 1.2583(SL) - 45.943	$WW = 3^{-06}L^{2.163}$
Spanish mackerel	TL = 1.1431(FL) + 12.204	TL = 1.1637(SL) + 54.978	FL = 0.81(SL) + 102.94	$WW = 4^{-09}L^{3.1396}$
Hogfish	TL = 1.0751(FL) + 29.796	TL = 1.1143(SL) + 109.92	FL = 1.0752(SL) + 51.23	$WW = 5^{-07}L^{2.5171}$

*Rock hind does not have a forked tail. **Blueline tilefish standard length not measured.

Table 8. Coefficient of variation (R^2) for measurement relationships for fourteen species of finfish.

Species	Total Length to Fork Length	Total Length to Standard Length	Fork Length to Standard Length	Whole Weight to Length
Vermilion snapper	0.9877	0.9472	0.9575	0.9463
Gag grouper	0.9916	0.9415	0.9394	0.9070
Red grouper	0.9820	0.9628	0.9568	0.8719
King mackerel	0.9248	0.9772	0.9858	0.9726
Scamp	0.9846	0.9478	0.9669	0.8383
Dolphin	0.9939	0.9933	0.9951	0.9792
Yellowfin tuna	0.9540	0.9188	0.9445	0.9567
Rock hind*	N/A	0.9452	N/A	0.7697
Blueline tilefish**	0.9930	N/A	N/A	0.9394
Wahoo	0.9101	0.8055	0.8164	0.7951
Squirrelfish	0.8167	0.6302	0.8215	0.8070
Red hind	0.9963	0.6250	0.9452	0.5756
Spanish mackerel	0.9989	0.9536	0.6988	0.9817
Hogfish	0.9408	0.8571	0.9497	0.6923

*Rock hind does not have a forked tail. **Blueline tilefish standard length not measured.

Gag Grouper

The number of gag grouper sampled was 392 with the majority of the samples coming from Pender County [Table 3, (n=113)]. Samples were also collected in Onslow (n=91), Carteret (n=86), Brunswick (n=52), and New Hanover (n=50) counties (Table 3). Gag grouper ranged from 550 mm to 950 mm FL (Figure 5). The conversion factor for gag grouper calculated from this study was 1.07 (Table 6 and Figures 6 and 7). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A3.

Multiple regression analysis indicated that the interaction effects of season*gutted weight (p-value = <0.0001) and county*gutted weight (p-value = 0.0286) were significant factors on whole weight indicating that the calculated slopes (conversion factors) between different season and different counties were significantly different. The calculated conversion factor for gag grouper sampled during the summer was 1.06 while those sampled in fall and spring were 1.08. The calculated conversion factor for gag grouper sampled by county was calculated to be 1.07 for Brunswick, Pender, and Onslow counties, 1.08 for Carteret County and 1.09 for New Hanover County. The interaction effect of gender*gutted weight was found to be insignificant (p = 0.0944). Figure A4 contains a scatter plot of the gutted weight and whole weight relationship by season, county, and gender.

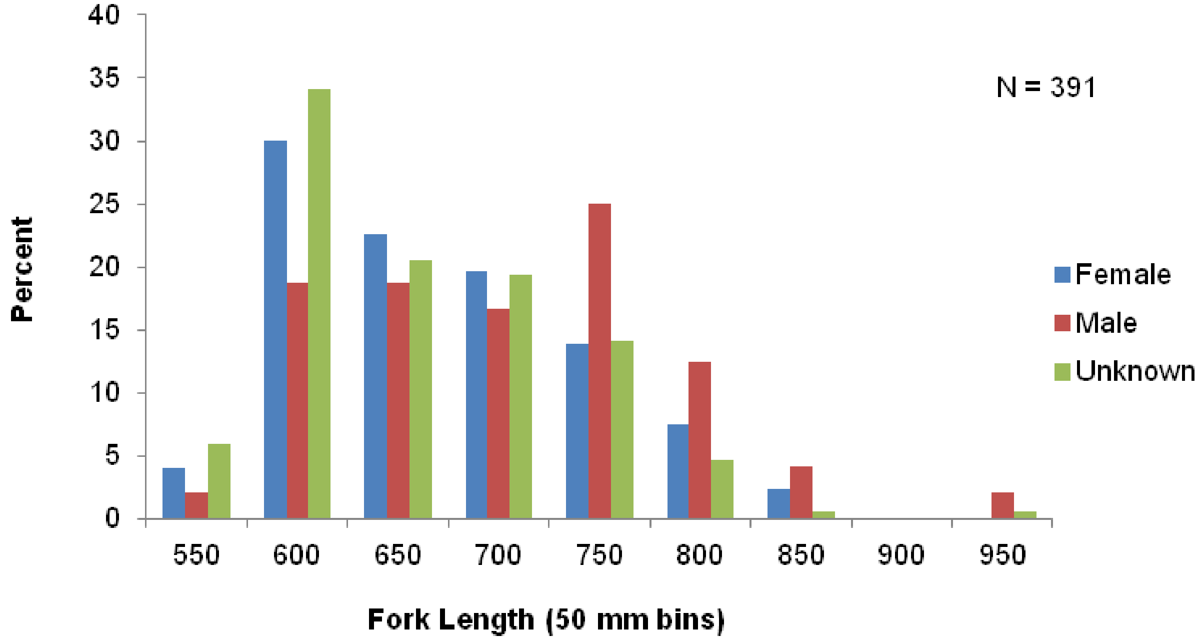

Figure 5. Length frequency (50 mm bins) for gag grouper.

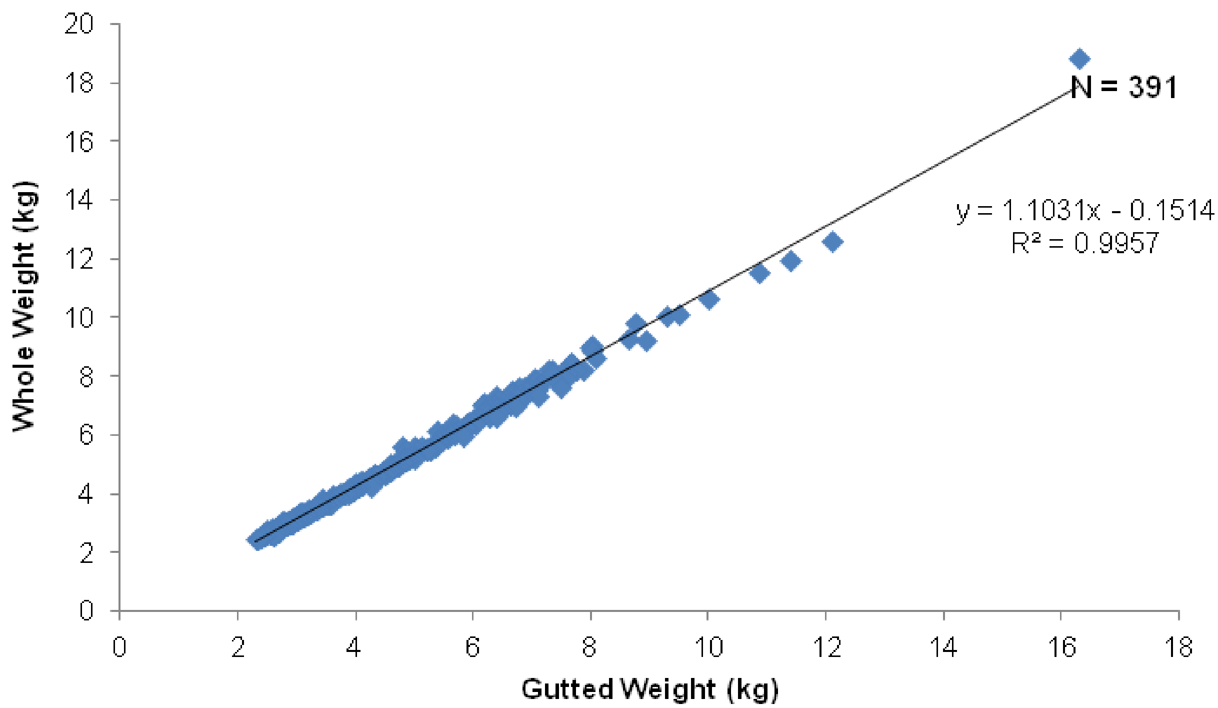

Figure 6. Gutted weight (kg) to whole weight (kg) relationship for gag grouper.

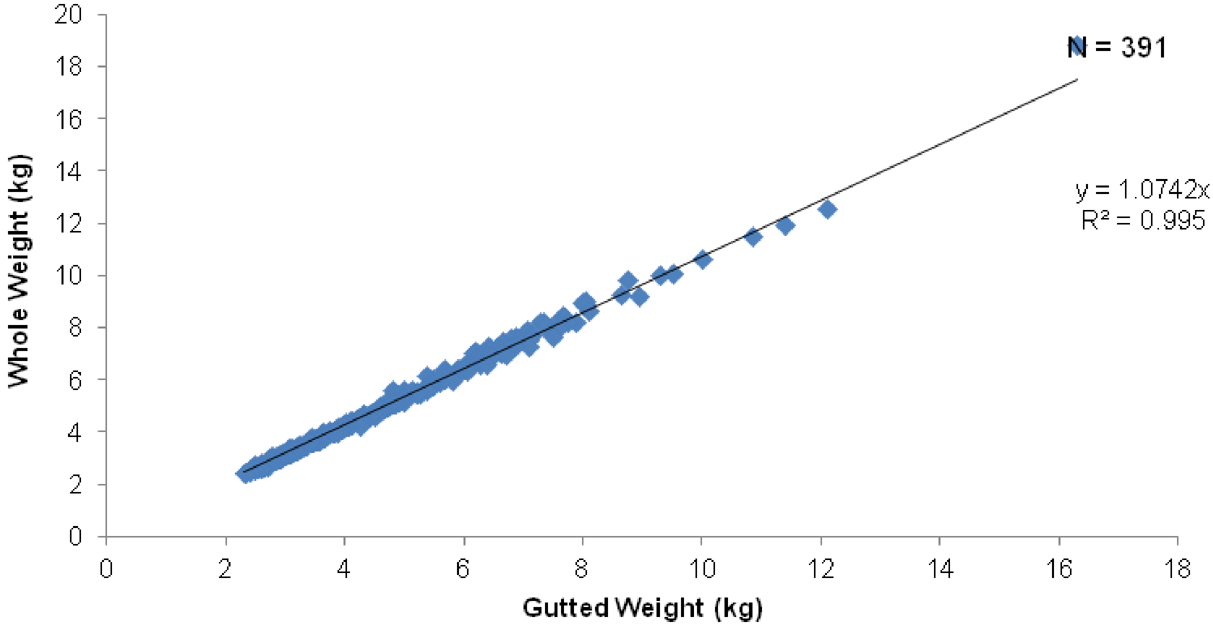

Figure 7 Gutted weight (kg) to whole weight (kg) relationship for gag grouper with intercept set at zero.

Red Grouper

The number of red grouper sampled was 290 with the majority of the samples coming from Brunswick (n=135) and Carteret (n=116) counties (Table 3). Samples were also collected in New Hanover (n=23) and Pender (n=16) counties (Table 3). Red grouper sampled ranged in size from 500 mm to 850 mm TL (Figure 8). The conversion factor for red grouper calculated from this study was estimated to be 1.06 (Table 6 and Figures 9 and 10). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A5.

Multiple regression analysis indicated that the interaction effects of season*gutted weight (p-value = 0.0161) and county*gutted weight (p-value = 0.0217) were significant factors on whole weight indicating that the calculated slopes (conversion factors) between different season and different counties were significantly different. The calculated conversion factor for red grouper sampled during the fall, spring and summer was 1.06 while those sampled in winter were 1.04. However, there were only five samples from the winter season. The calculated conversion factor for red grouper sampled by county was estimated to be 1.06 for Brunswick, Pender, and New Hanover counties and 1.05 for Carteret County. The interaction effect of gender*gutted weight was found to be insignificant (p = 0.1194). Figure A6 contains a scatter plot of the gutted weight and whole weight relationship by season, county, and gender.

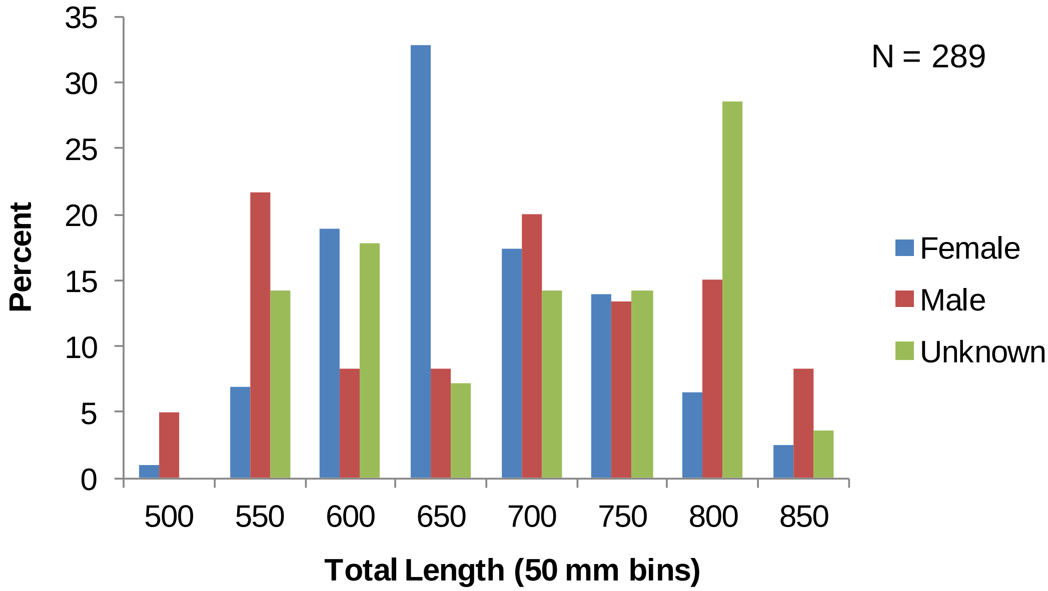

Figure 8. Length frequency (50 mm bins) for red grouper.

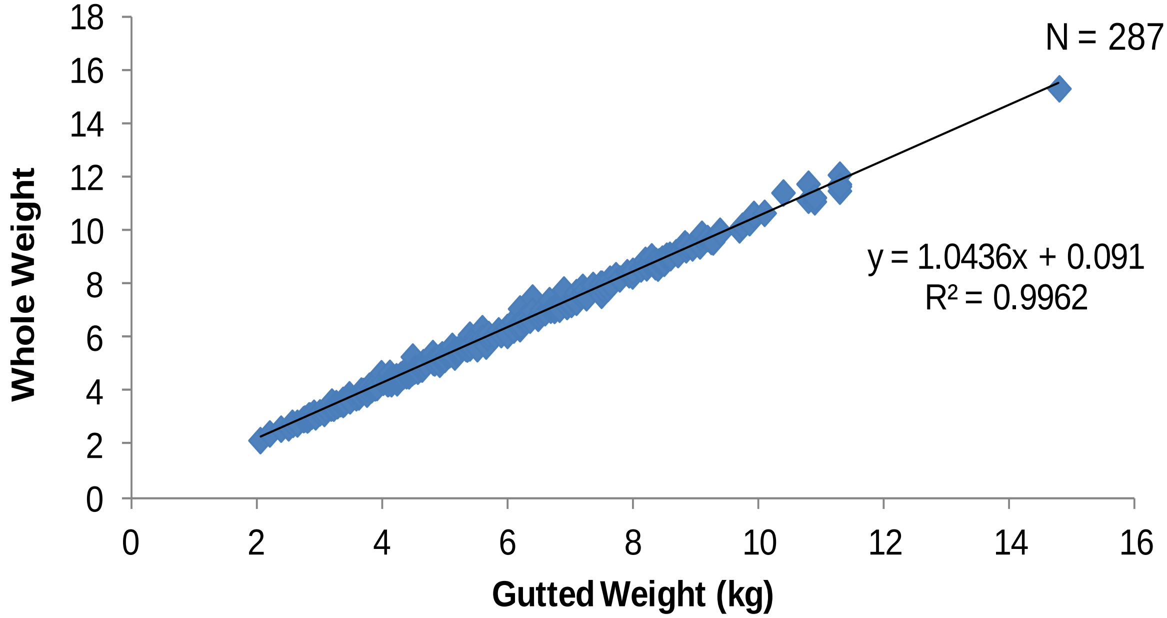

Figure 9. Gutted weight (kg) to whole weight (kg) relationship for red grouper.

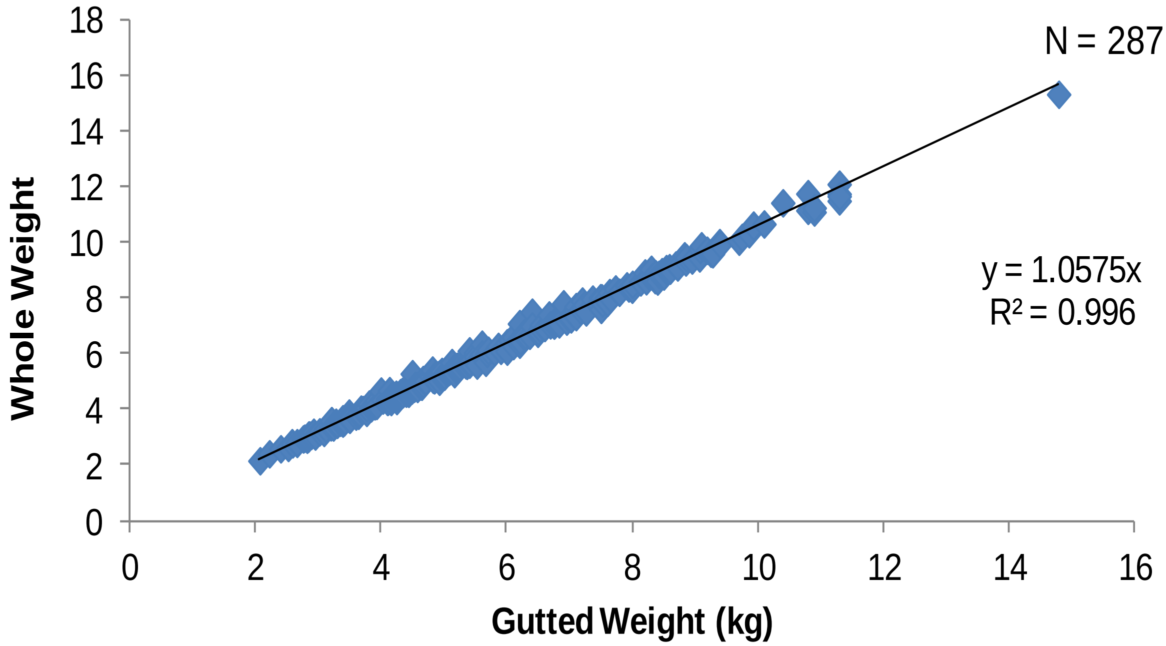

Figure 10. Gutted weight (kg) to whole weight (kg) relationship for red grouper with intercept set at zero.

King Mackerel

The number of king mackerel sampled was 283 with the majority of the samples coming from Onslow (n=93) and New Hanover (n=90) counties (Table 3). Samples were also collected from Brunswick (n=57) and Carteret (n=43) counties (Table 3). King mackerel sampled ranged in size from 550 mm to 1,400 mm FL (Figure 11). The conversion factor for king mackerel calculated from this study was calculated to be 1.07 (Table 6 and Figures 12 and 13). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A7.

Multiple regression analysis indicated that the interaction effects of season*gutted weight (p-value = 0.0014) and county*gutted weight (p-value = 0.0014) were significant factors on whole weight indicating that the calculated slopes (conversion factors) between different seasons and different counties were significantly different. The calculated conversion factor for king mackerel sampled during the fall was 1.06, those sampled during spring and summer had an calculated conversion factor of 1.07, while those sampled in winter were 1.04. The calculated conversion factor for king mackerel sampled by county was estimated to be 1.06 for Brunswick, Onslow, and New Hanover counties and 1.07 for Carteret County. The interaction effect of gender*gutted weight was found to be insignificant (p = 0.6994). Figure A8 contains a scatter plot of the gutted weight and whole weight relationship by season, county, and gender.

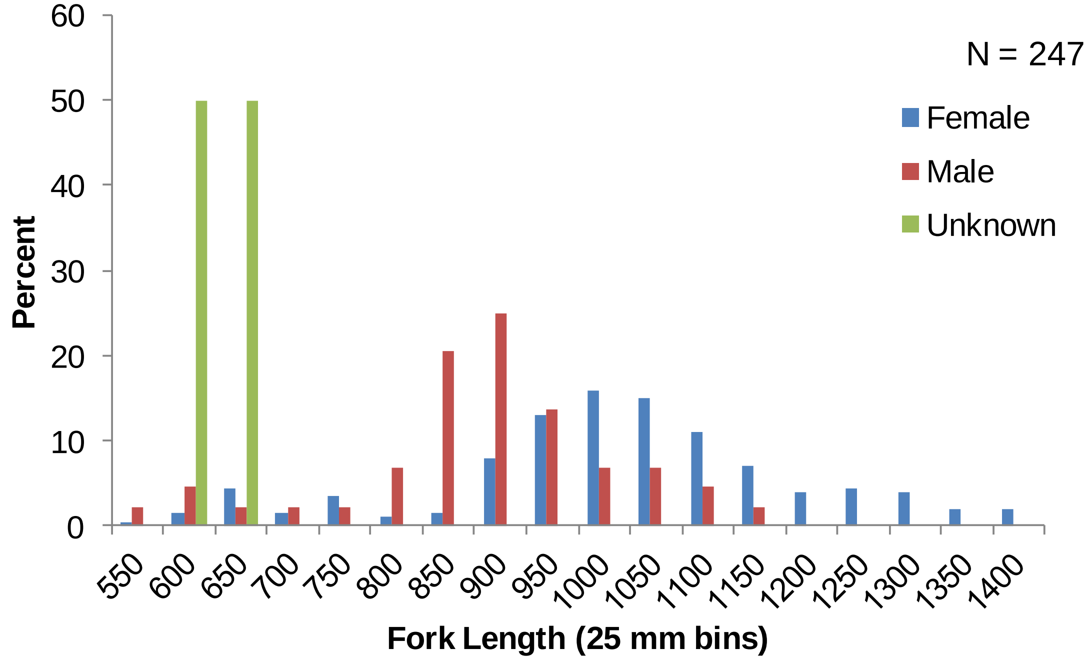

Figure 11. Length frequency (25 mm bins) for king mackerel.

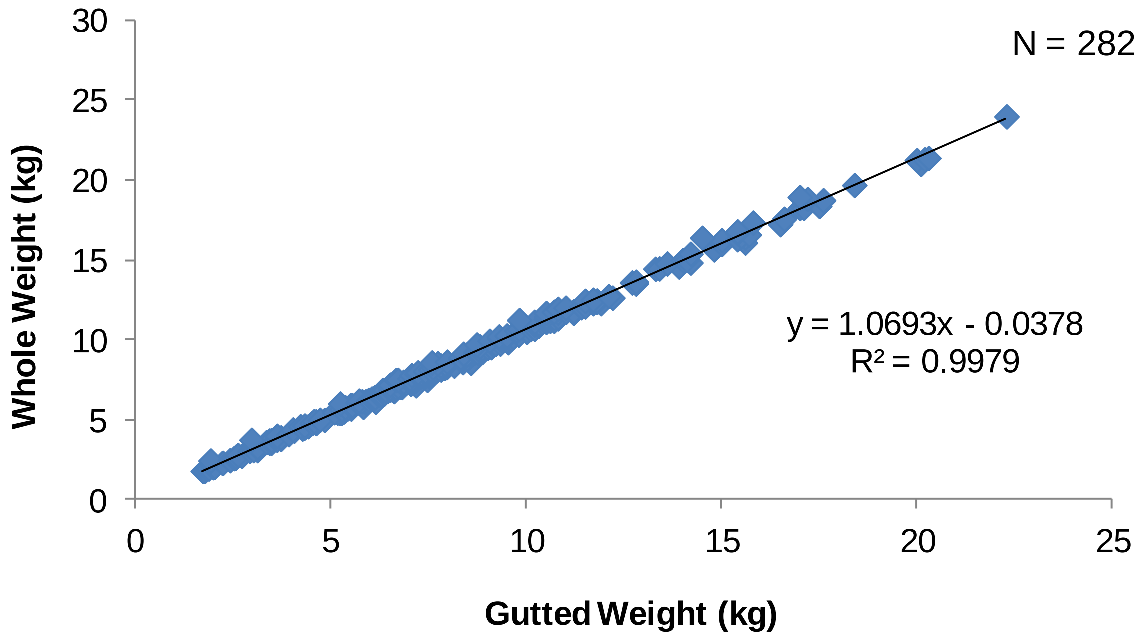

Figure 12. Gutted weight (kg) to whole weight (kg) relationship for king mackerel.

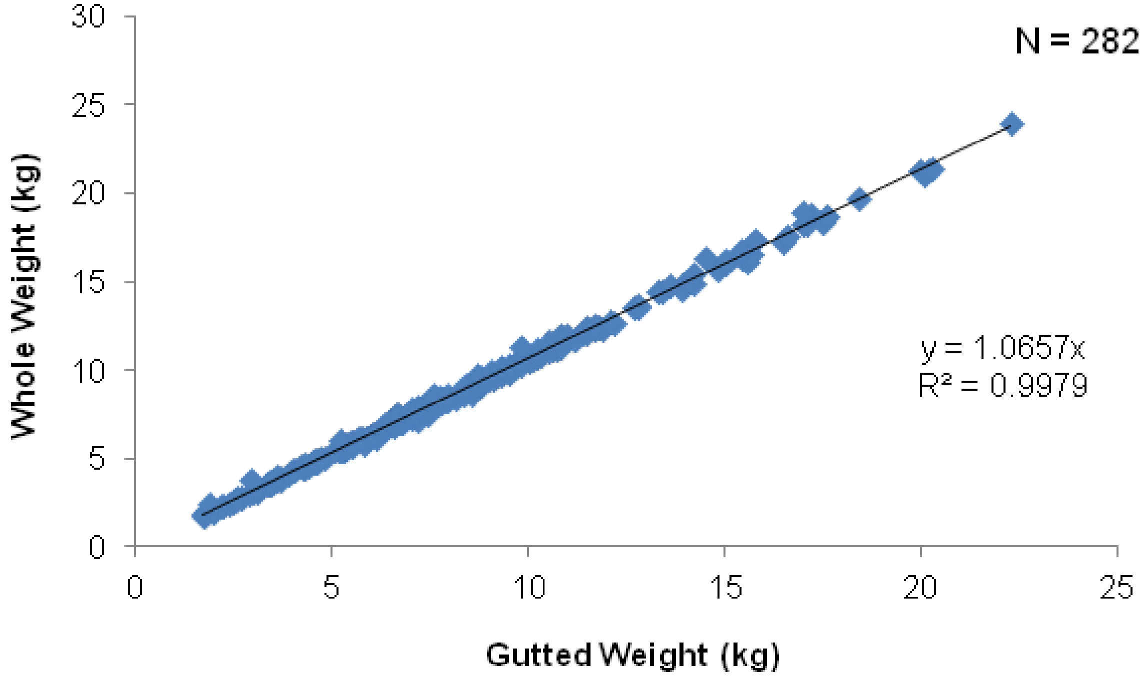

Figure 13. Gutted weight (kg) to whole weight (kg) relationship for king mackerel with intercept set at zero.

Scamp

The number of scamp sampled was 154 with the majority of the samples coming from Brunswick (n=144) County (Table 3). Samples were also collected from New Hanover (n=7) and Carteret (n=3) counties (Table 3). Scamp sampled ranged in size from 450 mm to 850 mm FL (Figure 22). The conversion factor for scamp calculated from this study was estimated to be 1.05 (Table 6 and Figures 23 and 24). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A9.

Multiple regression analysis indicated that the interaction effects of season*gutted weight (p-value = 0.6340) and gender*gutted weight (p-value = 0.0648) were insignificant factors on whole weight. There were not enough samples in the other counties to determine if county had any significant effect on whole weight. Figure A10 contains a scatter plot of the gutted weight and whole weight relationship by season, county, and gender.

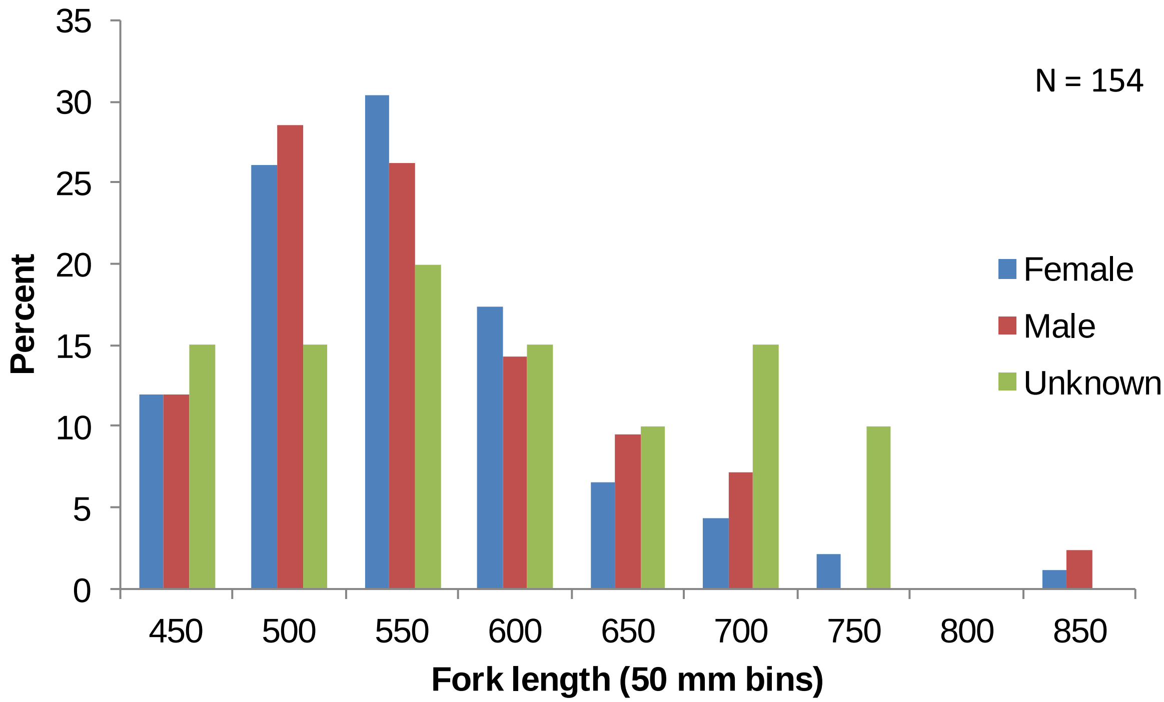

Figure 14. Length frequency (50 mm bins) for scamp.

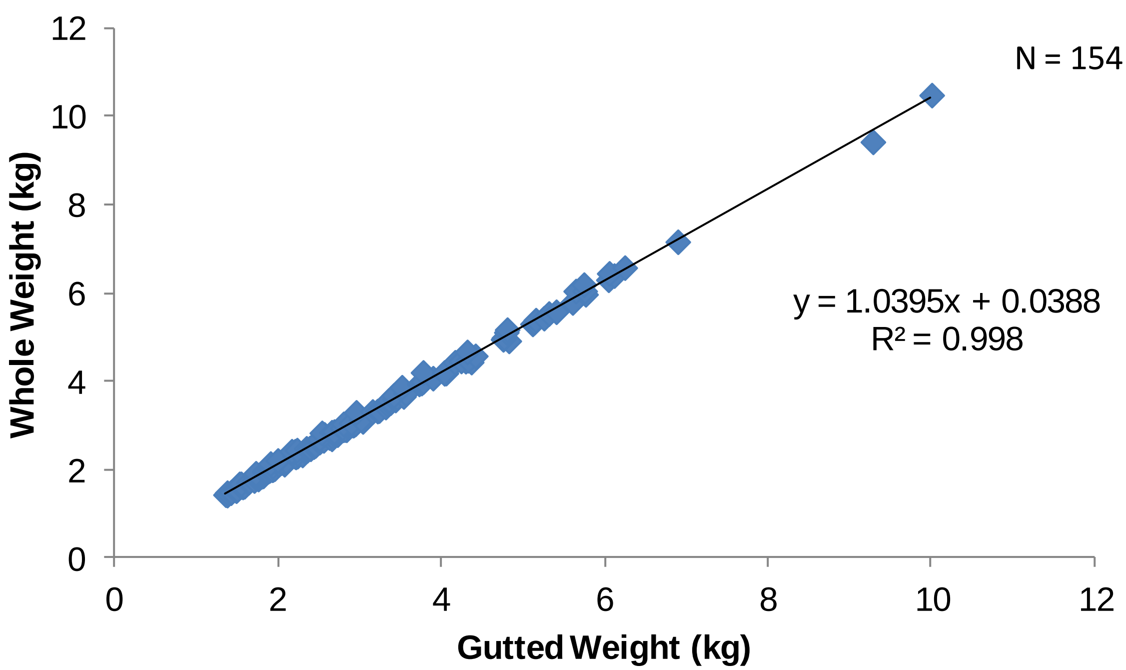

Figure 15. Gutted weight (kg) to whole weight (kg) relationship for scamp.

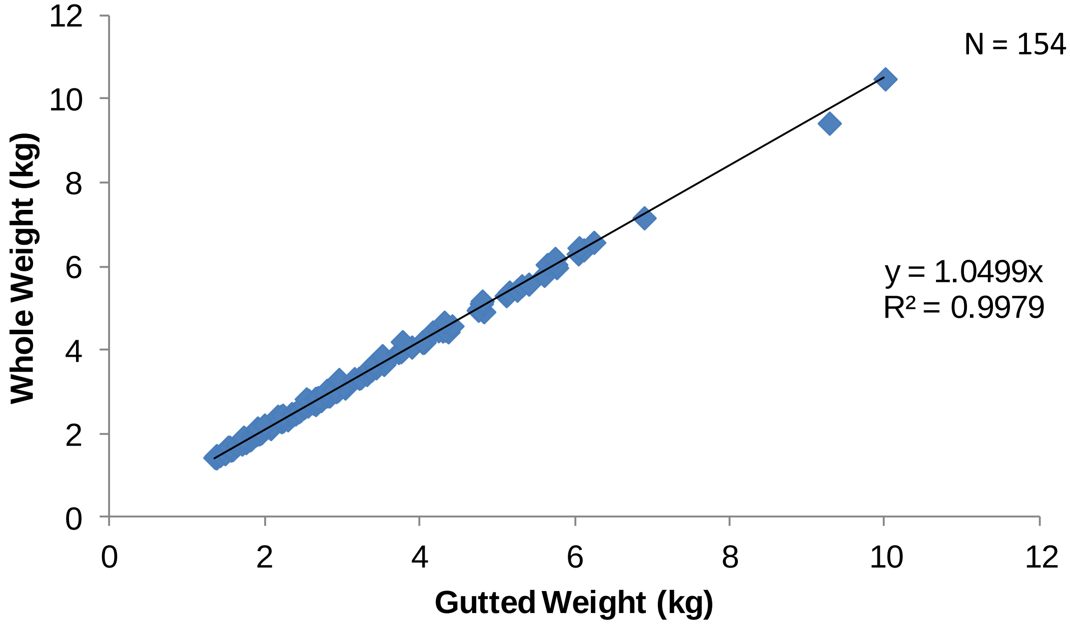

Figure 16. Gutted weight (kg) to whole weight (kg) relationship for scamp with intercept set at zero.

Dolphin

The number of dolphin sampled was 133 with the majority of the samples coming from Carteret (n=64) and New Hanover (n=42) counties (Table 3). Samples were also collected from Dare (n=16) and Brunswick (n=11) counties (Table 3). Dolphin sampled ranged in size from 400 mm to 1,200 mm FL (Figure 17). The conversion factor for dolphin calculated from this study was estimated to be 1.10 (Table 6 and Figures 18 and 19). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A11.

Multiple regression analysis indicated that the interaction effects of season*gutted weight (p-value = 0.2360) and county*gutted weight (p-value = 0.8036) were insignificant factors on whole weight. Multiple regression analysis indicated that the interaction effects of gender*gutted weight (p-value = 0.0002) was a significant factor on whole weight indicating that the calculated slopes (conversion factors) between different genders was significantly different. Female dolphin were calculated to have a conversion factor of 1.15 while males were estimated to have a conversion factor of 1.09. Figure A12 contains a scatter plot of the gutted weight and whole weight relationship by season, county, and gender.

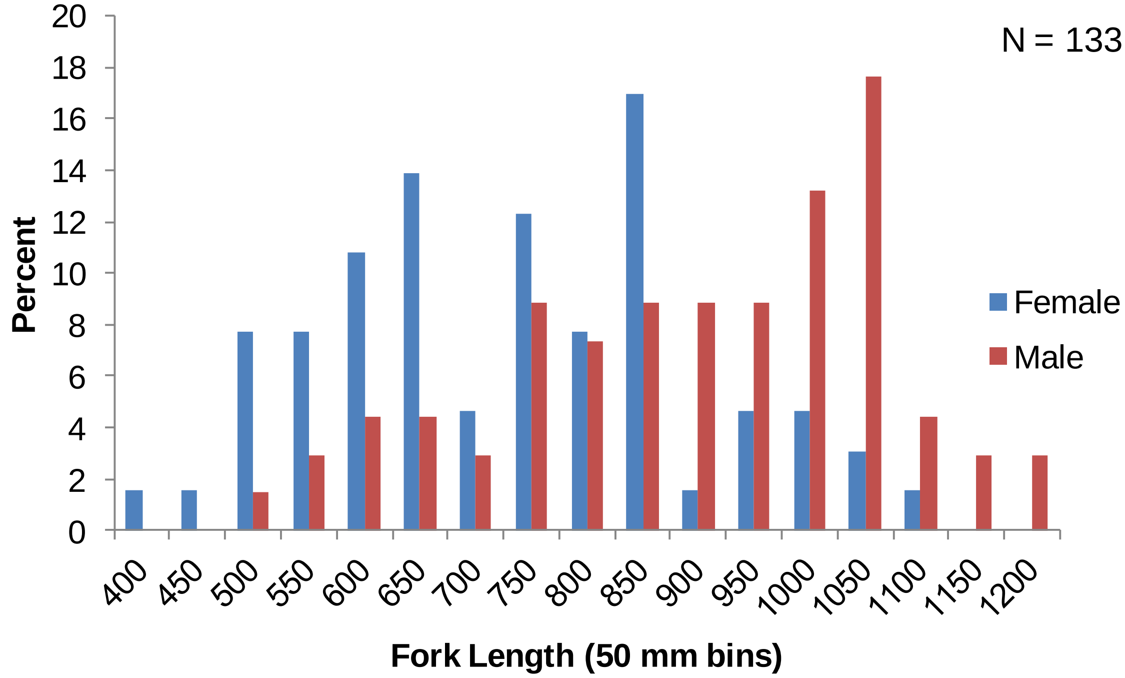

Figure 17. Length frequency (50 mm bins) for dolphin.

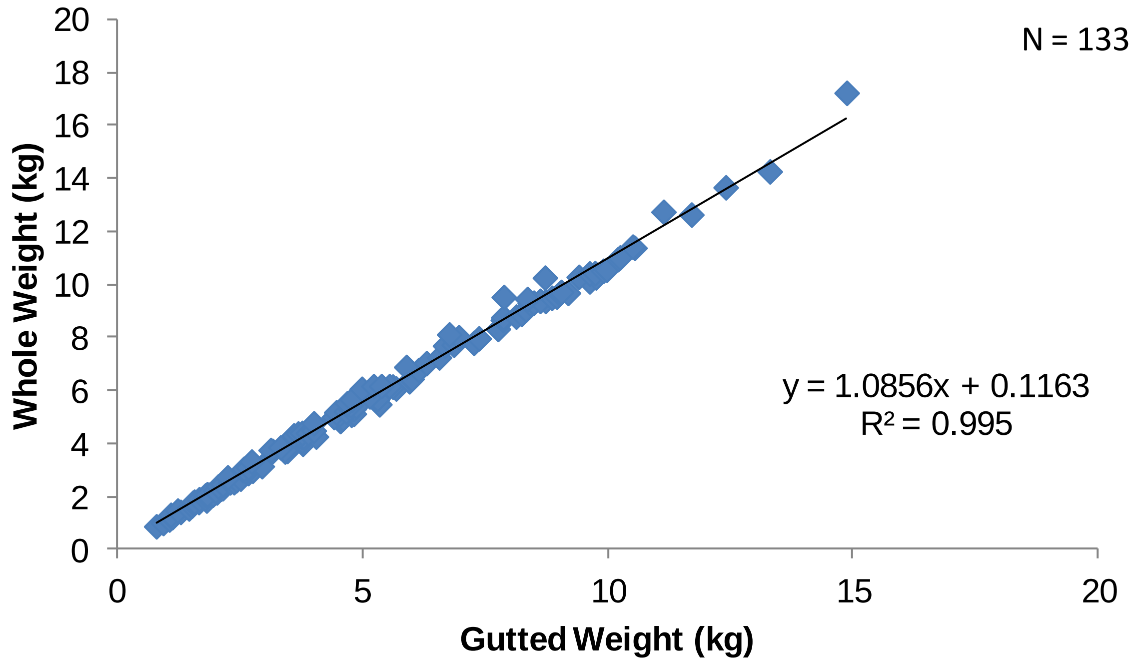

Figure 18. Gutted weight (kg) to whole weight (kg) relationship for dolphin.

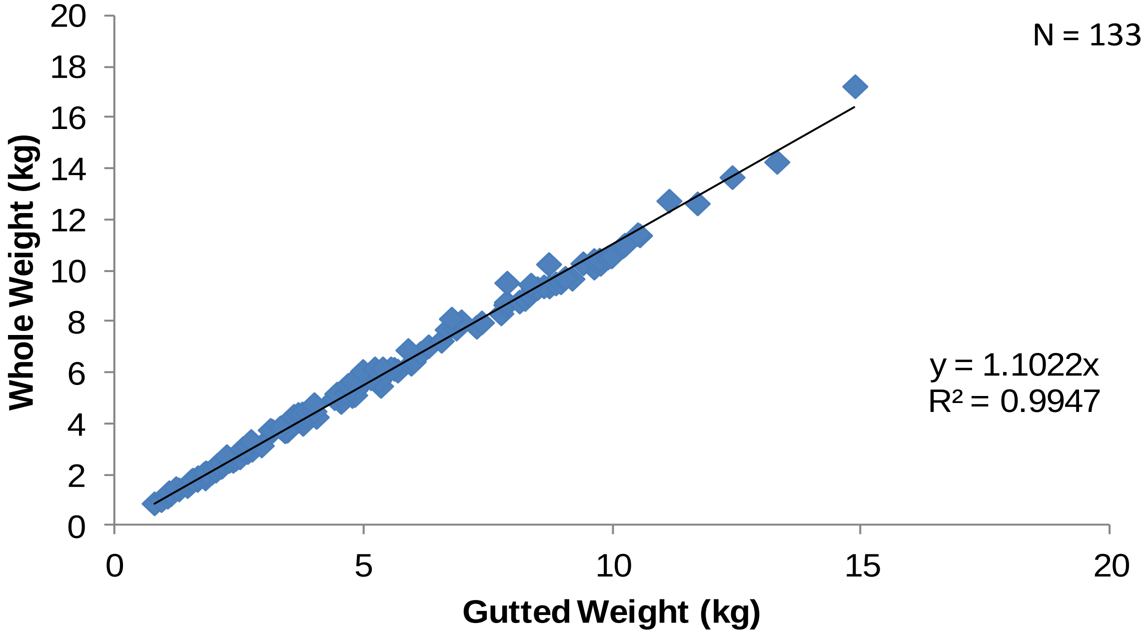

Figure 19. Gutted weight (kg) to whole weight (kg) relationship for dolphin with intercept set at zero.

Yellowfin Tuna

The number of yellowfin tuna sampled was 124 with the majority of the samples coming from Dare (n=122) County (Table 3). Two yellowfin tuna were collected in Carteret County (Table 3). Yellowfin tuna sampled ranged in size from 650 mm to 1,100 mm FL (Figure 32). The conversion factor for yellowfin tuna calculated from this study was estimated to be 1.07 (Table 6 and Figures 33 and 34). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A13.

Multiple regression analysis was only applied to gender because the sampling distribution for yellowfin tuna was not adequate between seasons (vast majority collected during the summer) or county (as mentioned above). Multiple regression analysis indicated that the interaction effects of gender*gutted weight ($p = 0.7554$) was an insignificant factor on whole weight. Figure A14 contains a scatter plot of the gutted weight and whole weight relationship by season, county, and gender.

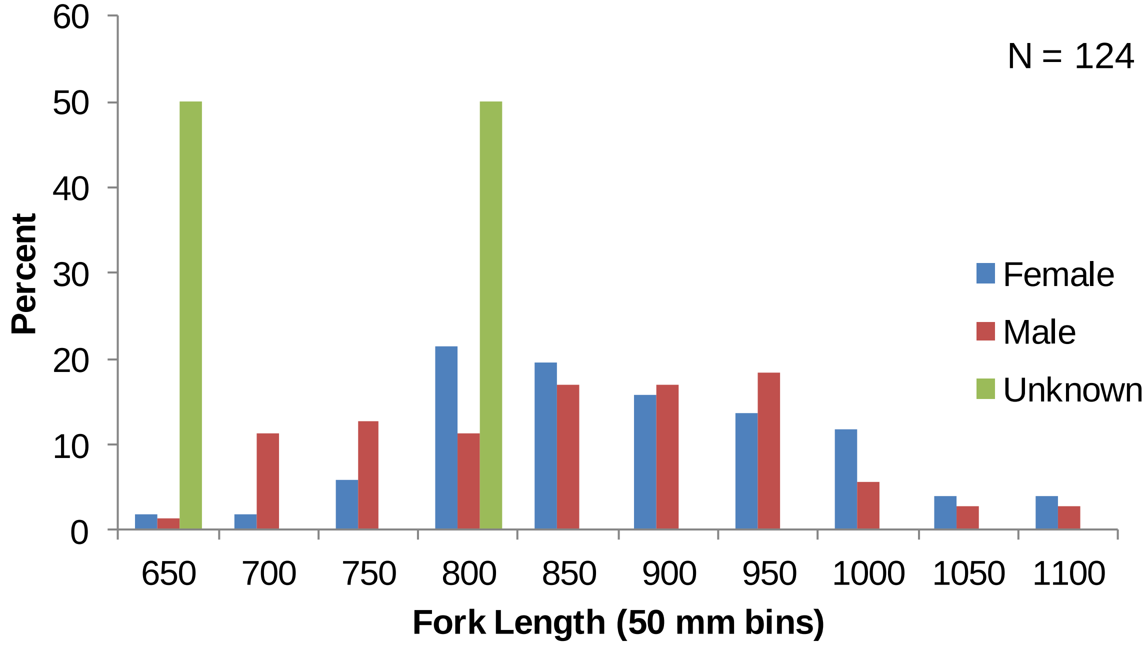

Figure 20. Length frequency (50 mm bins) for yellowfin tuna.

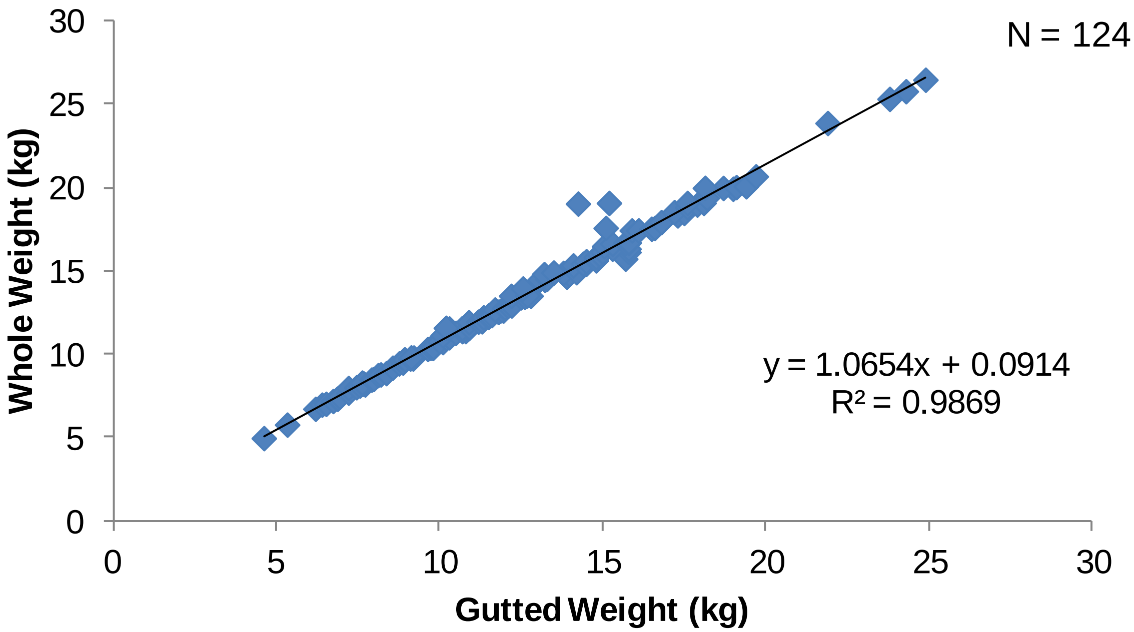

Figure 21. Gutted weight (kg) to whole weight (kg) relationship for yellowfin tuna.

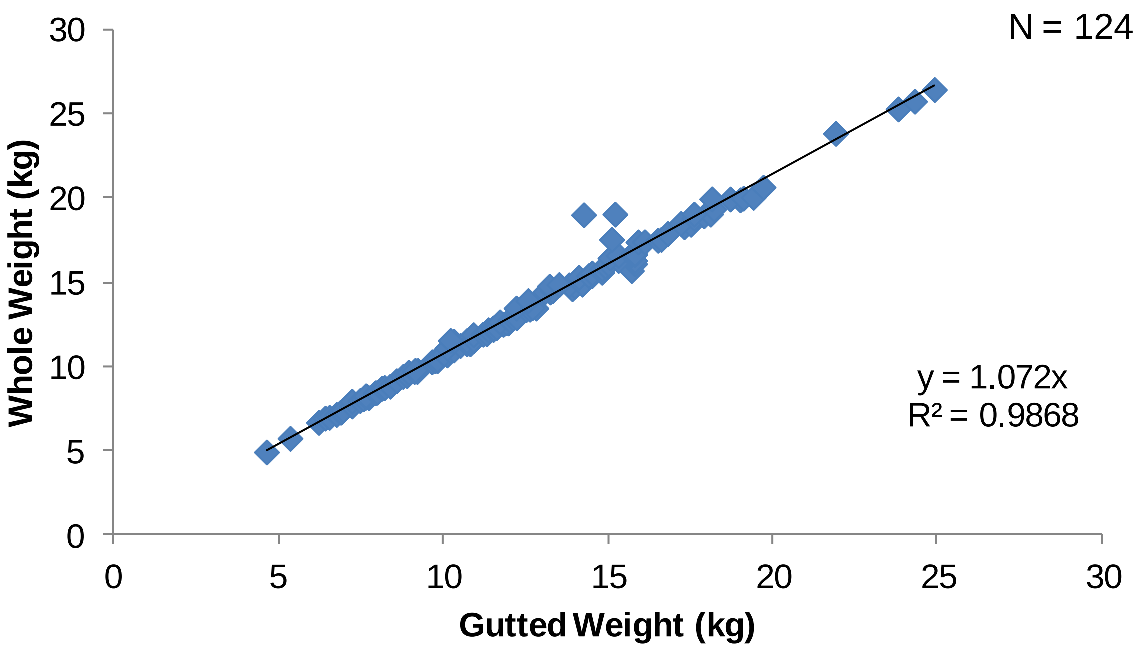

Figure 22. Gutted weight (kg) to whole weight (kg) relationship for yellowfin tuna with intercept set at zero.

Rock Hind

The number of rock hind sampled was 92 and they were all sampled from Brunswick County (Table 3). Rock hind sampled ranged in size from 300 mm to 450 mm TL (Figure 23). The conversion factor for rock hind calculated from this study was estimated to be 1.06 (Table 6 and Figures 24 and 25). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A15.

Multiple regression analysis indicated that gender*gutted weight ($p = 0.0338$) interaction had a significant effect on whole weight. The female conversion factor was calculated to be 1.06 while the male conversion factor was calculated to be 1.07; however this result may be due to an outlier. Season*gutted weight ($p = 0.2012$) was an insignificant factor on whole weight. Figure A16 contains a scatter plot of the gutted weight and whole weight relationship by gender and season.

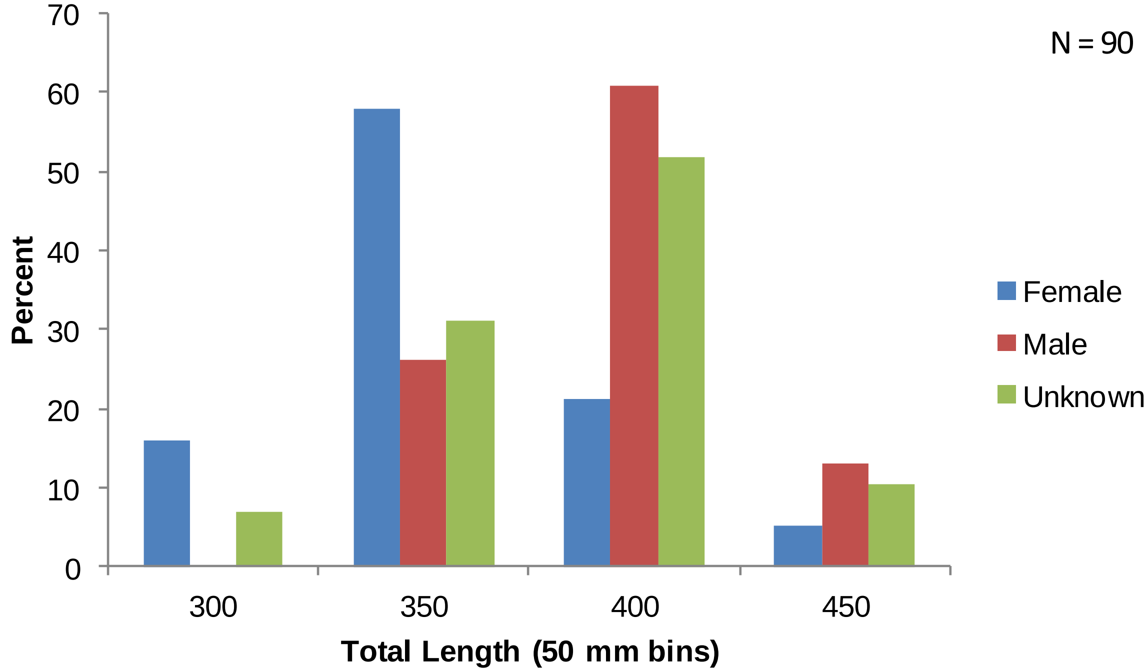

Figure 23. Length frequency (50 mm bins) for rock hind.

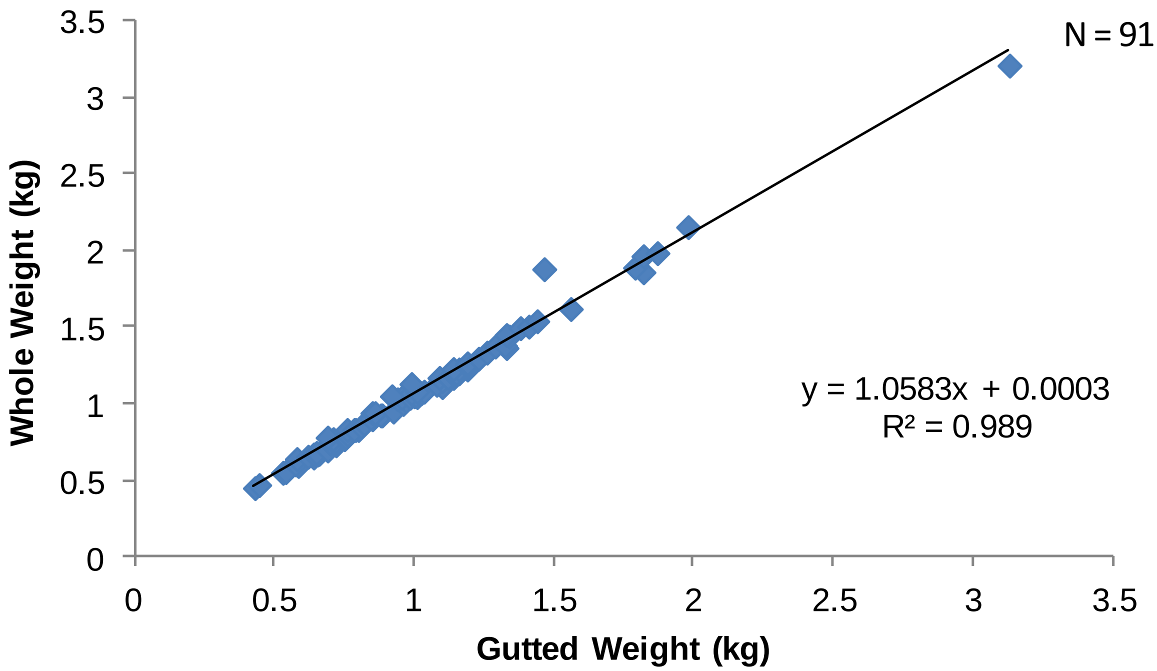

Figure 24. Gutted weight (kg) to whole weight (kg) relationship for rock hind.

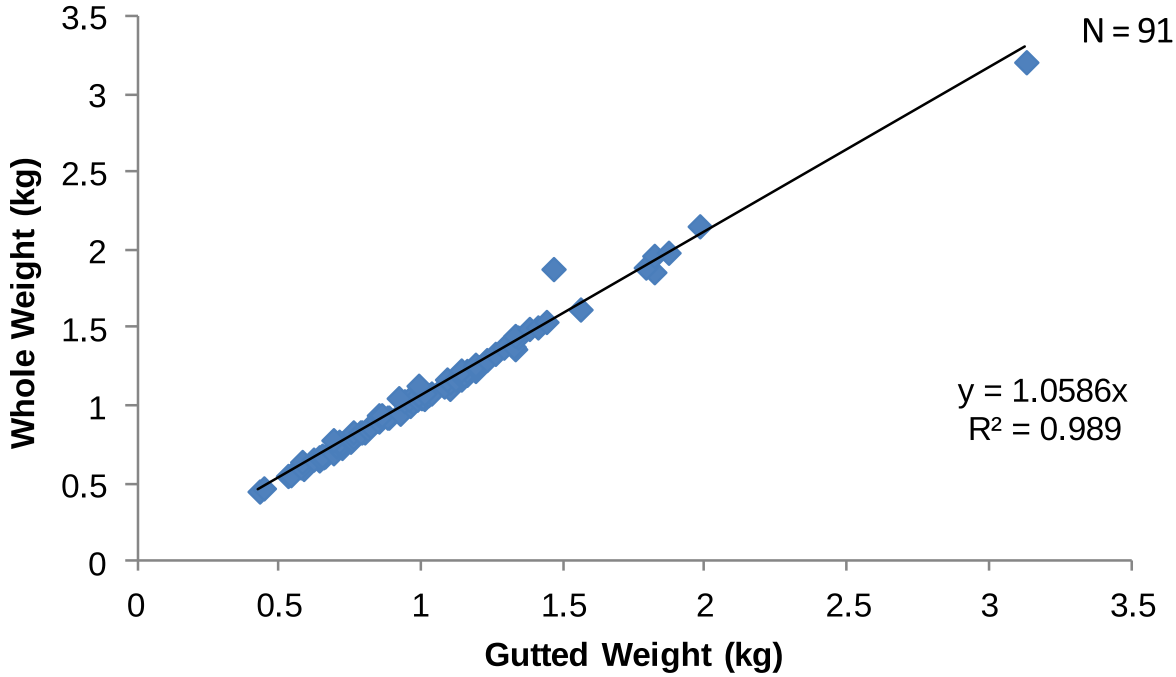

Figure 25. Gutted weight (kg) to whole weight (kg) relationship for rock hind with intercept set at zero.

Blueline Tilefish

The number of blueline tilefish sampled was 92 and they were all sampled from Dare County (Table 3). Blueline tilefish sampled ranged in size from 350 mm to 750 mm FL (Figure 26). The conversion factor for blueline tilefish calculated from this study was estimated to be 1.07 (Table 6 and Figures 27 and 28). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A17.

Multiple regression analysis indicated that gender*gutted weight ($p = 0.0049$) and season*gutted weight ($p = 0.0007$) interactions had a significant effect on whole weight. The female conversion factor was calculated to be 1.09 while the male conversion factor was calculated to be 1.05. Blueline tilefish sampled in the spring had an calculated conversion of 1.13 while those samples in the winter had an calculated conversion of 1.06. Figure A18 contains a scatter plot of the gutted weight and whole weight relationship by gender and season.

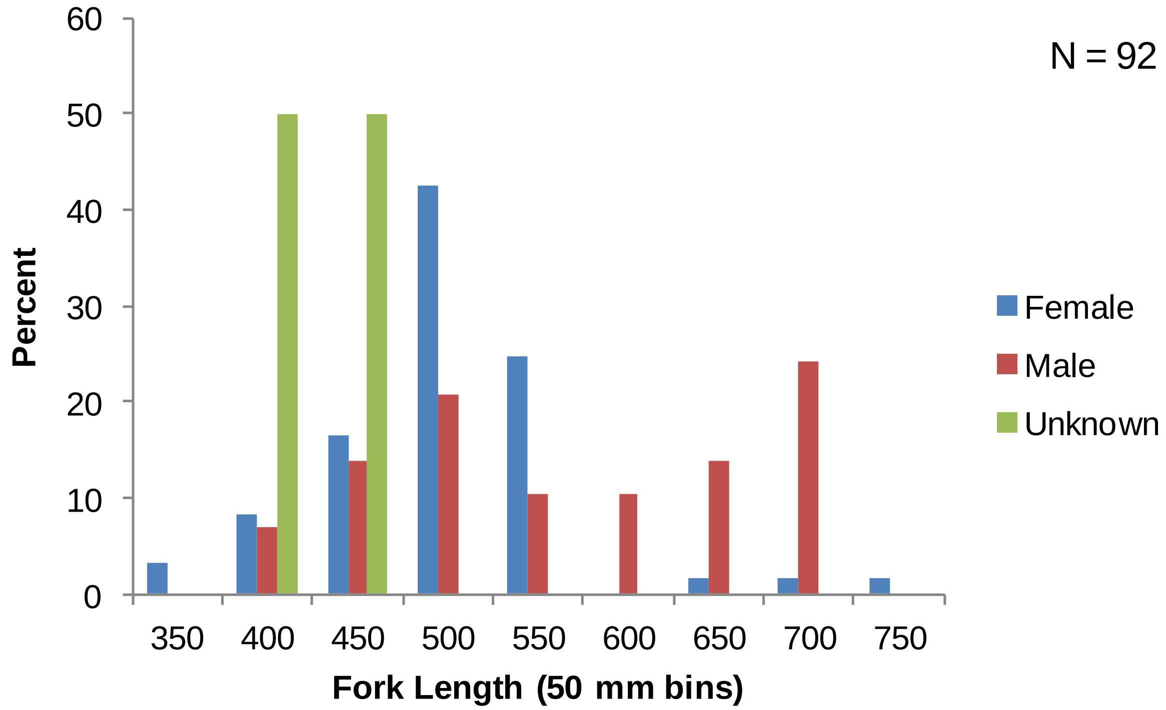

Figure 26. Length frequency (50 mm bins) for blueline tilefish.

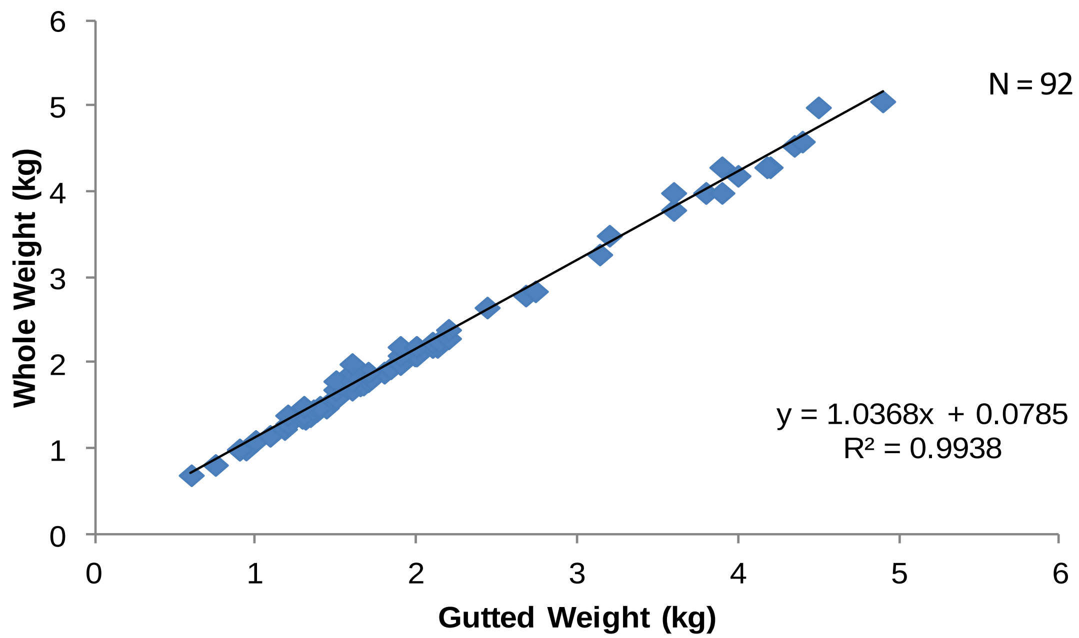

Figure 27. Gutted weight (kg) to whole weight (kg) relationship for blueline tilefish.

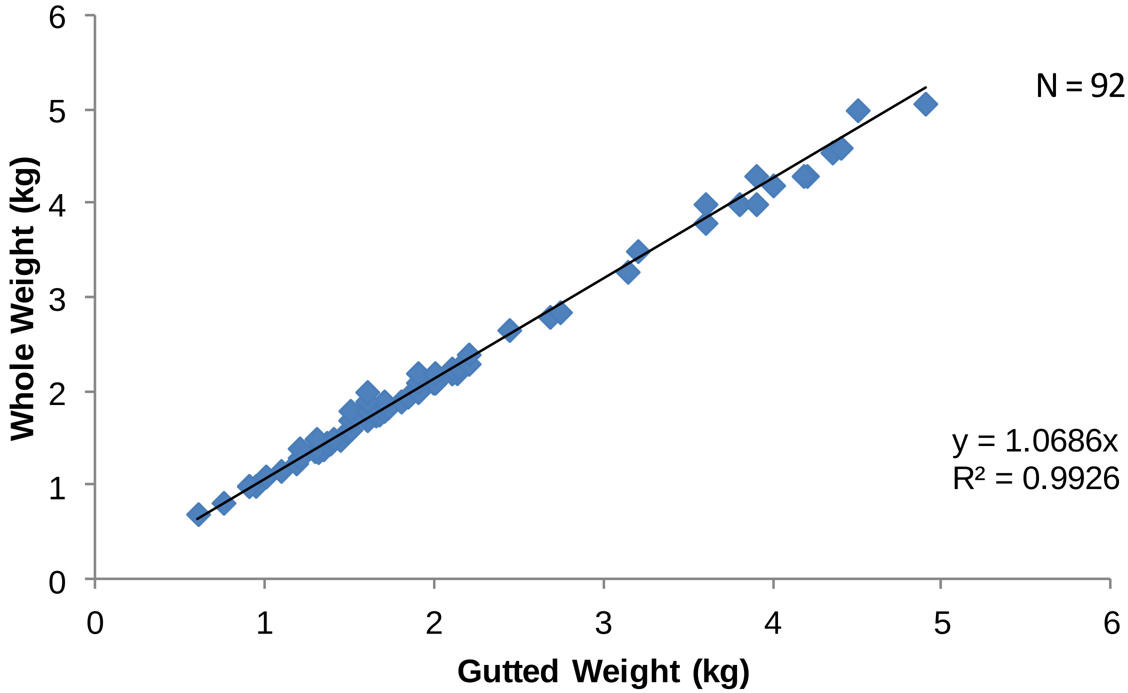

Figure 28. Gutted weight (kg) to whole weight (kg) relationship for blueline tilefish with intercept set at zero.

Wahoo

The number of wahoo sampled was 63 with the majority sampled from Carteret (n=29) and Dare (n=28) counties (Table 3). Six wahoo were also sampled in New Hanover County. Wahoo sampled ranged in size from 850 mm to 1,750 mm FL (Figure 29). The conversion factor for wahoo calculated from this study was estimated to be 1.08 (Table 6 and Figures 30 and 31). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A19.

Multiple regression analysis indicated that gender*gutted weight ($p = 0.0669$), season*gutted weight ($p = 0.1410$), and county*gutted weight ($p = 0.6489$) interactions all had an insignificant effect on whole weight. Figure A20 contains a scatter plot of the gutted weight and whole weight relationship by gender, season, and county.

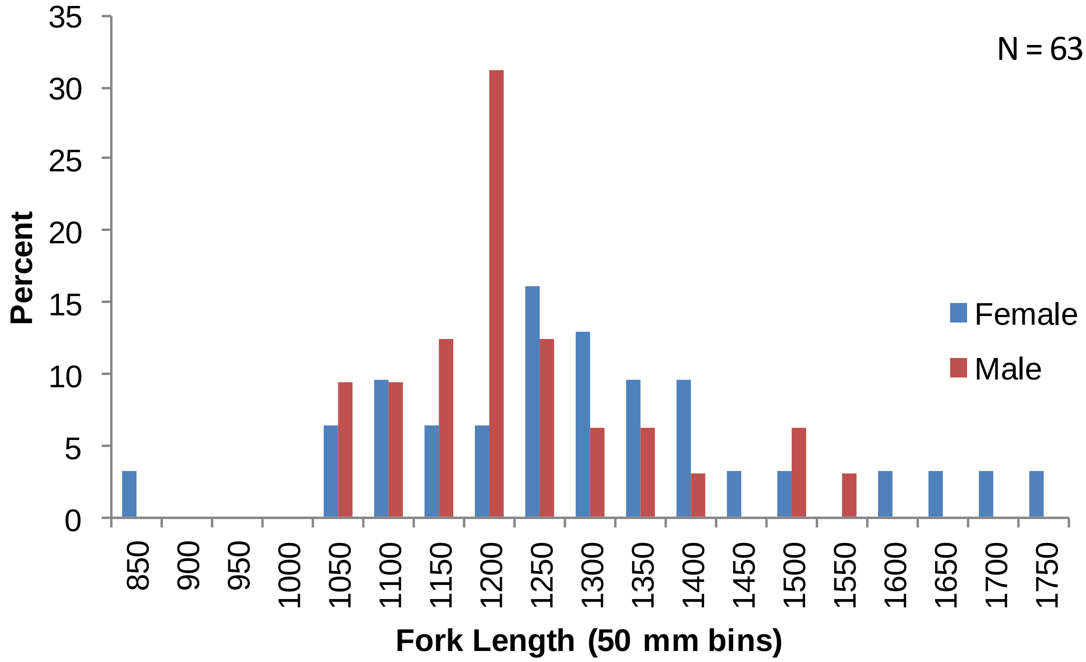

Figure 29. Length frequency (50 mm bins) for wahoo.

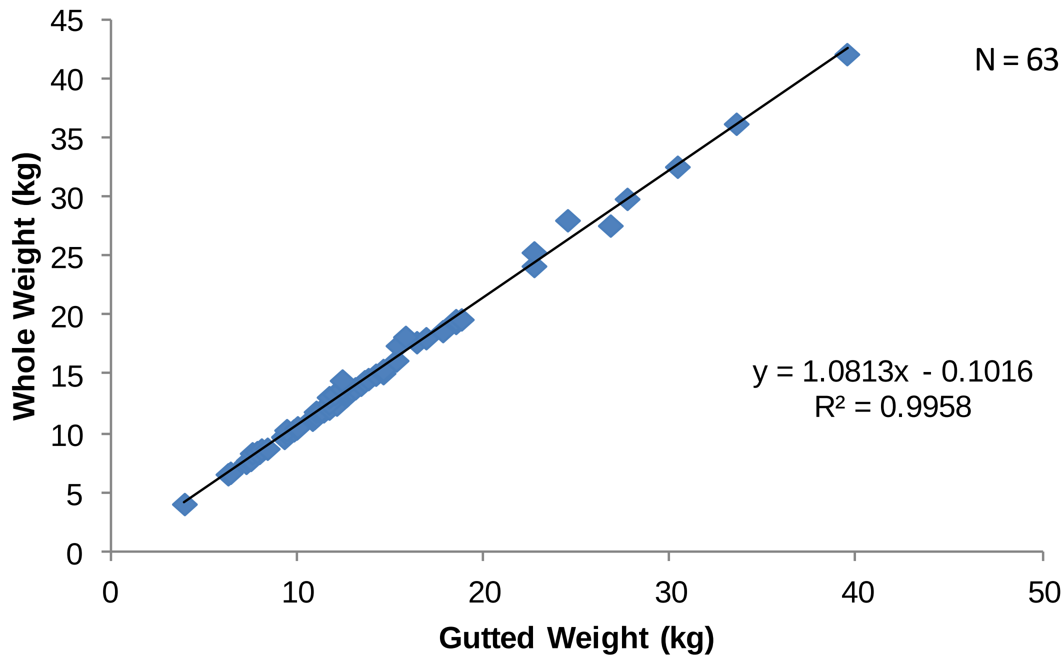

Figure 30. Gutted weight (kg) to whole weight (kg) relationship for wahoo.

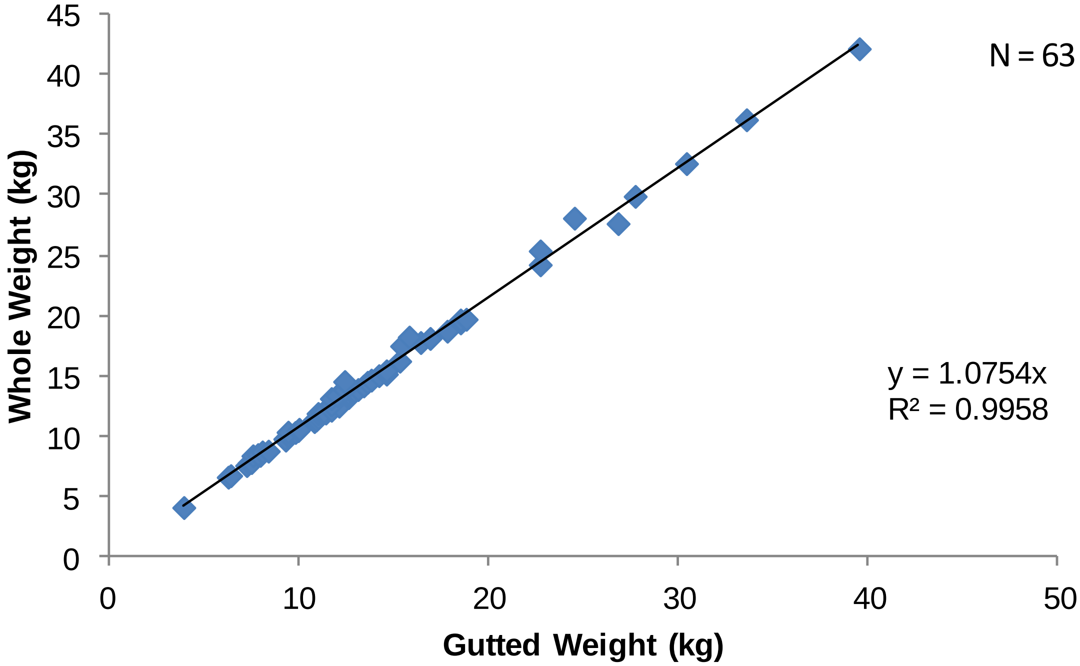

Figure 31. Gutted weight (kg) to whole weight (kg) relationship for wahoo with intercept set at zero.

Squirrelfish

The number of squirrelfish sampled was 38, all from Brunswick County (Table 3). Squirrelfish sampled ranged in size from 200 mm to 300 mm FL (Figure 32). The conversion factor for squirrelfish calculated from this study was calculated to be 1.09 (Table 6 and Figures 33 and 34). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A21.

Multiple regression analysis indicated that gender*gutted weight ($p = 0.0486$) was significant while season*gutted weight ($p = 0.5536$) was an insignificant effect on whole weight. Female squirrelfish had a calculated conversion factor of 1.12 while male squirrelfish had a calculated conversion factor of 1.08. Figure A22 contains a scatter plot of the gutted weight and whole weight relationship by gender and season.

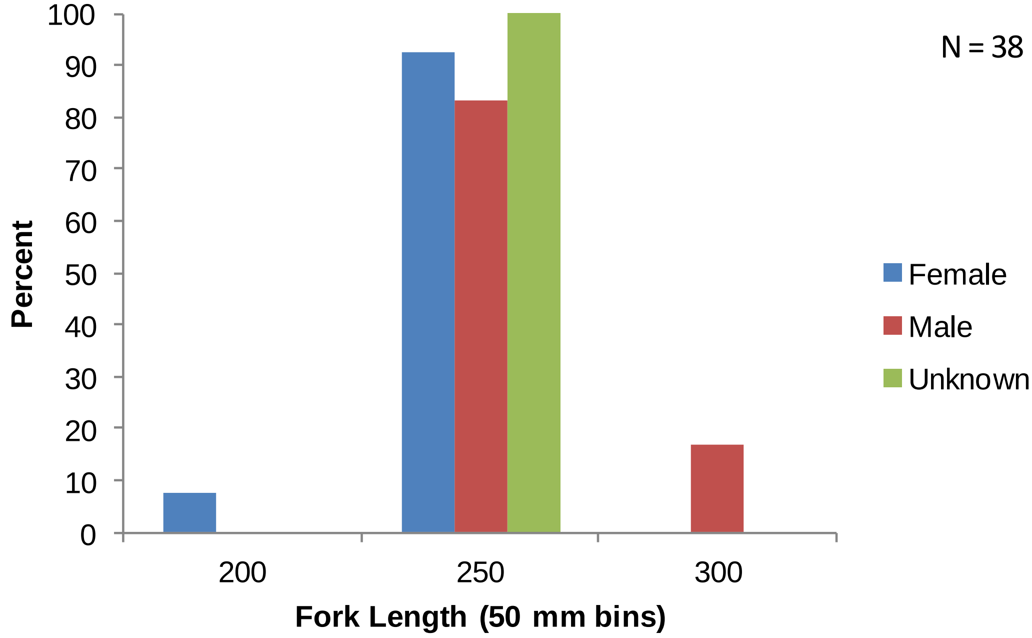

Figure 32. Length frequency (50 mm bins) for squirrelfish.

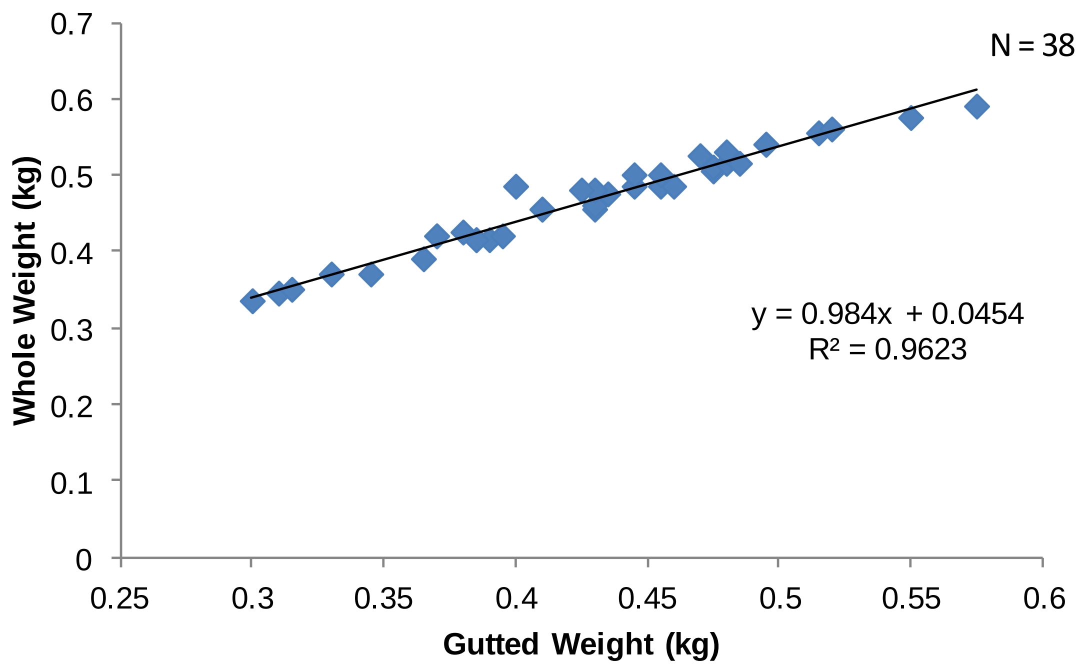

Figure 33. Gutted weight (kg) to whole weight (kg) relationship for squirrelfish.

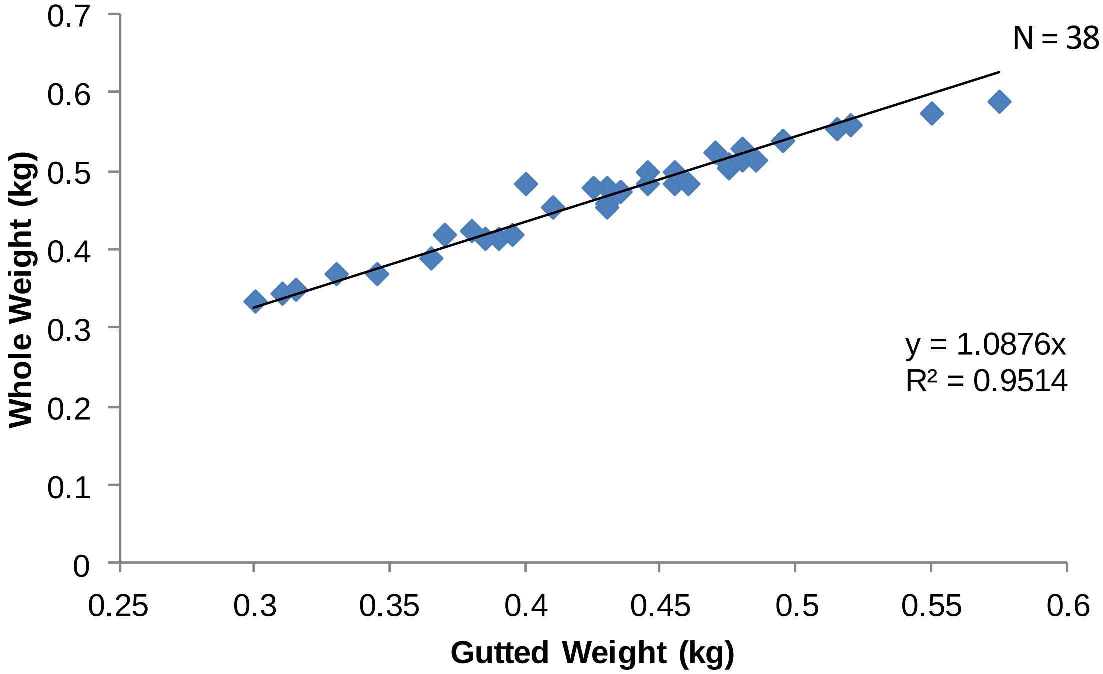

Figure 34. Gutted weight (kg) to whole weight (kg) relationship for squirrelfish with intercept set at zero.

Red Hind

The number of red hind sampled was 34, with 32 samples from Brunswick County and two samples from Carteret County (Table 3). Red hind sampled ranged in size from 350 mm to 750 mm TL (Figure 35). The conversion factor for red hind calculated from this study was estimated to be 1.07 (Table 6 and Figures 36 and 37). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A23.

Multiple regression analysis indicated that gender*gutted weight ($p = 0.5761$) was an insignificant factor on whole weight. Not enough samples were collected to test for the effects of season*gutted weight and county*gutted weight. Figure A24 contains a scatter plot of the gutted weight and whole weight relationship by gender, season, and county.

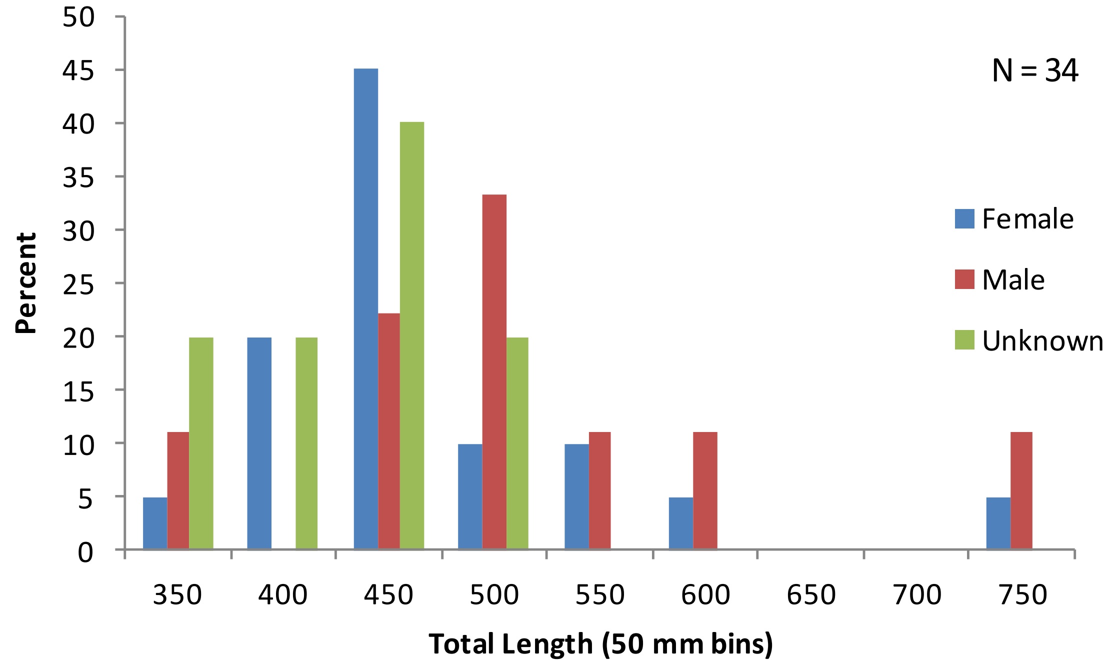

Figure 35. Length frequency (50 mm bins) for red hind.

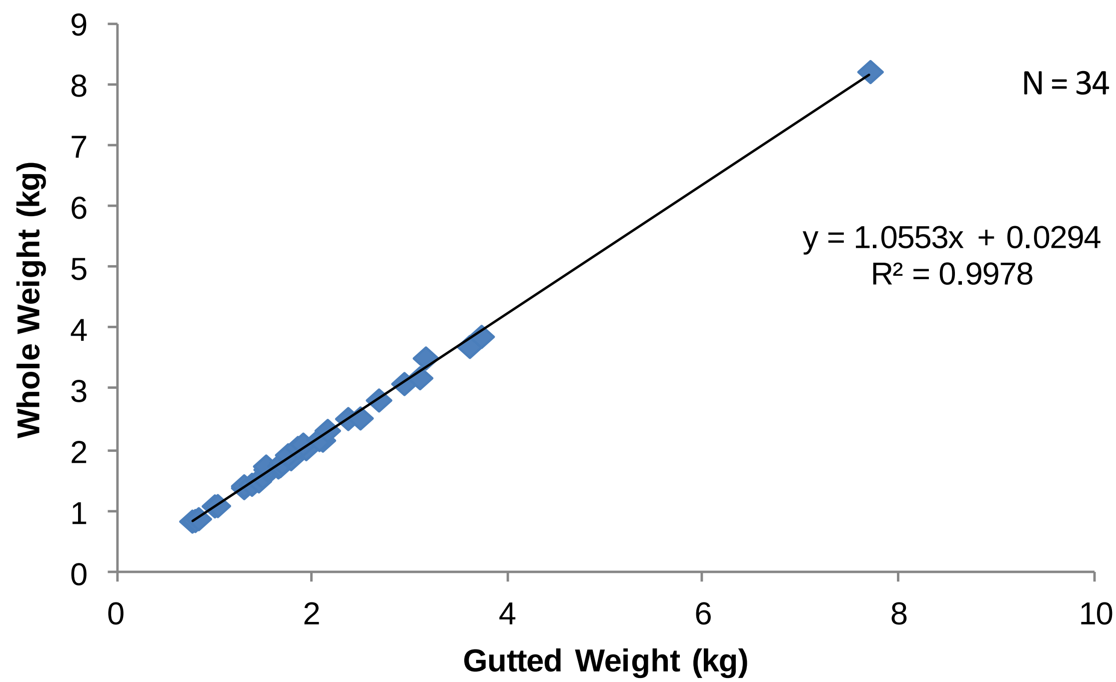

Figure 36. Gutted weight (kg) to whole weight (kg) relationship for red hind.

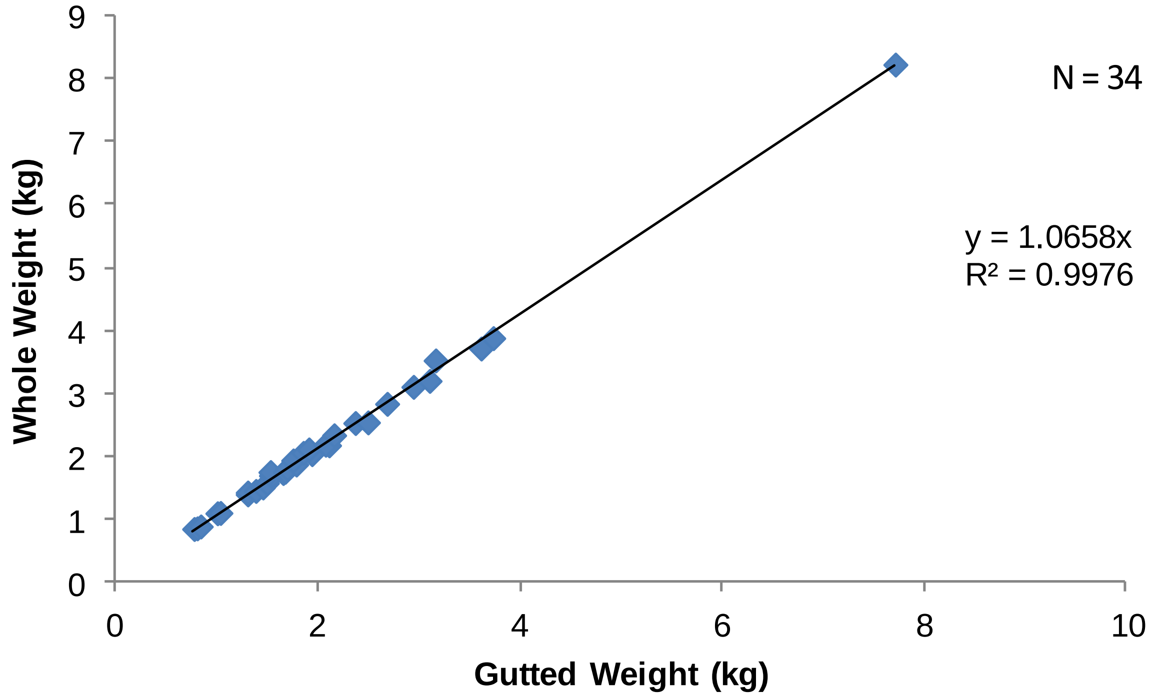

Figure 37. Gutted weight (kg) to whole weight (kg) relationship for red hind with intercept set at zero.

Spanish Mackerel

The number of Spanish mackerel sampled was 33, with the majority of samples coming from Onslow (n=18) and Carteret (n=13) counties (Table 3). Two Spanish mackerel were also sampled from New Hanover County (Table 3). Spanish mackerel ranged in size from 300 mm to 650 mm FL (Figure 38). The conversion factor for Spanish mackerel calculated from this study was estimated to be 1.12 (Table 6 and Figures 39 and 40). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A25.

Multiple regression analysis indicated that gender*gutted weight ($p = 0.2139$) and county*gutted weight ($p = 0.6608$) were both an insignificant factor on whole weight. All samples of Spanish mackerel were collected during the spring so the seasonal effect couldn’t be determined. Figure A26 contains a scatter plot of the gutted weight and whole weight relationship by gender and county.

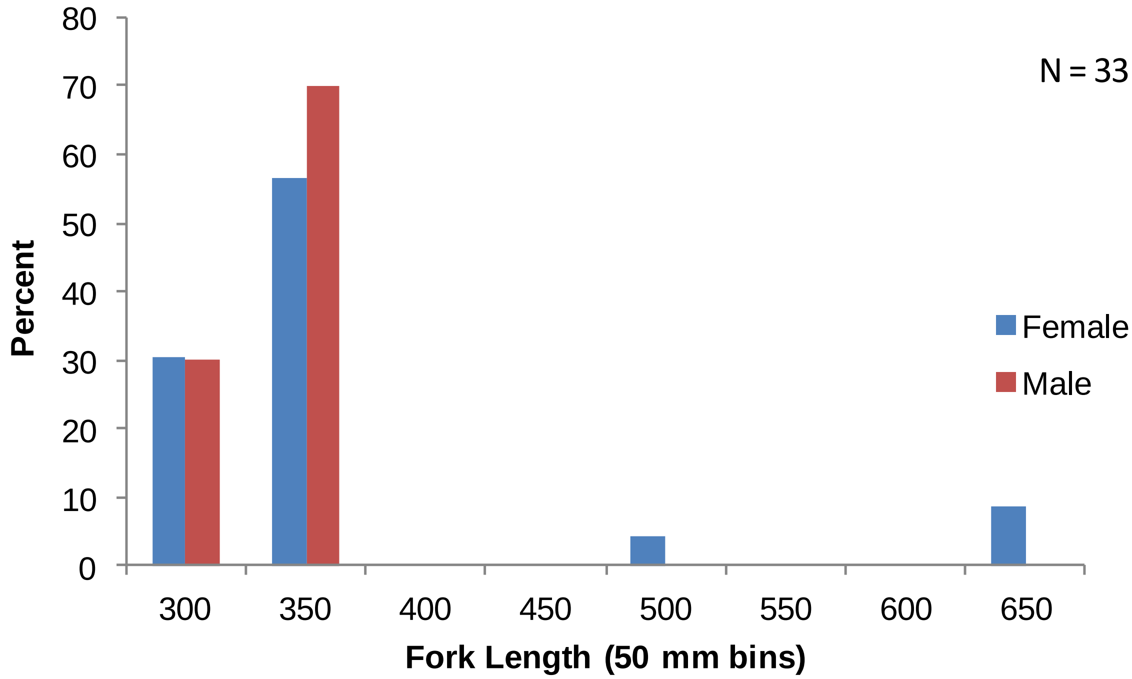

Figure 38. Length frequency (50 mm bins) for Spanish mackerel.

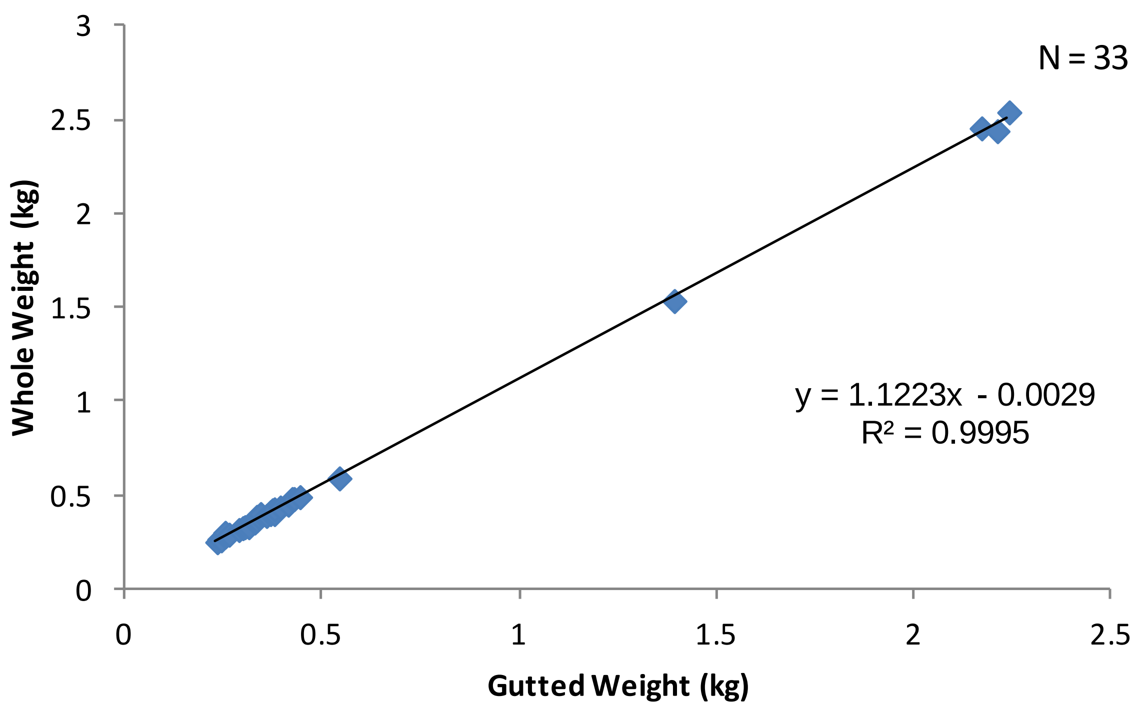

Figure 39. Gutted weight (kg) to whole weight (kg) relationship for Spanish mackerel.

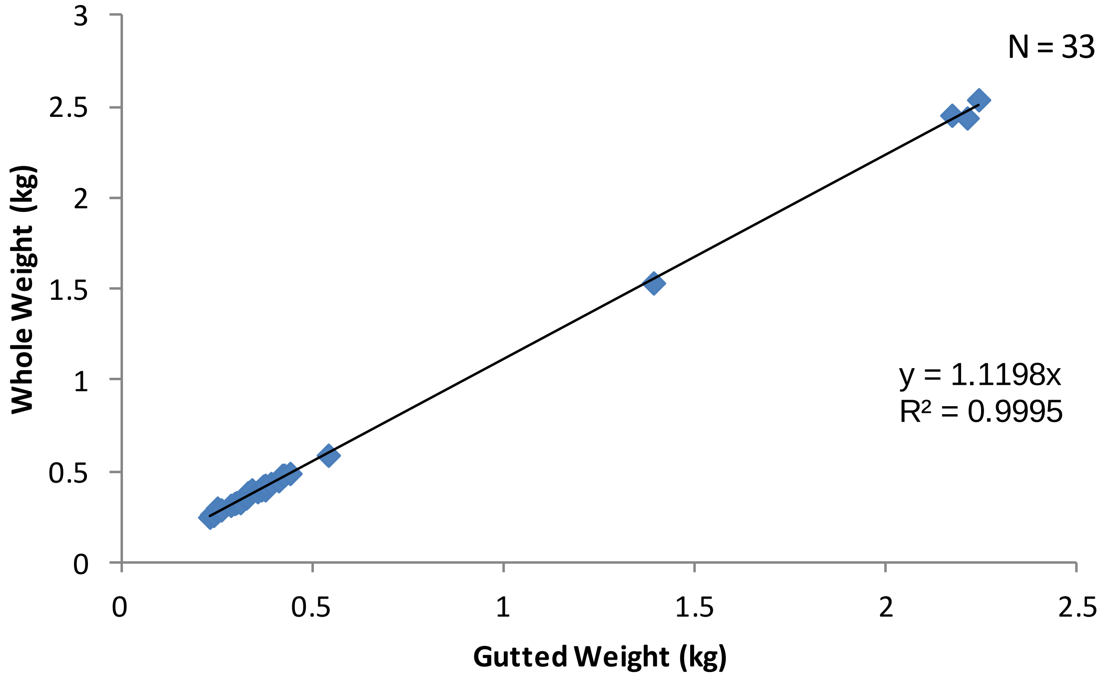

Figure 40. Gutted weight (kg) to whole weight (kg) relationship for Spanish mackerel with intercept set at zero.

Hogfish

The number of hogfish sampled was 31 with samples coming from Brunswick (n=18) and New Hanover (n=13) counties (Table 3). Hogfish sampled ranged in size from 450 mm to 800 mm FL (Figure 41). The conversion factor for hogfish calculated from this study was estimated to be 1.04 (Table 6 and Figures 42 and 43). The relationship between various length measurements and between whole weight and length are reported in Tables 7 and 8 and illustrated in Figure A27.

Multiple regression analysis indicated that gender*gutted weight ($p = 0.9630$) was an insignificant factor on whole weight. However, season*gutted weight ($p = <0.0001$) and county*gutted weight ($p = 0.001$) were both significant factors on whole weight indicating that the calculated conversion factors across seasons and counties were significantly different. Figure A28 contains a scatter plot of the gutted weight and whole weight relationship by gender and county.

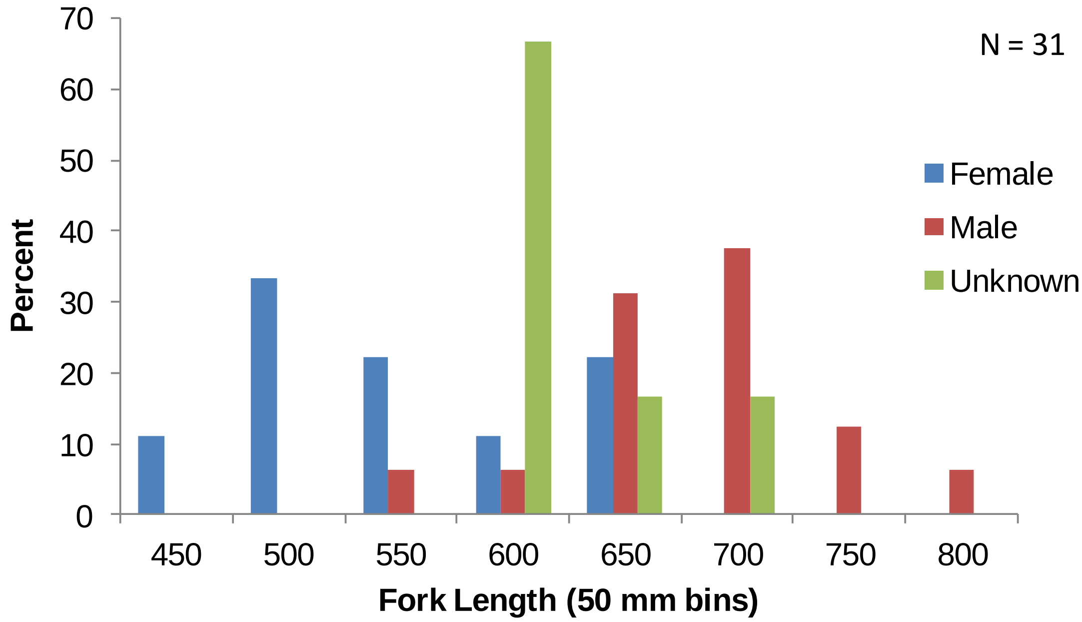

Figure 41. Length frequency (50 mm bins) for hogfish.

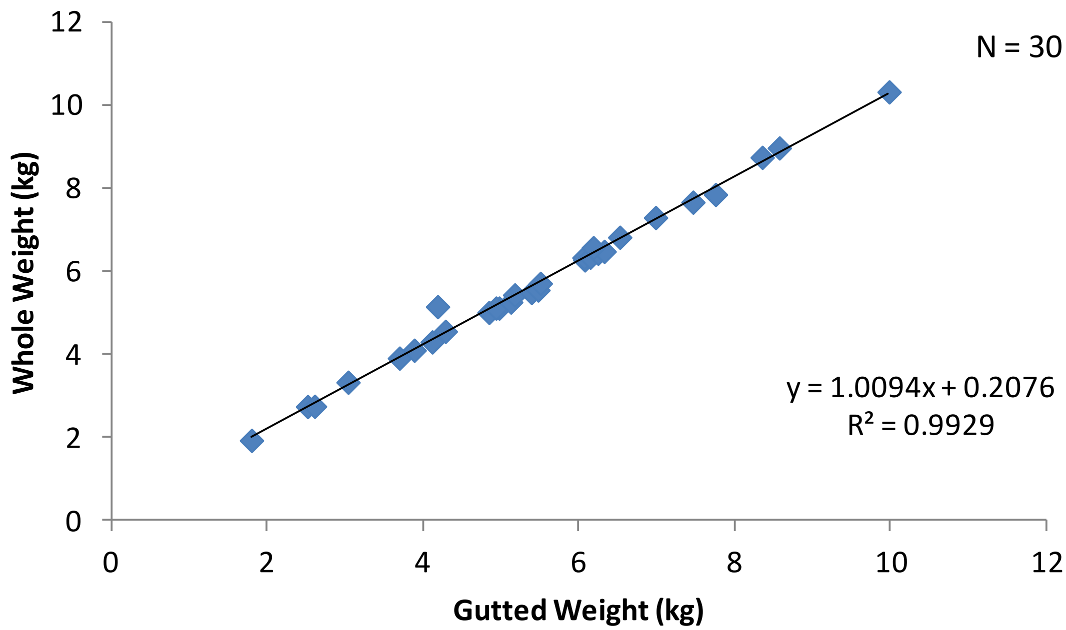

Figure 42. Gutted weight (kg) to whole weight (kg) relationship for hogfish.

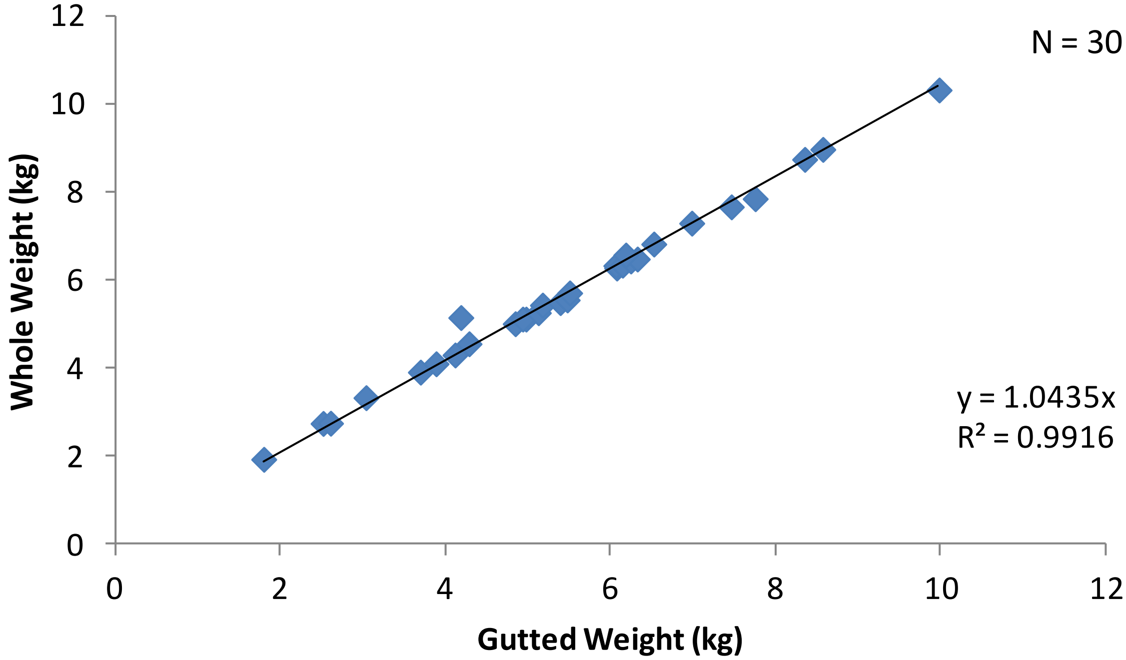

Figure 43. Gutted weight (kg) to whole weight (kg) relationship for hogfish with intercept set at zero.

Grouper Comparison

A multiple regression analysis was used to determine if species within the same group of fish had significantly different gutted to whole weight conversion factors. All grouper species that had a sample size of at least 30 were included (gag grouper, red grouper, scamp, red hind, and rock hind). The interaction term of species*gutted weight ($p = <0.0001$) was a significant factor affecting whole weight indicating that the conversion factor between species is significantly different.

In 2011, 150,153 lbs of gag grouper (gutted condition) were landed in North Carolina. Using the current conversion factor of 1.25, it is estimated that whole pounds of these gutted wish is 187,691 lbs. Applying the conversion factor calculated from this study of 1.07 yields an estimate of 160,663 lbs. whole weight.

SHELLFISH RESULTS

Although a large number of individual shellfish during this project period were sampled (Table 1), the number of marketed units (bushels, bags, etc.) was relatively small. Shellfish sampling occurred during the winter months when most fishing of offshore species is at a minimum and peeler crabs are only sampled during the short spring season. In total, four bushels of oysters were sampled during this study. Several hard clams, peeler blue crabs, and sea urchins were also collected. All data were combined with those collected from the pilot study. No additional data were collected for bay scallops or soft blue crabs so results from those species didn't change from those reported in the pilot study (Bianchi 2010).

Oyster

A total of 2,097 individual oysters were sampled from eight bushels during this study and the pilot study. Samples of oysters were obtained from Brunswick, Carteret, and Hyde counties and ranged from 20 mm to 190 mm in shell length (Figure 44).

The current conversion factor used by the NCTTP to convert oysters from bushels to pounds of meat is 5.29 pounds of meat per bushel. Table 8 shows the meat weight obtained from each bushel during the project period and the average meat weight across all bushels. All estimates were below the 5.29 conversion except for one bushel that produced 7.05 pounds of meat (Table 9). Average pounds of meat per bushel were 4.48, which is less than what was found during the pilot study which had an estimate of 5.09 (Bianchi 2010).

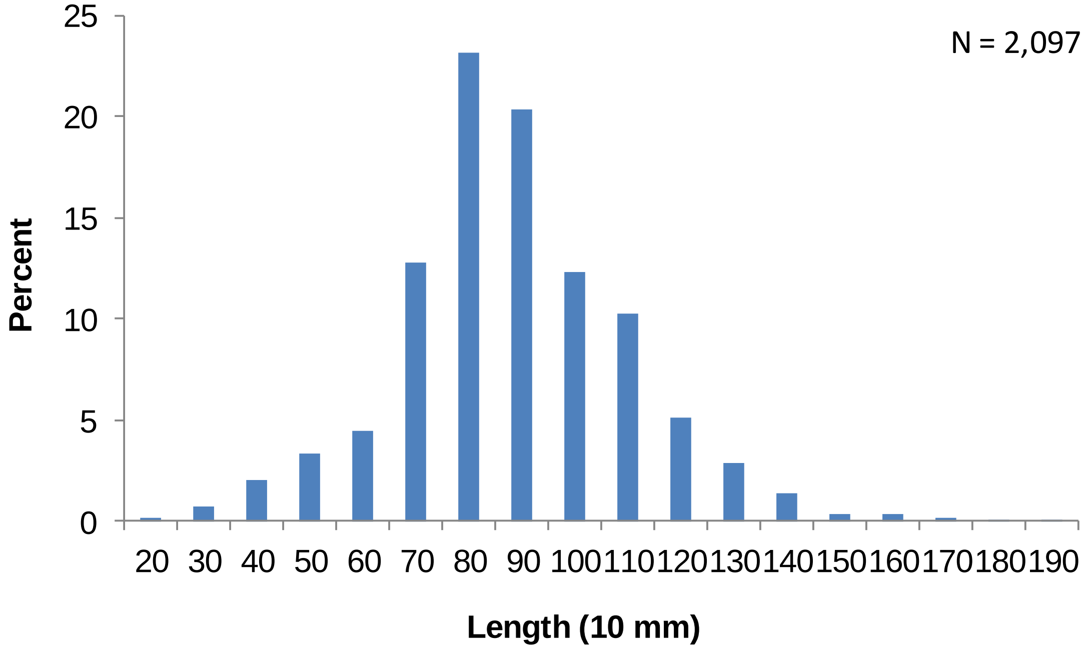

Figure 44. Shell length frequency (10 mm bins) for oysters.

Table 9. Meat weight for oysters obtained from four different bushels.

Bushel	Meat Weight
1	7.05 lb (3.20 kg)
2	4.61 lb (2.09 kg)
3	4.72 lb (2.14 kg)
4	4.03 lb (1.83 kg)
5	4.13 lb (1.87 kg)
6	4.61 lb (2.09 kg)
7	4.19 lb (1.90 kg)
8	2.49 lb (1.13 kg)
Average	4.48 lb (2.03 kg)

Hard Clam

Three hundred and sixty-two clams were sampled during the project period and the pilot study from Carteret (n=357) and New Hanover (n=5) counties and ranged from 40 mm to 90 mm in shell length (Figure 45).

Hard clams are typically marketed by market grade in numbers or bags. Hard clams sampled for this project were from three market grades: cherrystones (1 ¾" to 2" in thickness), topnecks(1 ½" to 1 ¾" in thickness) and, littlenecks (1" to 1 ½" in thickness) however, most of the samples were littlenecks and topnecks. The current conversion for each market grade and the calculated conversion for each market grade are reported in Table 10. All of the calculated conversions were higher than the currently used conversion factor.

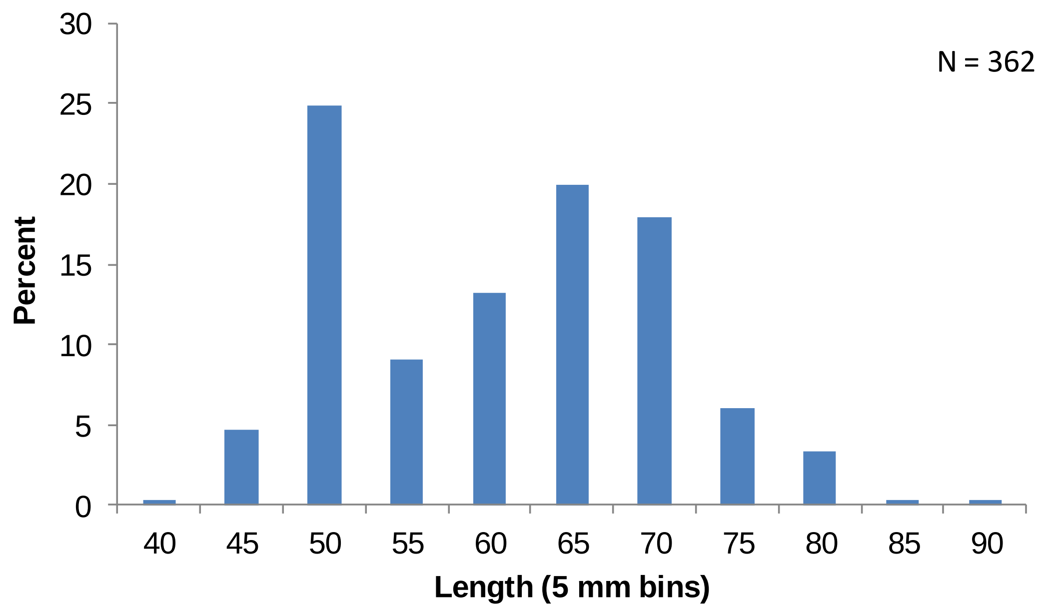

Figure 45. Shell length frequency (5 mm bins) for hard clams.

Table 10. Total number of hard clams by market grade, sampled meat weight, calculated conversion and current conversion used by the NCTTP.

Market Grade	Observations	Meat Weight	Calculated Conversion	NCTTP Conversion
Cherrystone	62	2.84 lb (1.288 kg)	0.046	0.029
Littleneck	138	4.11 lb (1.862 kg)	0.030	0.013
Topneck	162	5.78 lb (2.621 kg)	0.036	0.019

Peeler Crabs

Peeler crabs were sampled in only Beaufort County (n=77) and ranged from 80 mm to 160 mm in carapace width (Figure 46).

The majority of peeler crabs are reported in numbers harvested and the current conversion factor used by the NCTTP to determine the total weight landed is 0.33 pounds per crab. The calculated conversions from this study is 0.24 pounds for females and 0.33 pounds for males and when the samples are combined across sexes a conversion of 0.29 pounds per crab is obtained (Table 11). The relationship between carapace width and weight can be seen in Figure 47 and Table 12.

Table 11. Total number of peeler crabs sampled by sex and weight.

Gender	Observations	Pounds	LB / #	KG
Female	22	5.25	0.24	2.38
Male	51	16.69	0.33	7.57
Unknown	4	0.60	0.15	0.27
Combined	77	22.54	0.29	10.22

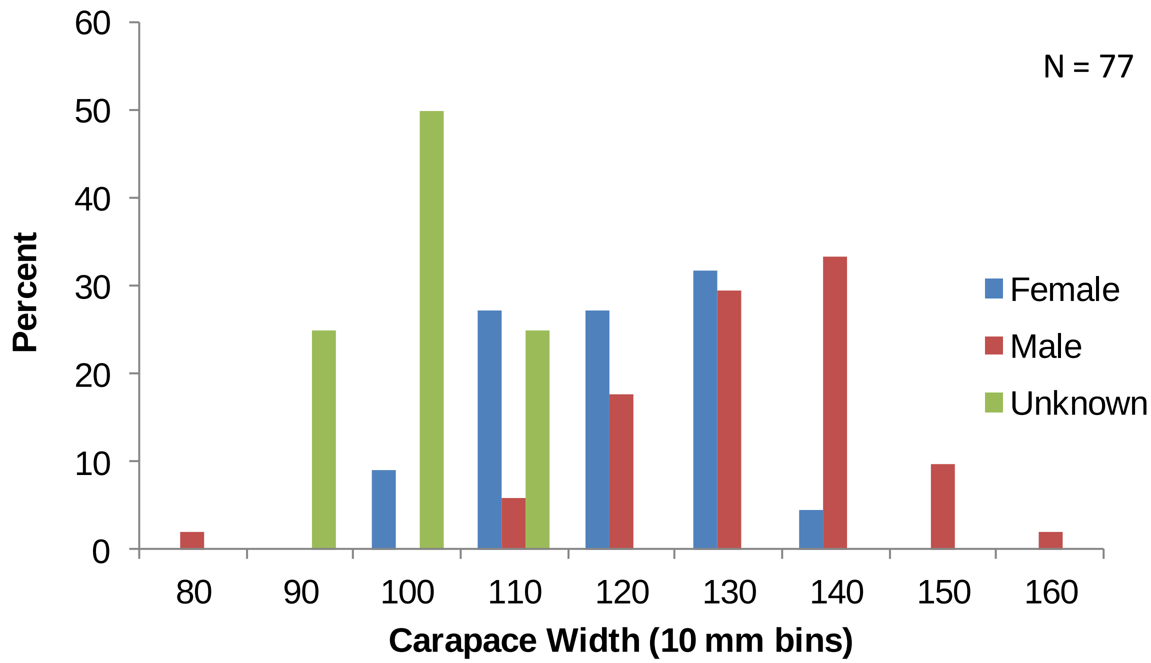

Figure 46. Carapace width (10 mm bins) frequency for peeler blue crabs.

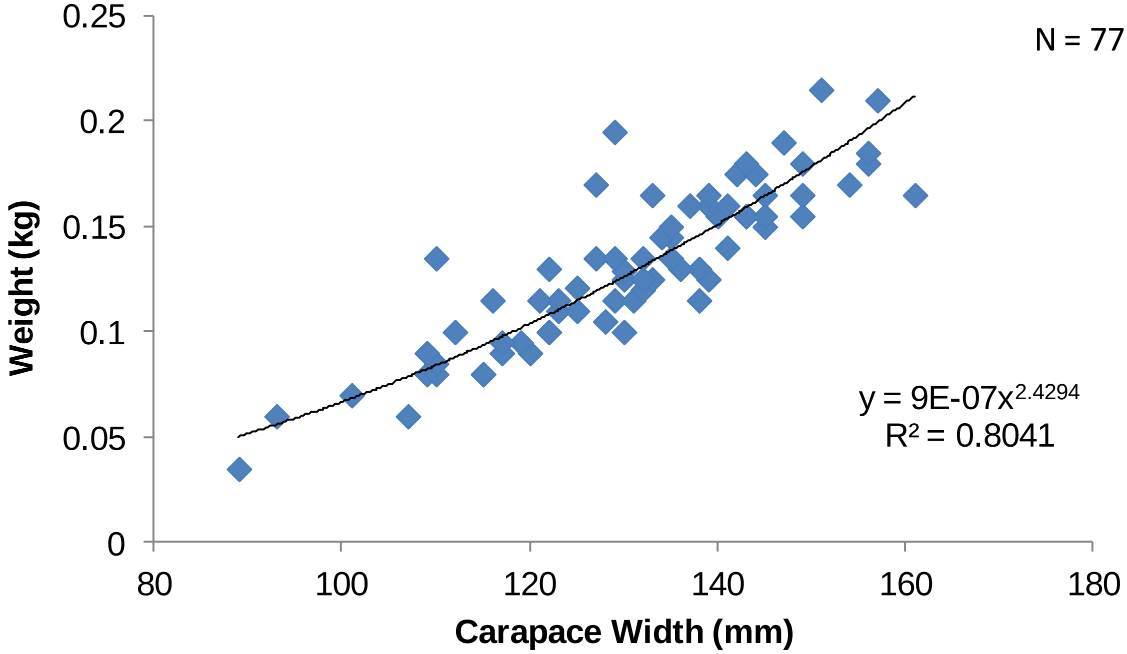

Figure 47. Carapace width (mm) and weight (kg) relationship for peeler blue crabs.

Table 12. Carapace width (mm) and weight (kg) relationship for soft and peeler blue crabs.

Species	$WW = a*CW^b$	R^2
Peeler blue crab	$W = 9^{-7}CW^{2.4294}$	0.8041

Sea Urchins

Sea urchins were sampled in only New Hanover County (n=31). The total weight sampled was 4.14 kg (9.13 lb). The current conversion factor for the NCTTP is 0.04 lb per individual. This study had a conversion factor of 0.30 lb per individual.

DISCUSSION

Although it is a common practice to use conversion factors to determine the whole weight for commercial landings, different factors are used from state to state. Hesselman and Kemp (2006) noted this inconsistency in a preliminary assessment of conversion factors used by states along the Atlantic coast that were sent to the Atlantic Coast Cooperative Statistics Program (ACCSP). This inconsistency between states is also commonly noted during the Southeast Data, Assessment, and Review (SEDAR) Data Workshops. As a result, the SEDAR Data Workshops generally use a calculated, gutted to whole weight conversion factor from independent sampling programs and apply that conversion factor to commercial landings for modeling purposes.

Varying conversion factors across regions lead to confusion with fisheries managers and fishermen. Inaccurate conversion factors can also have impacts on those species that are managed under quotas and that may be pre-processed (or gutted) at sea. Questions about these situations occurred over the summer of 2012 with gag grouper through the South Atlantic Fisheries Management Council Facebook webpage. When the gag grouper fishery was quickly approaching its quota limit, questions were raised about which conversion factors were used to help keep track of the quota, which is based on gutted weight. Although the quota is tracked by gutted weight there are a number of commercial fishing operations that conduct single day trips and land their gag grouper in a whole condition. Applying the appropriate conversion factor to these landings is important to track the quota appropriately and it was unclear what conversion factor was being used.

Differences between conversion factors calculated in this study and conversion factors currently in use by the NCTTP varied by species. Gutted to whole weight conversion factors currently used by the NCTTP for groupers (gag grouper, red grouper, scamp, red hind, and rock hind) appear to be over-estimated at 1.25 when the calculated conversion factor for these groupers sampled in this study ranged from 1.06 to 1.07. However, the conversion factor used by the NCTTP for vermilion snapper (1.08) was confirmed with this study and the pilot study (Bianchi 2010). The calculated conversion factors for king mackerel, wahoo, dolphin, and squirrelfish from this study were all higher than those currently used by the NCTTP. Those conversion factors calculated for yellowfin tuna, blueline tilefish, Spanish mackerel, and hogfish were lower than those currently used by the NCTTP (Table 6).

For shellfish species, the preliminary results indicate the conversion factor for oysters from bushels to pounds of meat used by the NCTTP of 5.29 might be over-estimating the total meat weight (Table 9). For hard clams, preliminary results indicate the market grade conversions currently used by the NCTTP are too low and may be underestimating the meat weight of hard clams (Table 10). For peeler crabs, the NCTTP uses a conversion of 0.33 pounds per crab and the preliminary results from this study ranged from 0.15 to 0.33 pounds per crab (Table 10). However, DMF sampling of peeler crabs from Program 436 were generally of smaller size and covered a broader area than the current program and showed a conversion factor of 0.17 to 0.25 pounds per crab. The conversion factor for sea urchins was also determined to be larger (0.30 lb) per individual than what is currently (0.04 lb) used.

Multiple regression analysis indicated that the gutted to whole weight conversion factor is significantly affected by gender, season, and area for some species, while other species did not show an effect. Gag grouper, red grouper, king mackerel, and hogfish showed significant effects due to season and county. Gender had a significant effect on dolphin, rock hind, and squirrelfish. Gender and season had a significant effect on the conversion factor for blueline tilefish. Vermilion snapper, scamp, yellowfin tuna, red hind, and Spanish mackerel had no significant effects from gender, season, or area. The mechanism as to why these various factors had an impact or didn't have an impact is still unclear. The effect of season was most likely due to changes in bait and prey availability, as it was noted during many of the sampling trips that the species composition of the stomachs was quite variable. Also the presence of growths/tumors and parasites in some of the samples was also noted, which may have an impact on the gutted to whole weight ratio. Although county had a significant effect on some of the species sampled, it was hard to determine a solid pattern (e.g. conversion factor smaller in the southern counties) and is probably more indicative of the areas being fished as opposed to where the landings occur. Gender was not a significant factor in the majority of these species; however this was probably because many of these species are not available for harvest during their spawning periods, for instance the four month closed spawning season for groupers. For those species in which gender was a significant factor, females had larger conversion factors except for squirrelfish. Also, season was generically defined and was not defined based on spawning season for each species. This may have resulted in some of the analyses showing insignificant effects due to the spawning seasons spanning over the generically defined season.

Multiple regression analysis also determined that using a single conversion factor for groupers is not appropriate. The gutted to whole weight conversion factor for gag, scamp, red hind, and rock hind were significantly different from each other suggesting that each grouper species should have its own conversion factor. Other species assemblages could not be analyzed because there were not enough samples collected.

Other multiple regression analysis methods should also be explored when these data are combined with those from the other states. Methods such as Akaike information criterion (AIC) should be used to compare competing models and determine which model has the best fit. The individual datasets from each state should be compiled into one large dataset and new regression models developed. Parameters that were not significant in North Carolina could vary along the coast. Life history parameters such as length at age are known to vary lattitudinally (Shepard 1991; Potts et al. 1998; Potts and Manooch 2001) and these differences might influence the conversion equations developed in this paper.

The samples collected across shellfish species was relatively low in this study and further sampling needs to be completed to validate the conversion factors that are currently used for those species. It is also likely that the conversion factor for oysters, hard clams, and blue crabs may be influenced by area or water body. For example, it is typical for oysters to be smaller in the southern regions of the state. Also, oysters in the southern part of the state are more likely to clump up and form clusters versus larger single oysters harvested from subtidal waters in the central and northern parts of the state. As a result of this effect, we sampled a number of undersized oysters which could have an effect on conversion calculations. We also were not able to collect samples of horseshoe crabs, whelks, and other shellfish that all have conversion factors that need to be evaluated and validated due to time constraints and lack of sampling opportunities.

Collecting sufficient samples of a number of finfish species was also problematic. Obtaining samples of some of the larger pelagic species, such as swordfish, and sharks was difficult. This was primarily due to the short availability for these species and in difficulty in contacting fishermen and seafood dealers. These fleets are highly mobile and the majority of these fisheries land in counties north of where the technician was stationed making it hard to coordinate sampling activities. It will most likely take a specific study to obtain samples from these fisheries.

OUTREACH

As part of an outreach program to help obtain samples during this project, approximately 30 t-shirts were designed and printed with key species sampled during the project and handed to those fishermen and industry representatives that helped us obtain samples. The technician from this project also helped gather samples for a stomach content study being conducted at the University of North Carolina at Wilmington by Dr. Fred Sharff, samples for a bluefin tuna otolith collection program from the University of Maryland, and samples for the South Carolina Department of Natural Resources MARMAP program. As a result, our technician also received help from staff of those respective agencies and organizations fostering stewardship and cooperation.

CONCLUSION

The results of this gutted to whole weight conversion factor study showed that the conversion factors used by the NCTTP need to be updated for some species and are accurate for other species. The data from this study need to be combined from those obtained from other member states of the ACCSP and further analysis conducted to determine the next step in getting these conversion factors updated and standardized.

LITERATURE CITED

Bianchi, A. 2010. Pilot Study of Conversion Factors Used by the North Carolina Trip Ticket Program. Final Report for NOAA Award NA05NMF4741003. North Carolina Division of Marine Fisheries, Morehead City, North Carolina, 33 pp.

Hesselman, D and G. Kemp. 2006. ACCSP Conversion Factor Assessment Summary of Findings. North Carolina Division of Marine Fisheries, Morehead City, North Carolina. 19 pp.

Lupton, B. Y. and P. S. Phalen. 1996. Designing and Implementing a Trip Ticket Program. North Carolina Division of Marine Fisheries, Morehead City, North Carolina. 32 pp + appendices.

NMFS. 1990. NMFS Conversion Factors. NMFS, Silver Spring, Maryland. 58 pp.

Potts, J.C., C.S. Manooch, III, and D.S. Vaughan. 1998. Age and growth of vermilion snapper from the Southeastern United States. Transactions of the American Fisheries Society 127: 787-795.

Potts, J.C., and C.S. Manooch III. 2001. Differences in age and growth of white grunt from North Carolina and South Carolina compared with southeast Florida. Bull. Mar. Sci. 68:1-12.

Sabo, L. 2001. Interstate Fisheries Management Program Implementation for North Carolina: North Carolina Commercial Statistics System Enhancement, April 1999-September 2001. North Carolina Division of Marine Fisheries, Morehead City, North Carolina. 119 pp.

SAS®. 2004. SAS/STAT® User's Guide, Version 9.1, Volume 1, Cary, North Carolina: SAS Institute Inc. 809 pp.

Shepherd, G.R. 1991. Meristic and morphometric variation in black sea bass north of Cape Hatteras, North Carolina. North American Journal of Fisheries Management. 11:139-148.

Watterson, J. C. 1999. Interstate Fisheries Management Program Implementation for North Carolina: North Carolina Commercial Statistics System Enhancement, April 1996-March 1999. North Carolina Division of Marine Fisheries, Morehead City, North Carolina. 182 pp. + appendix.

APPENDIX

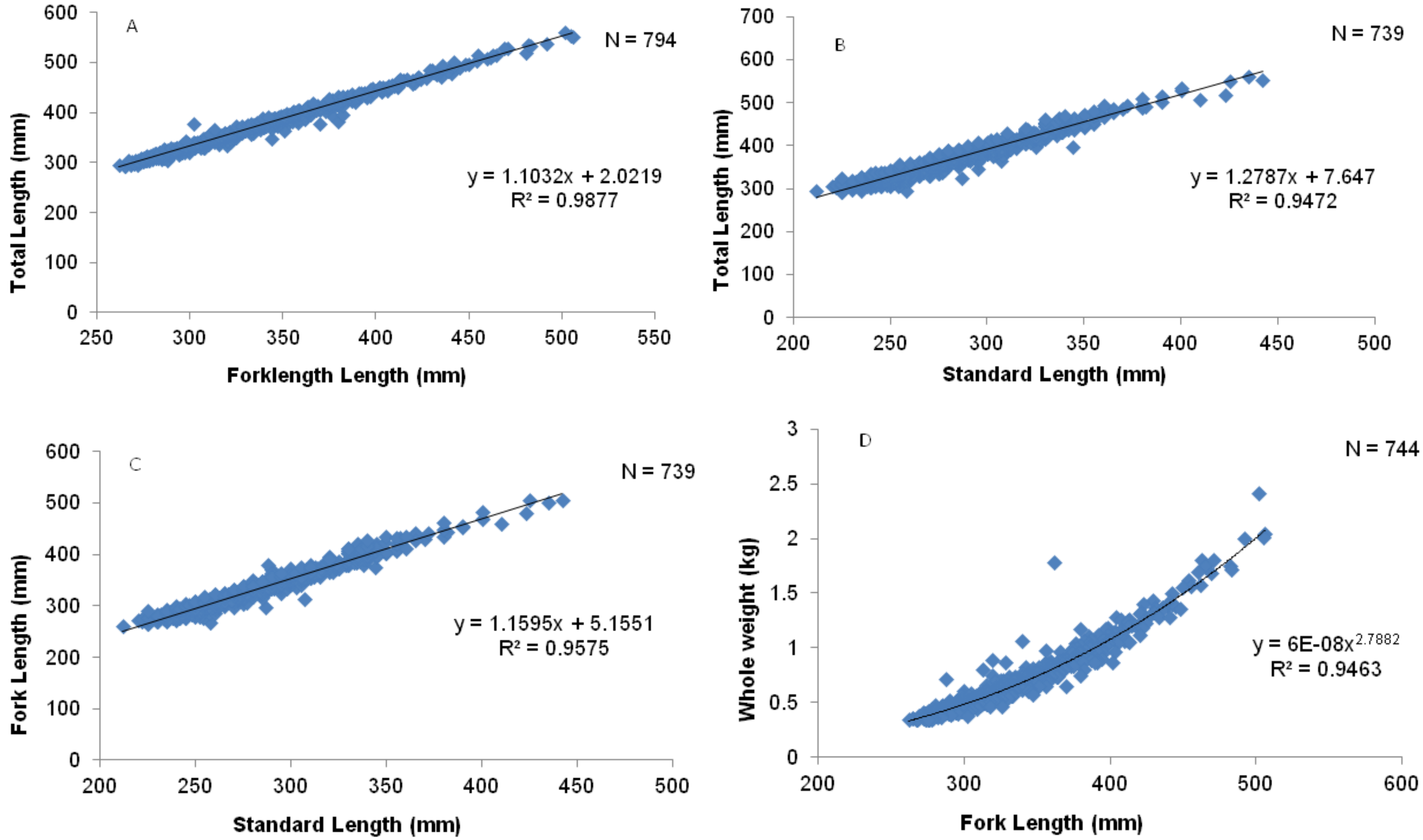

Figure A1 (A) Fork length (mm) to total length (mm), (B) standard length (mm) to total length (mm), (C) standard length (mm) to fork length (mm), and (D) fork length (mm) to whole weight (kg) relationships for vermilion snapper.

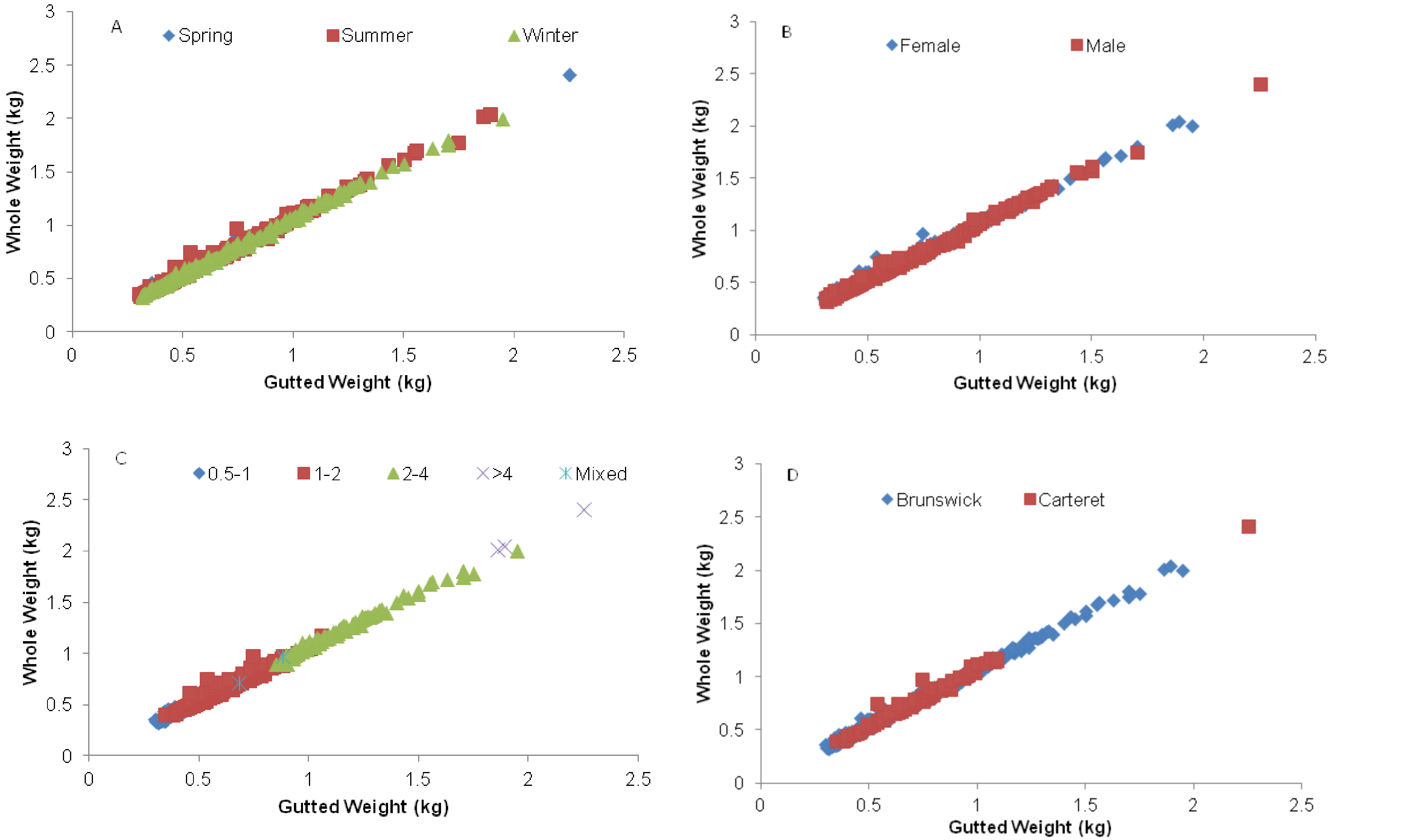

Figure A2. (A) Gutted weight (kg) to whole weight (kg) by season, (B) gutted weight (kg) to whole weight (kg) by gender, (C) gutted weight (kg) to whole weight (kg) by market grade, and (D) gutted weight (kg) to whole weight (kg) by county scatter plots for vermilion snapper.

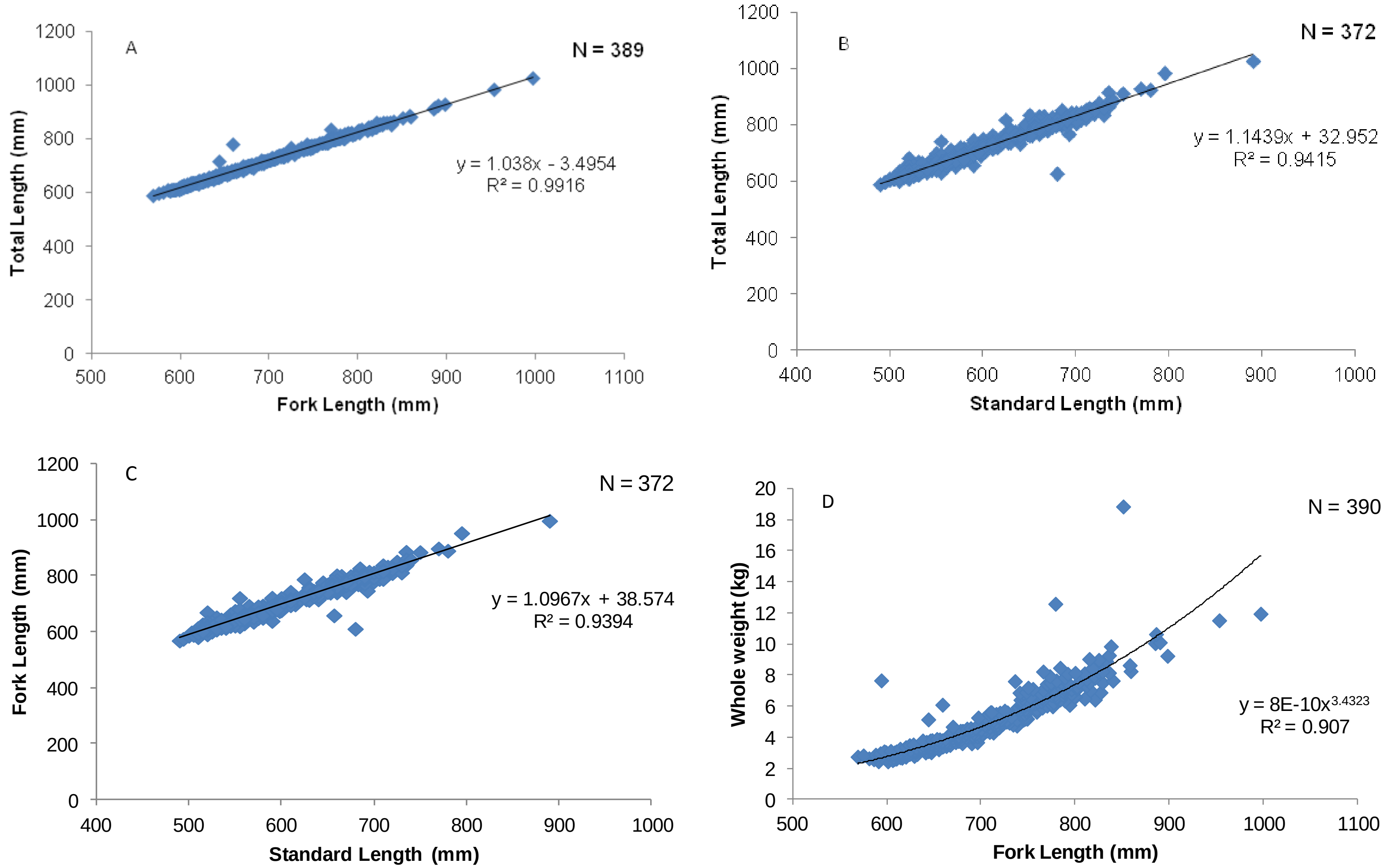

Figure A3. (A) Fork length (mm) to total length (mm), (B) standard length (mm) to total length (mm), (C) standard length (mm) to fork length (mm), and (D) fork length (mm) to whole weight (kg) relationships for gag grouper.

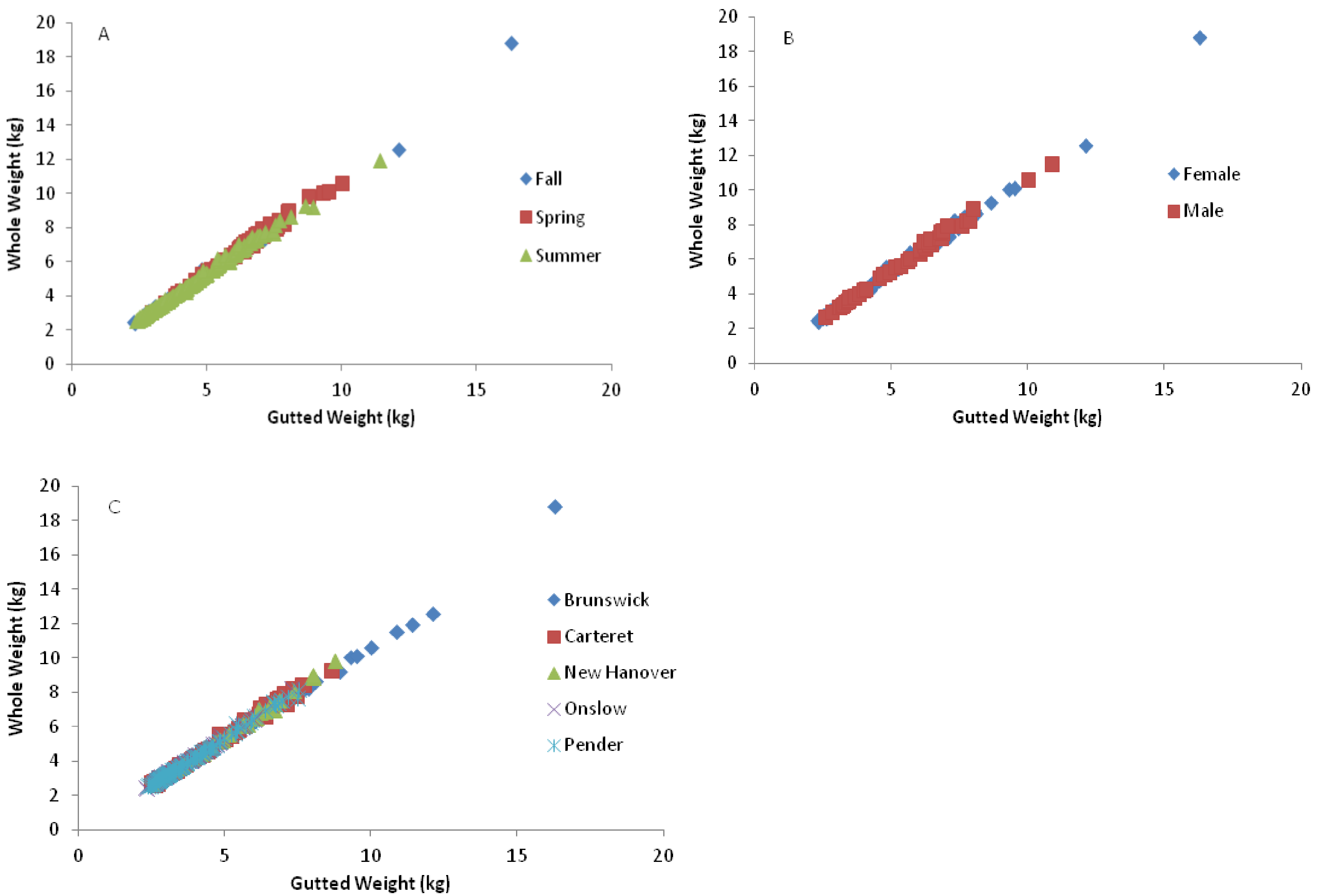

Figure A4. (A) Gutted weight (kg) to whole weight (kg) by season, (B) gutted weight (kg) to whole weight (kg) by gender, and (C) gutted weight (kg) to whole weight (kg) by county scatter plots for gag grouper.

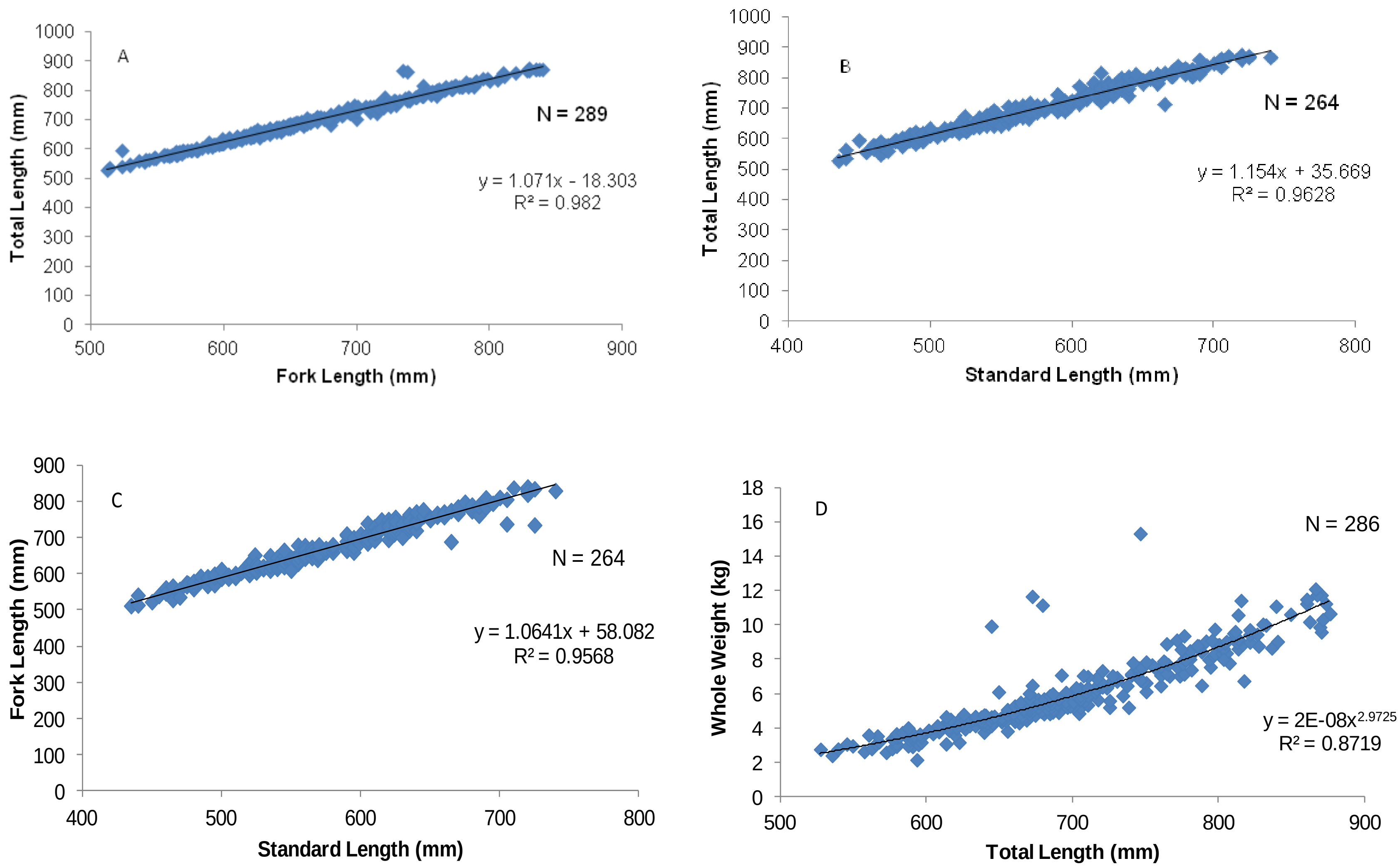

Figure A5. (A) Fork length (mm) to total length (mm), (B) standard length (mm) to total length (mm), (C) standard length (mm) to fork length (mm), and (D) total length (mm) to whole weight (kg) relationships for red grouper.

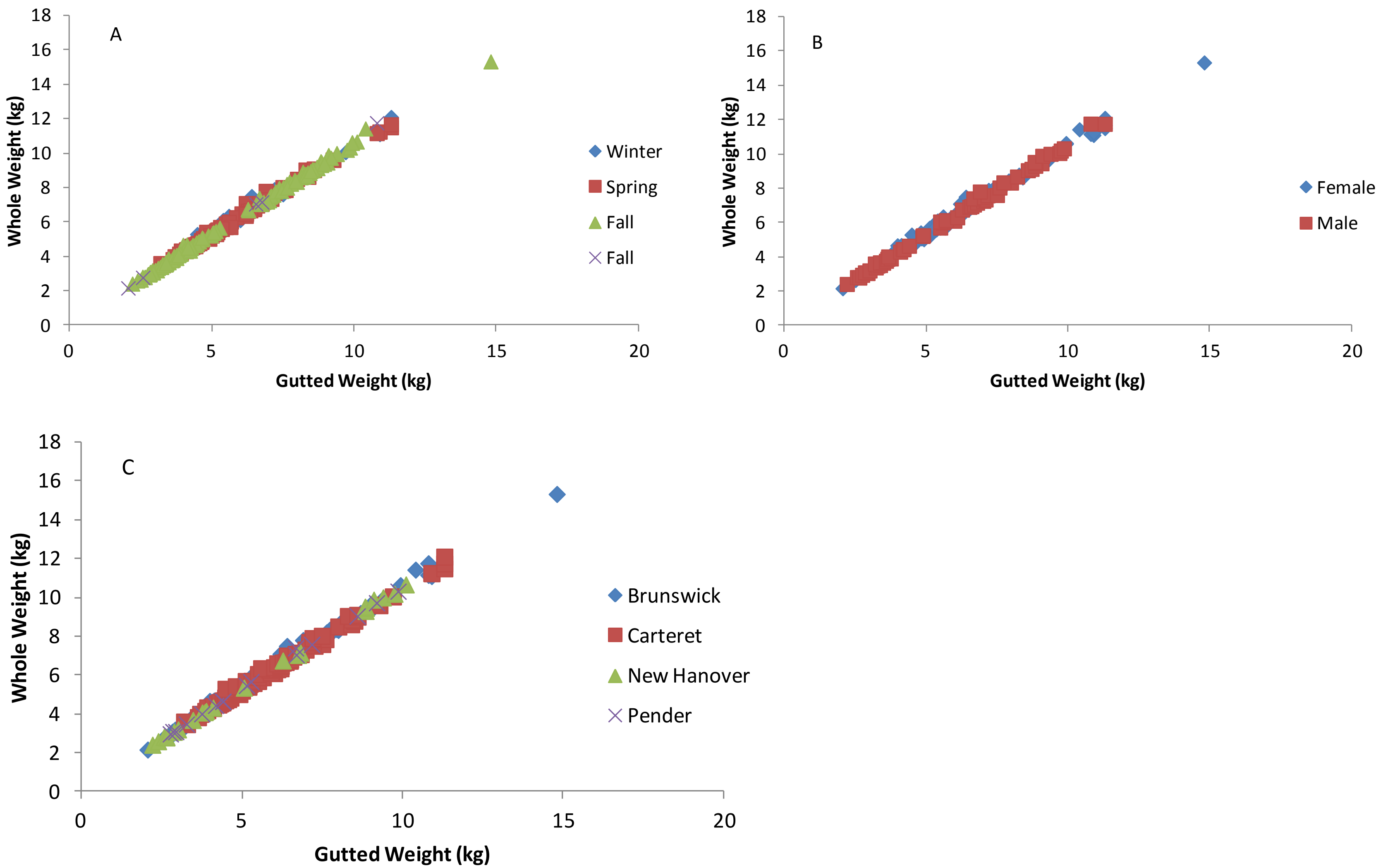

Figure A6. (A) Gutted weight (kg) to whole weight (kg) by season, (B) gutted weight (kg) to whole weight (kg) by gender, and (C) gutted weight (kg) to whole weight (kg) by county scatter plots for red grouper.

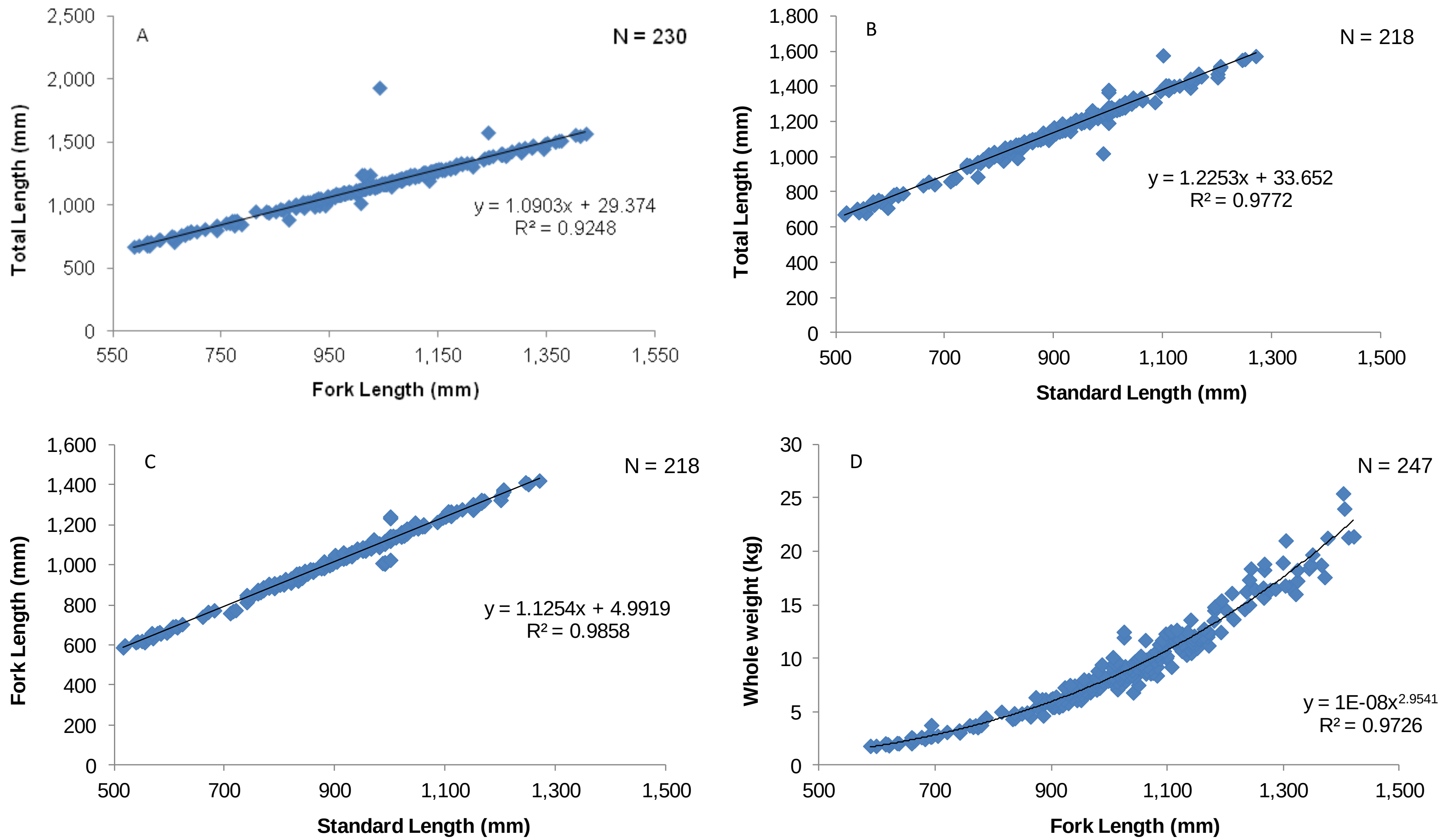

Figure A7. ((A) Fork length (mm) to total length (mm), (B) standard length (mm) to total length (mm), (C) standard length (mm) to fork length (mm), and (D) fork length (mm) to whole weight (kg) relationships for king mackerel.

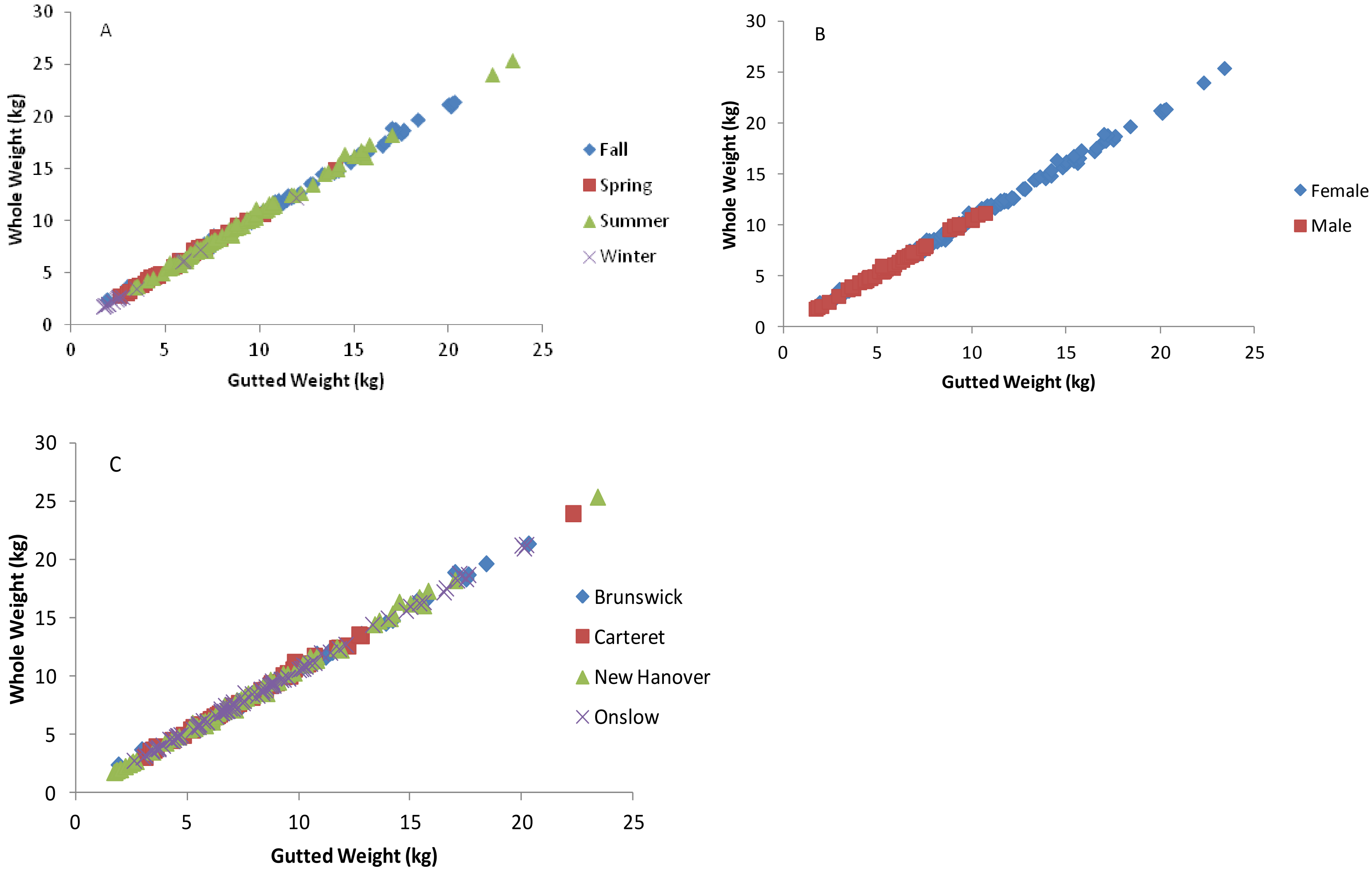

Figure A8. (A) Gutted weight (kg) to whole weight (kg) by season, (B) gutted weight (kg) to whole weight (kg) by gender, and (C) gutted weight (kg) to whole weight (kg) by county scatter plots for king mackerel.

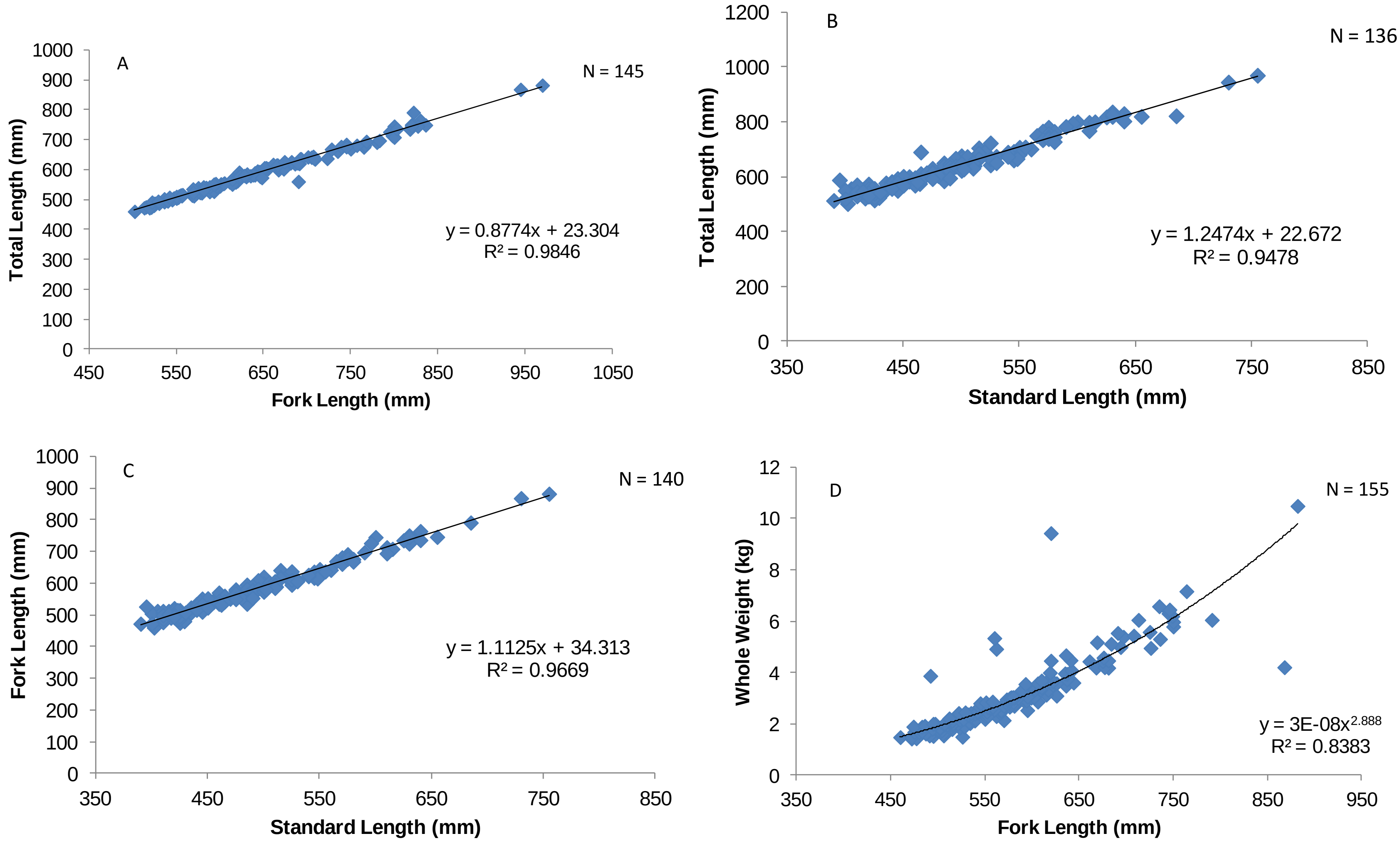

Figure A9. (A) Fork length (mm) to total length (mm), (B) standard length (mm) to total length (mm), (C) standard length (mm) to fork length (mm), and (D) fork length (mm) to whole weight (kg) relationships for scamp.

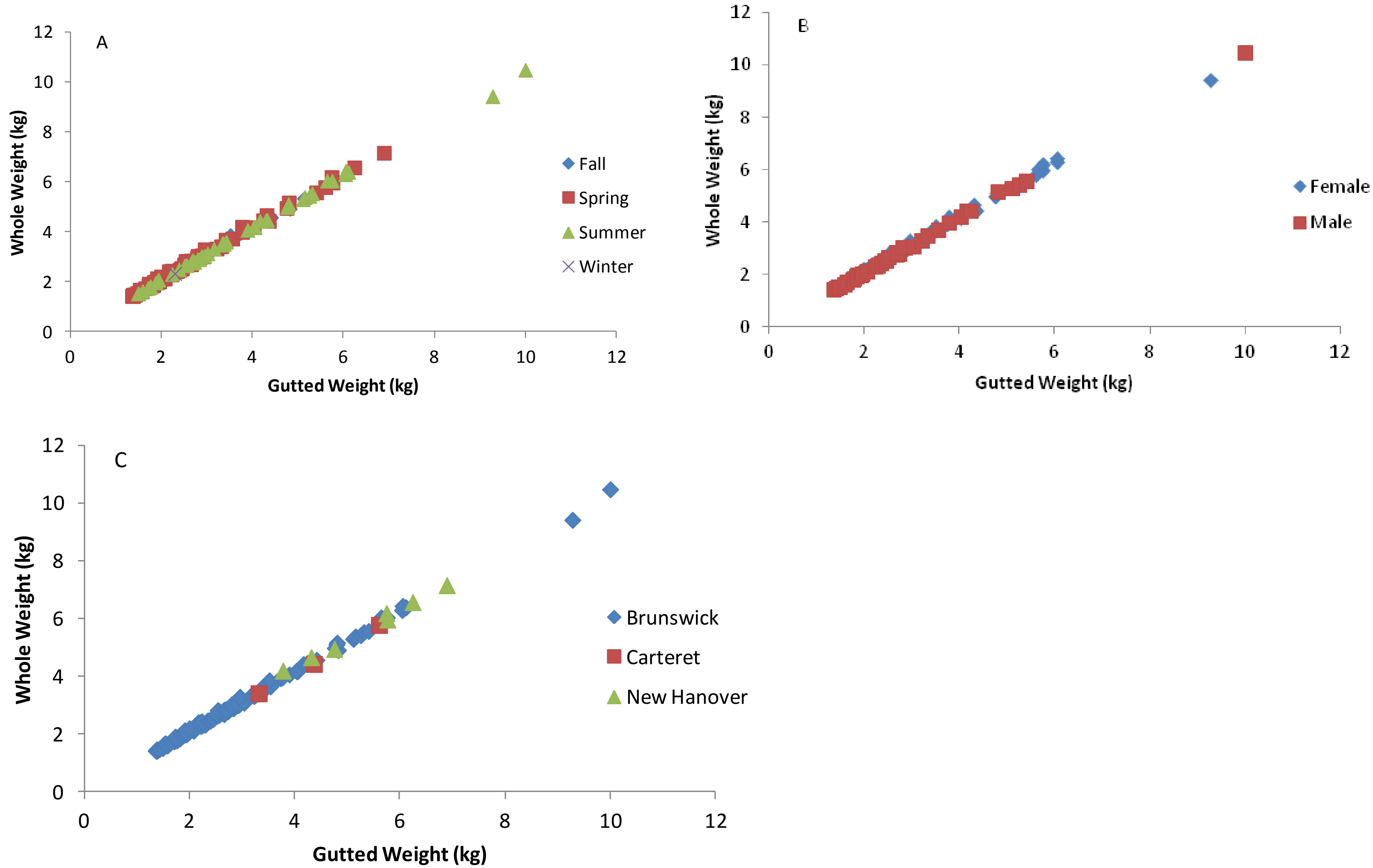

Figure A10. (A) Gutted weight (kg) to whole weight (kg) by season, (B) gutted weight (kg) to whole weight (kg) by gender, and (C) gutted weight (kg) to whole weight (kg) by county scatter plots for scamp

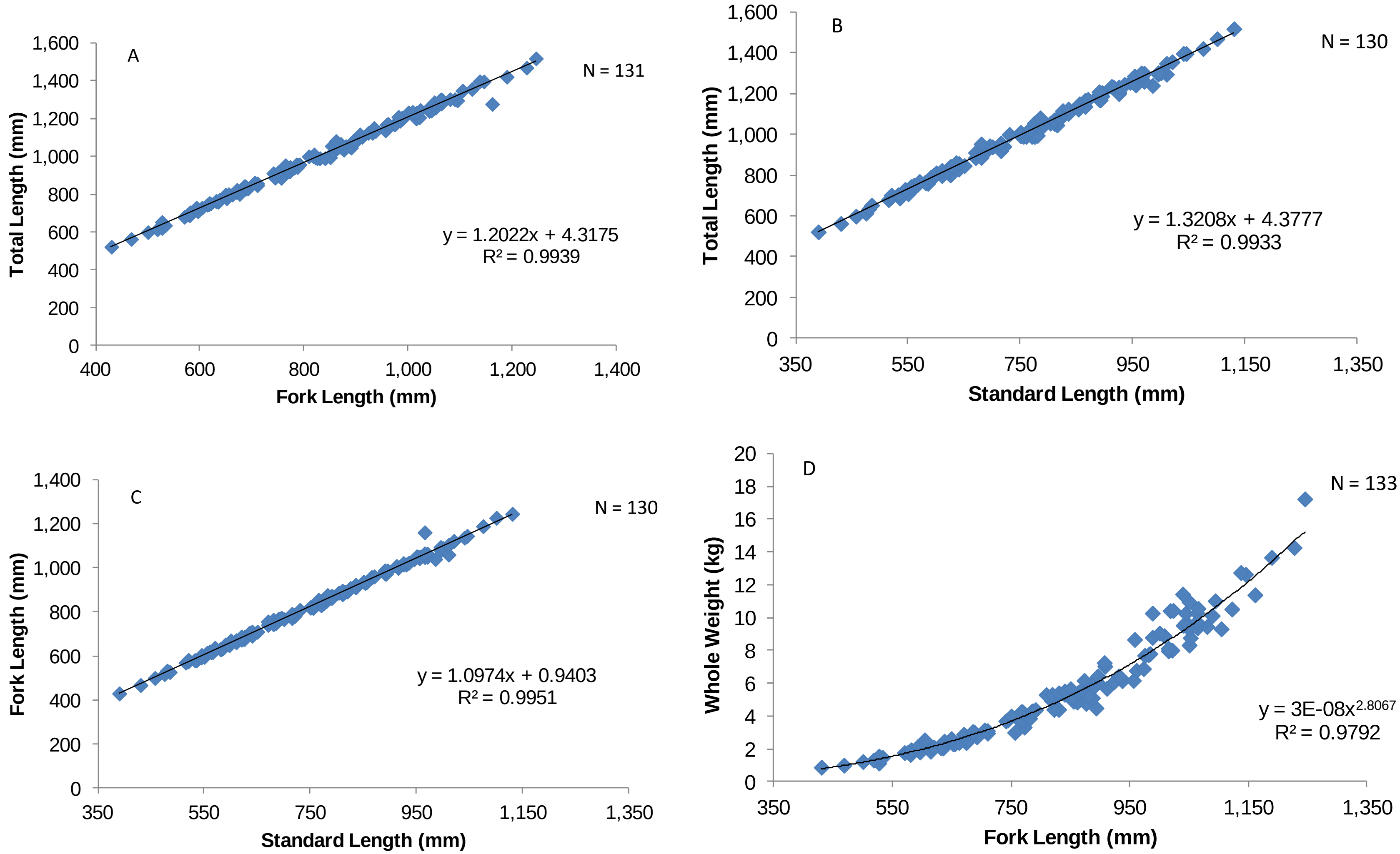

Figure A11. (A) Fork length (mm) to total length (mm), (B) standard length (mm) to total length (mm), (C) standard length (mm) to fork length (mm), and (D) fork length (mm) to whole weight (kg) relationships for dolphin.

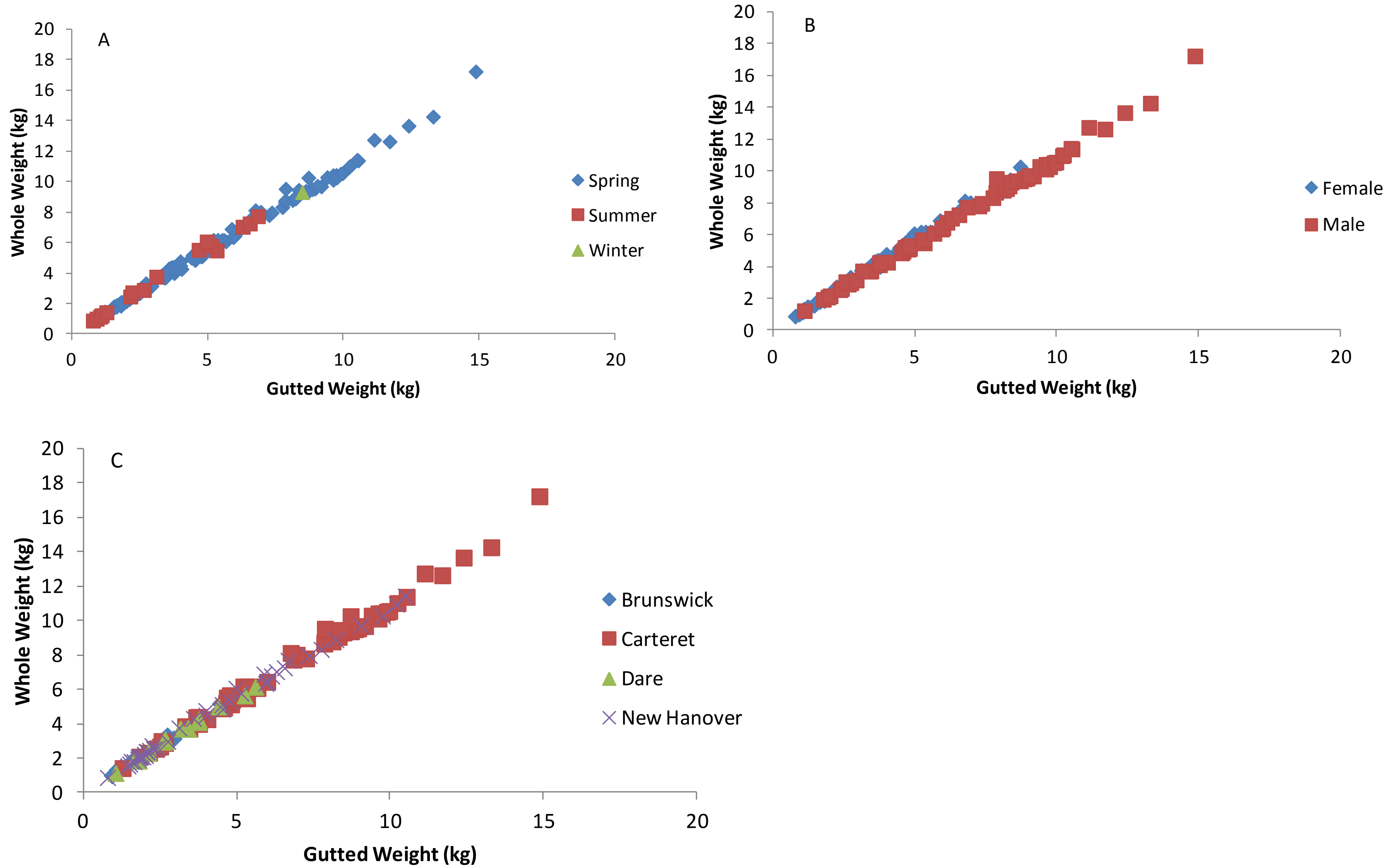

Figure A12. (A) Gutted weight (kg) to whole weight (kg) by season, (B) gutted weight (kg) to whole weight (kg) by gender, and (C) gutted weight (kg) to whole weight (kg) by county scatter plots for dolphin.

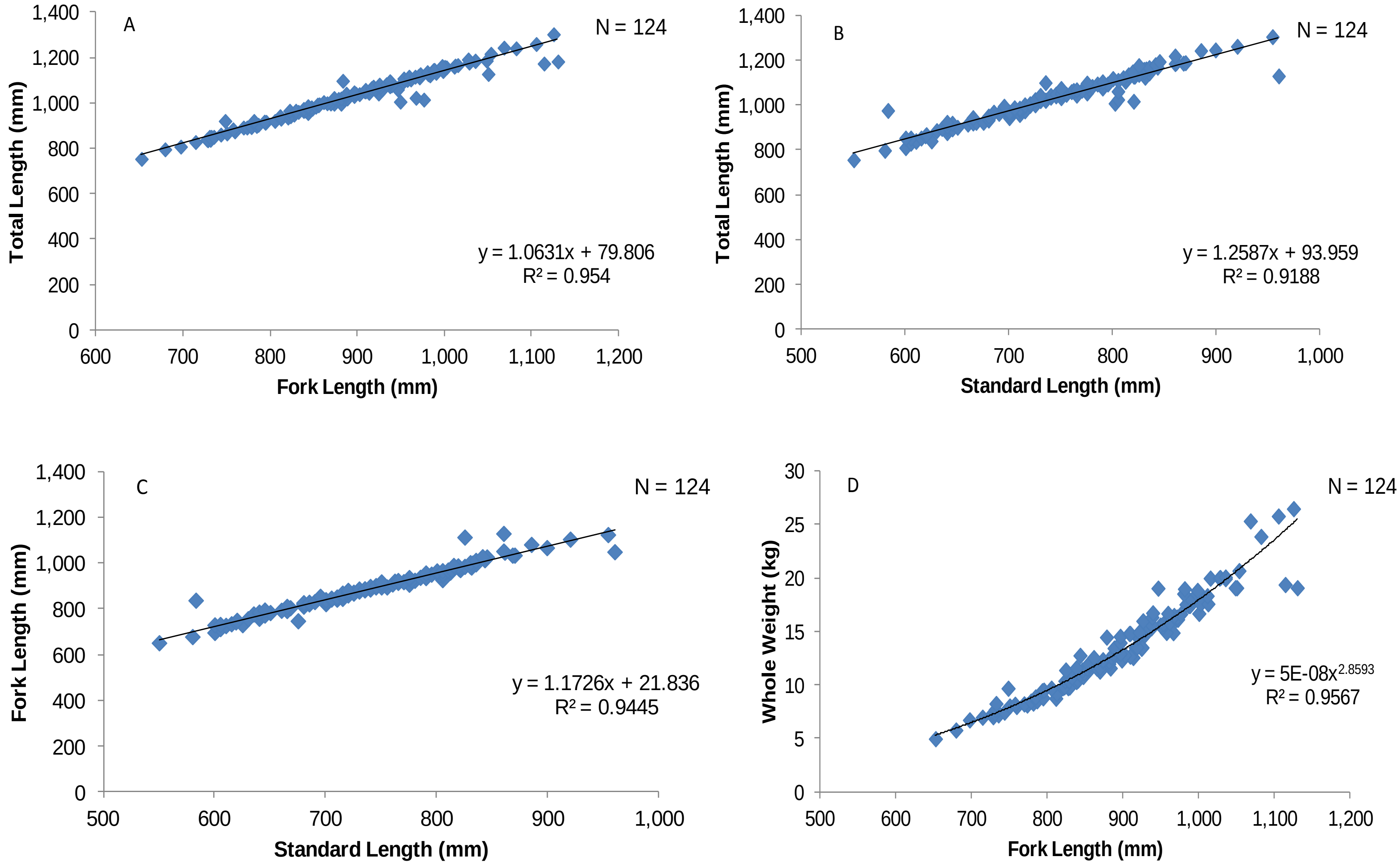

Figure A13. (A) Fork length (mm) to total length (mm), (B) standard length (mm) to total length (mm), (C) standard length (mm) to fork length (mm), and (D) fork length (mm) to whole weight (kg) relationships for yellowfin tuna.

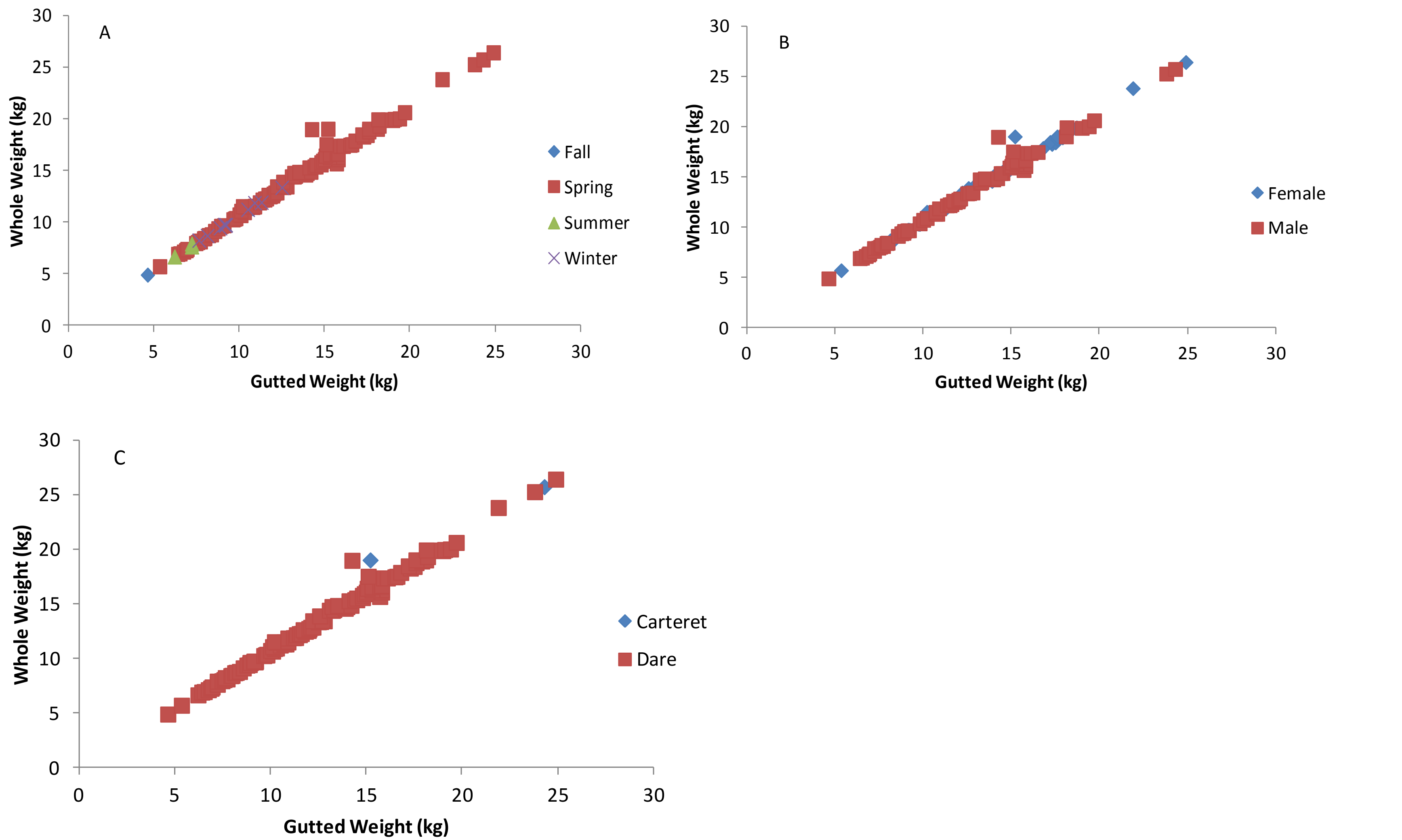

Figure A14. (A) Gutted weight (kg) to whole weight (kg) by season, (B) gutted weight (kg) to whole weight (kg) by gender, and (C) gutted weight (kg) to whole weight (kg) by county scatter plots for yellowfin tuna.

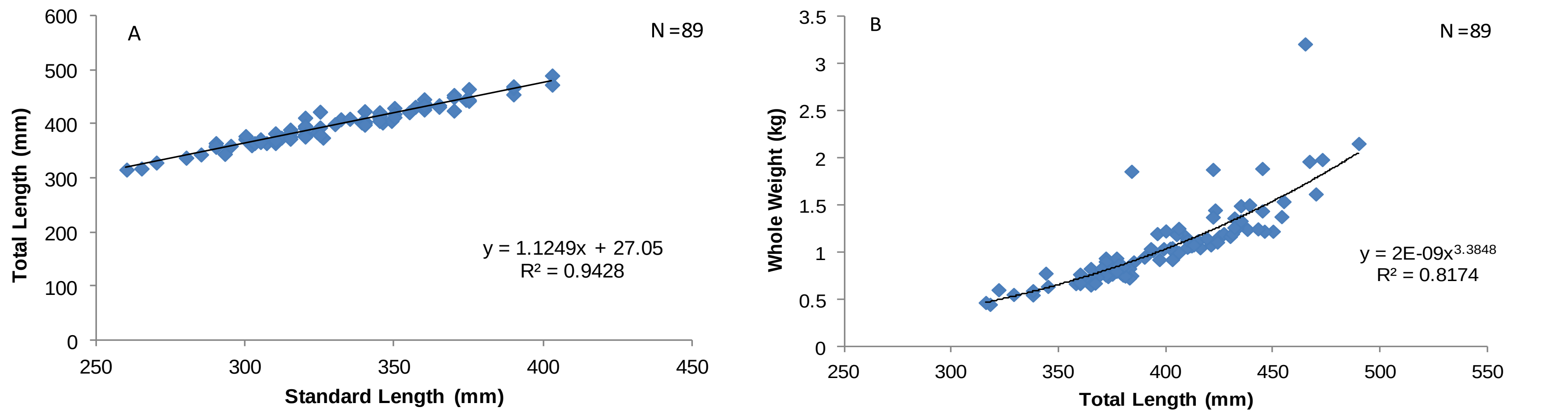

Figure A15. (A) Standard length (mm) to total length (mm) and (B) total length (mm) to whole weight (kg) relationships for rock hind.

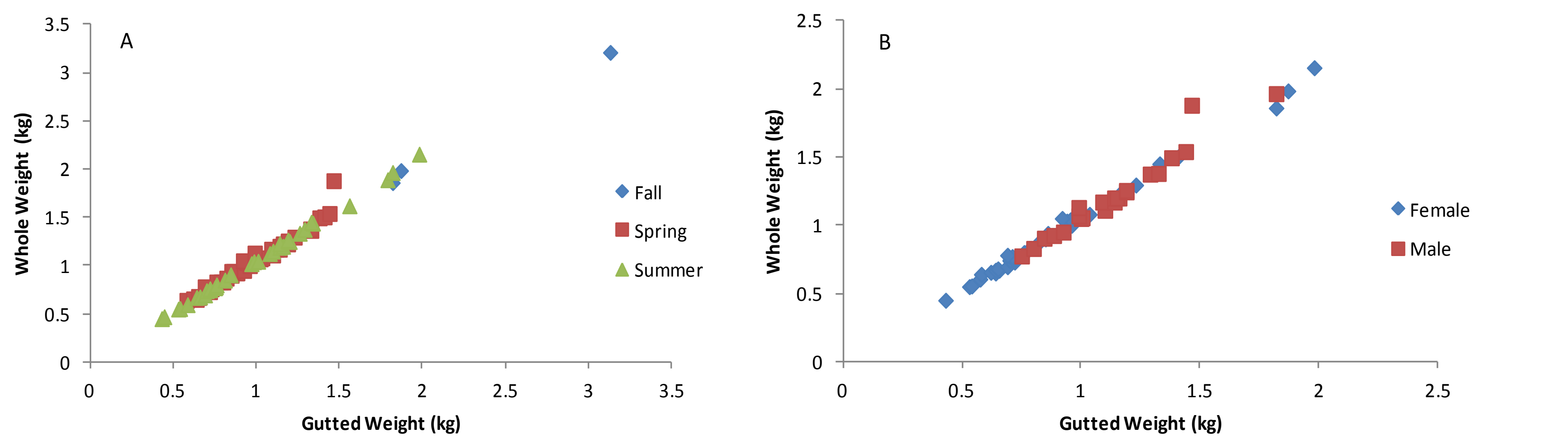

Figure A16. (A) Gutted weight (kg) to whole weight (kg) by season and (B) gutted weight (kg) to whole weight (kg) by gender scatter plots for rock hind.

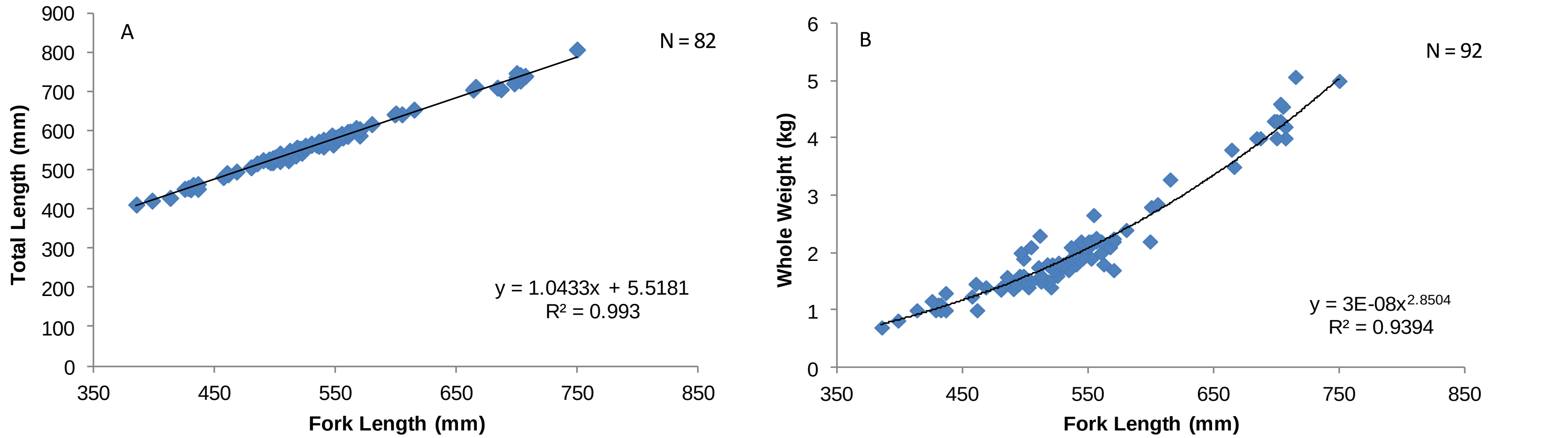

Figure A17. (A) Fork length (mm) to total length (mm) and (B) fork length (mm) to whole weight (kg) relationships for blueline tilefish.

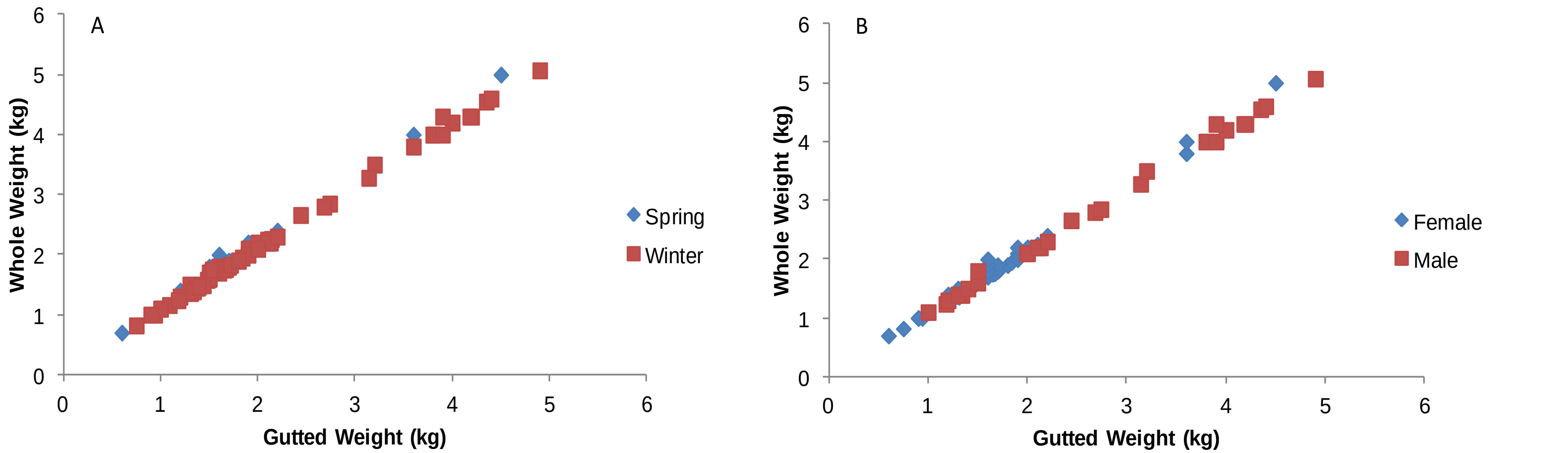

Figure A18. (A) Gutted weight (kg) to whole weight (kg) by season and (B) gutted weight (kg) to whole weight (kg) by gender scatter plots for blueline tilefish

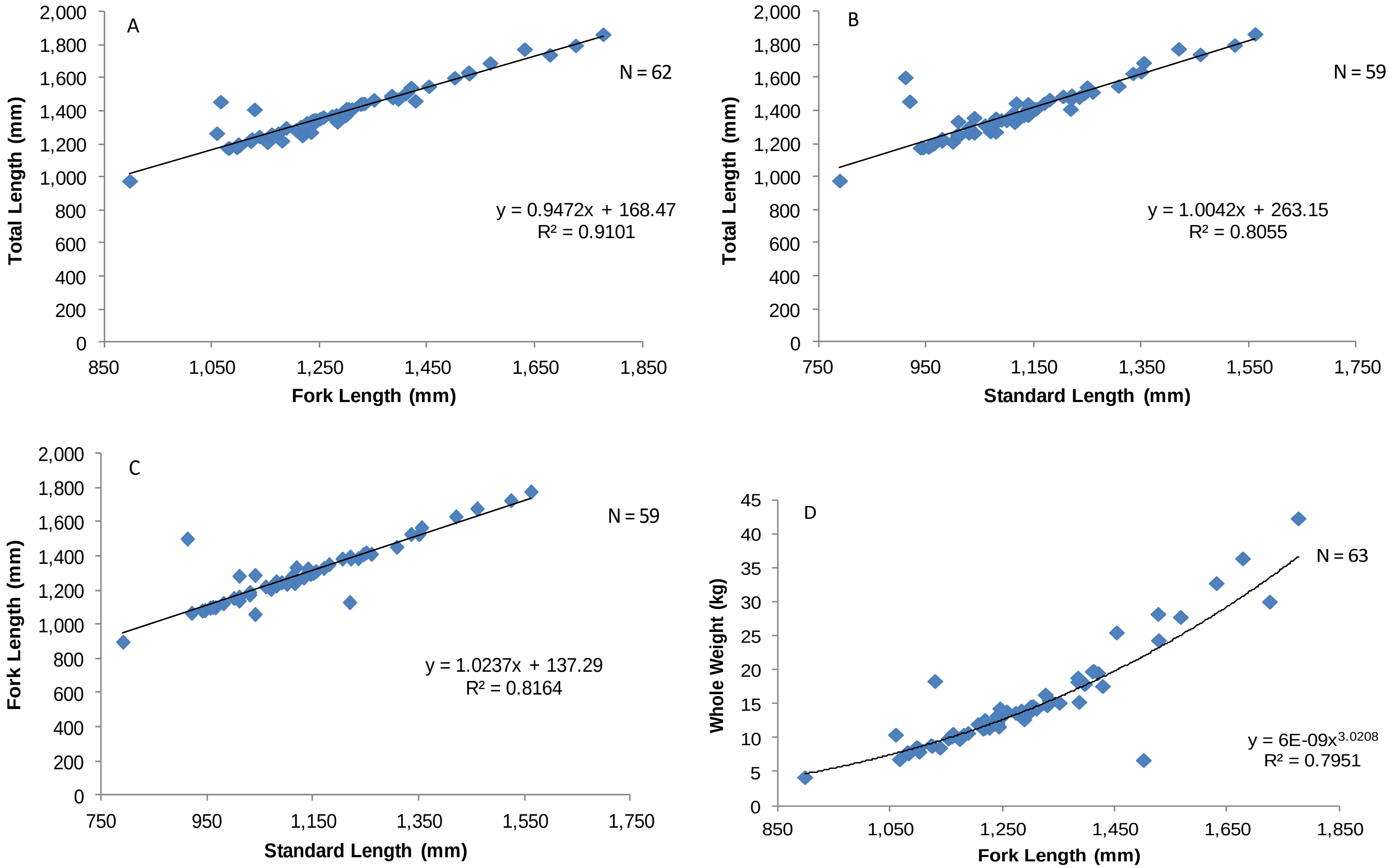

Figure A19. (A) Fork length (mm) to total length (mm), (B) standard length (mm) to total length (mm), (C) standard length (mm) to fork length (mm), and (D) fork length (mm) to whole weight (kg) relationships for wahoo.

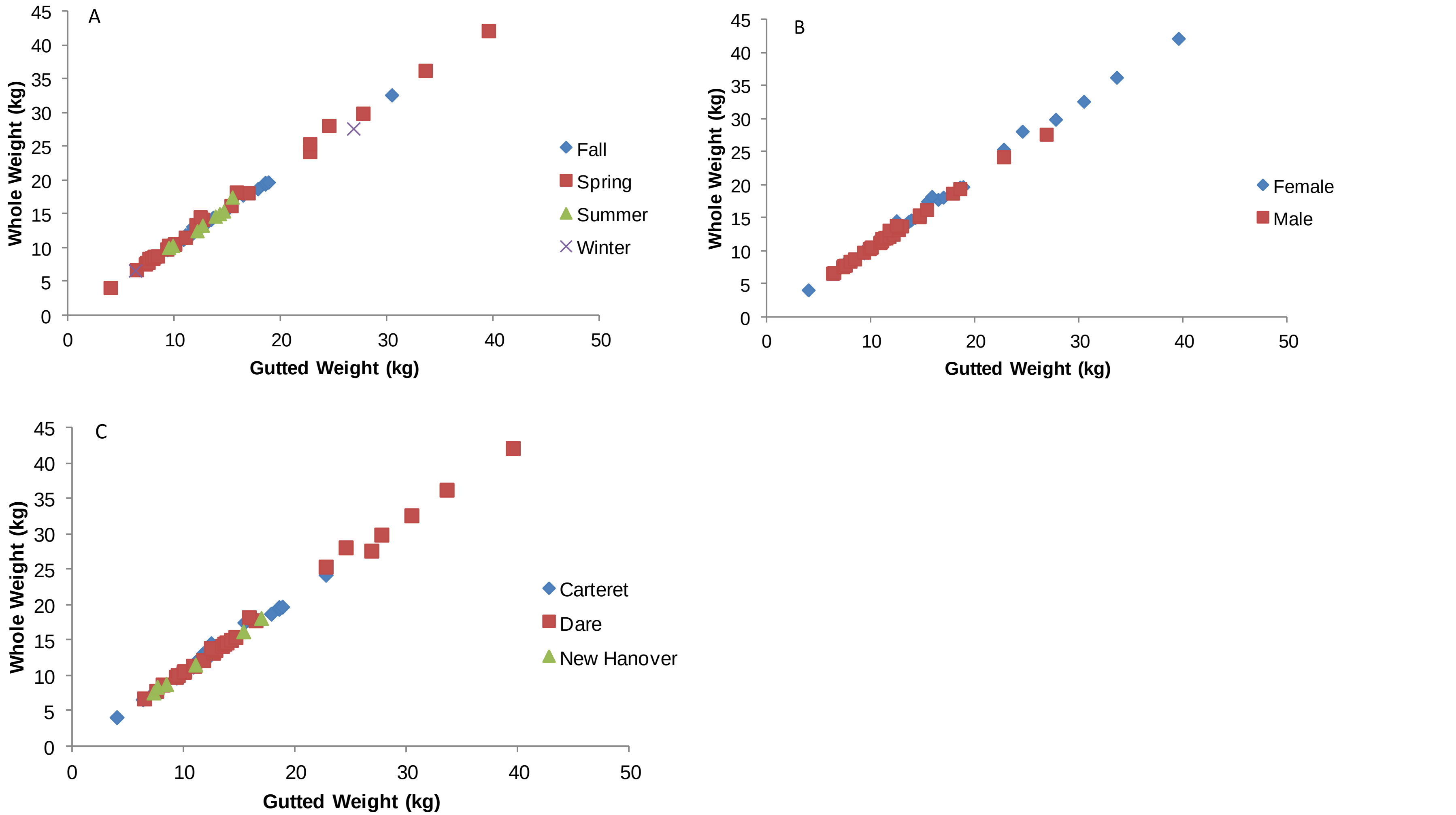

Figure A20. (A) Gutted weight (kg) to whole weight (kg) by season, (B) gutted weight (kg) to whole weight (kg) by gender, and (C) gutted weight (kg) to whole weight (kg) by county scatter plots for wahoo.

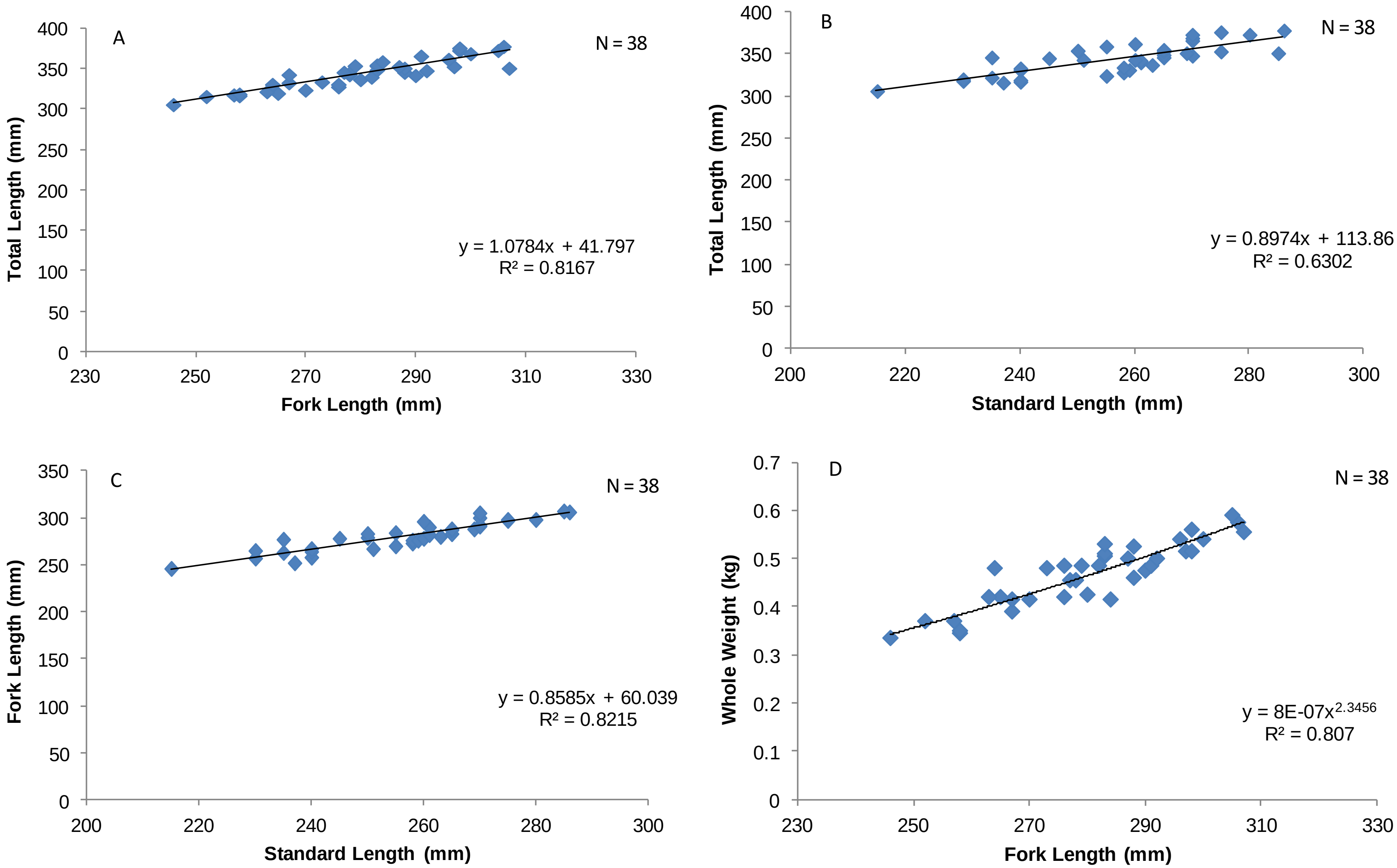

Figure A21. (A) Fork length (mm) to total length (mm), (B) standard length (mm) to total length (mm), (C) standard length (mm) to fork length (mm), and (D) fork length (mm) to whole weight (kg) relationships for squirrelfish.

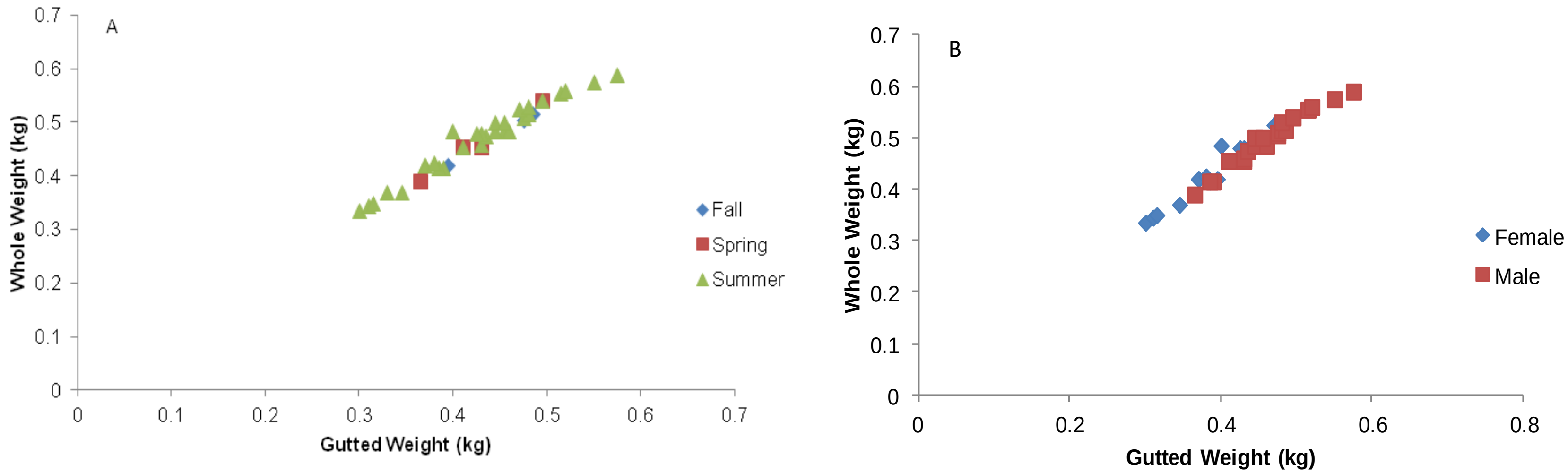

Figure A22. (A) Gutted weight (kg) to whole weight (kg) by season and (B) gutted weight (kg) to whole weight (kg) by gender scatter plots for squirrelfish.

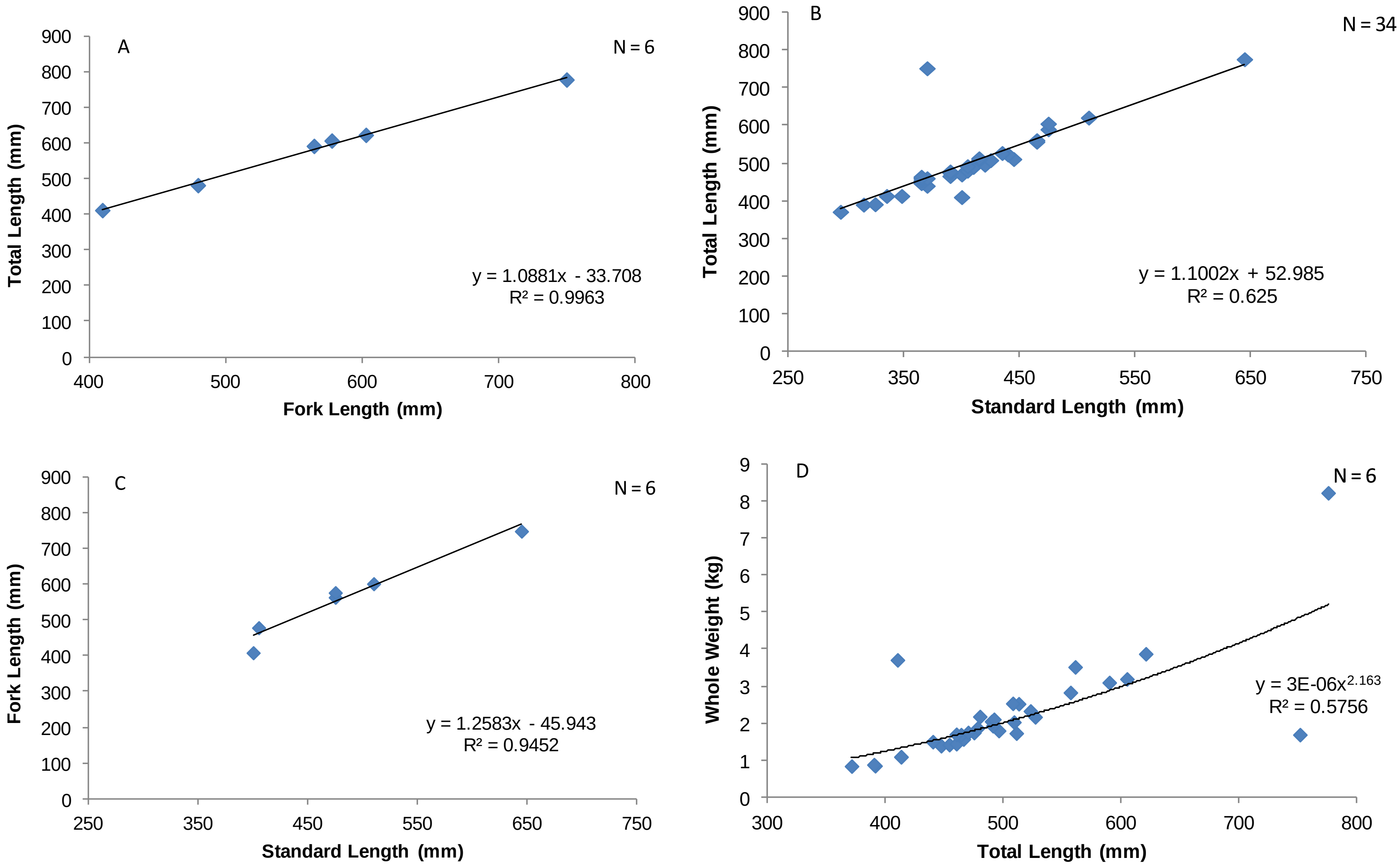

Figure A23. (A) Fork length (mm) to total length (mm), (B) standard length (mm) to total length (mm), (C) standard length (mm) to fork length (mm), and (D) total length (mm) to whole weight (kg) relationships for red hind.

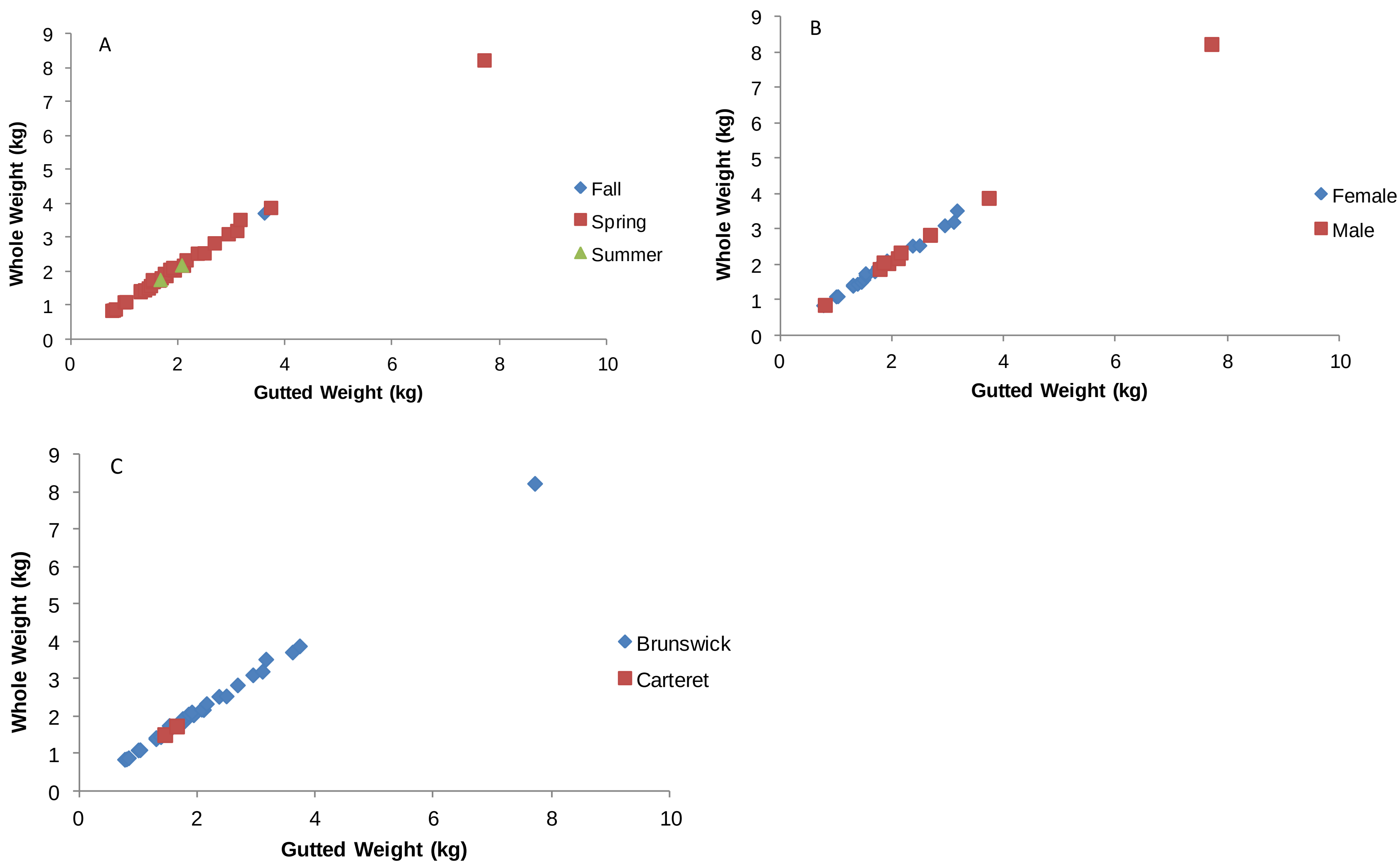

Figure A24. (A) Gutted weight (kg) to whole weight (kg) by season, (B) gutted weight (kg) to whole weight (kg) by gender, and (C) gutted weight (kg) to whole weight (kg) by county scatter plots for red hind.

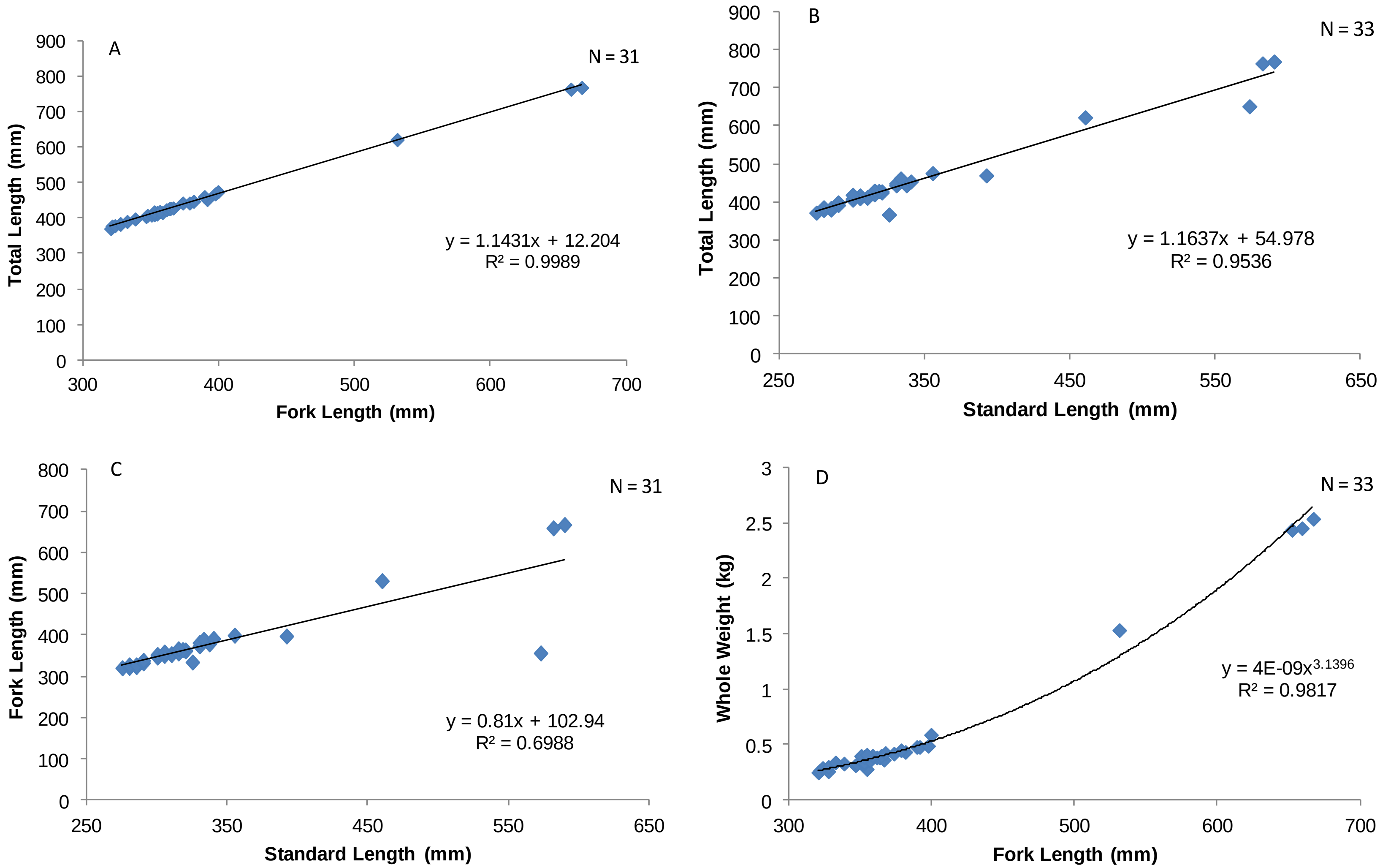

Figure A25. (A) Fork length (mm) to total length (mm), (B) standard length (mm) to total length (mm), (C) standard length (mm) to fork length (mm), and (D) total length (mm) to whole weight (kg) relationships for Spanish mackerel

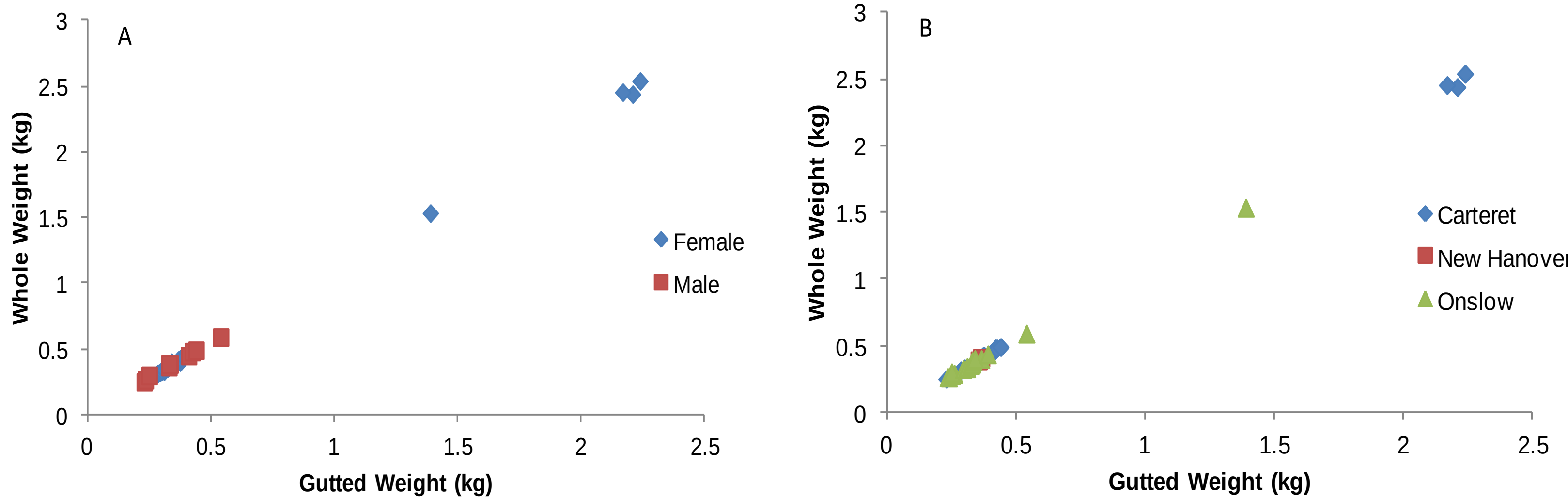

Figure A26. (A) Gutted weight (kg) to whole weight (kg) by gender and (B) gutted weight (kg) to whole weight (kg) by county scatter plots for Spanish mackerel.

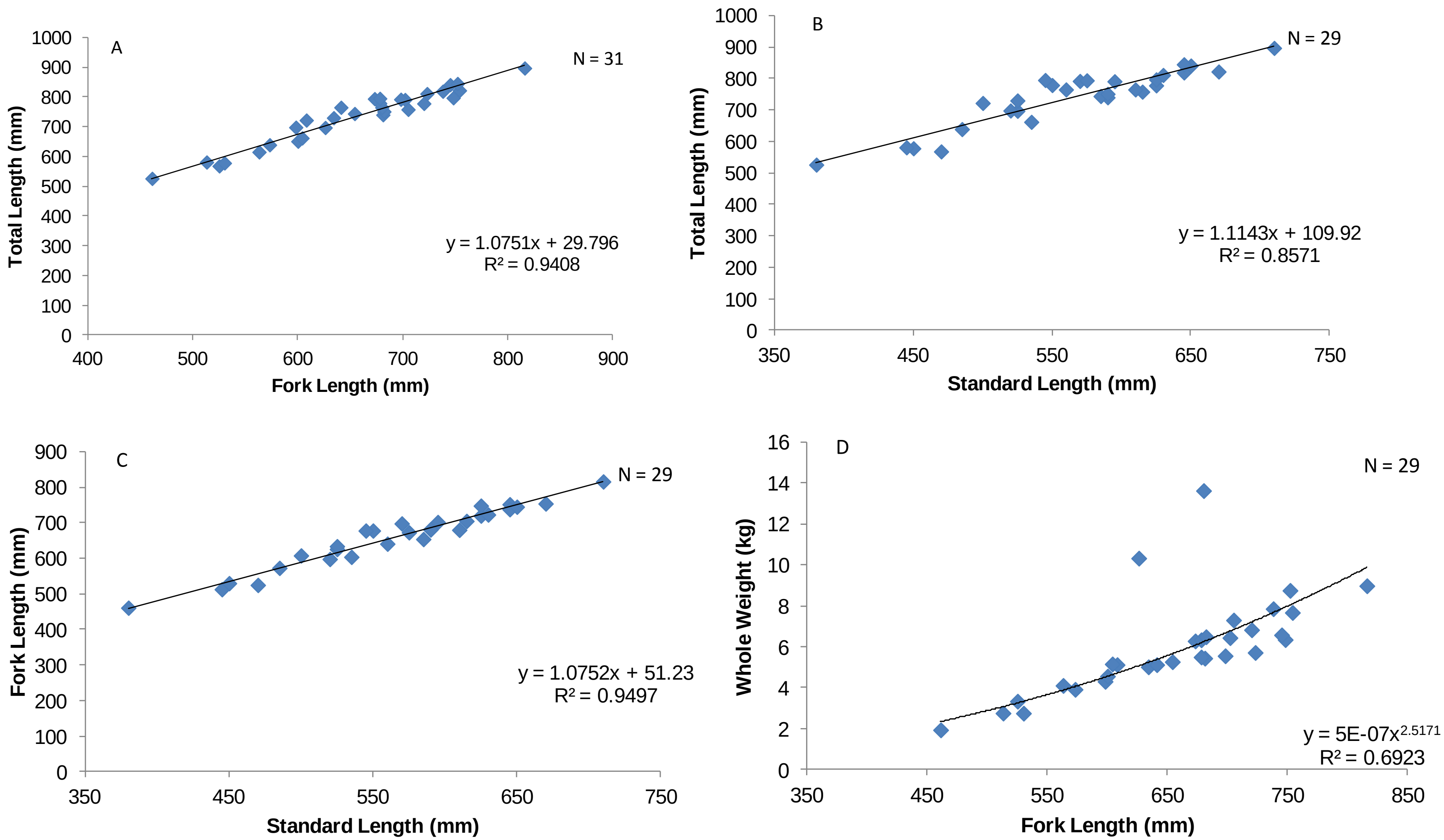

Figure A27. (A) Fork length (mm) to total length (mm), (B) standard length (mm) to total length (mm), (C) standard length (mm) to fork length (mm), and (D) total length (mm) to whole weight (kg) relationships for hogfish.

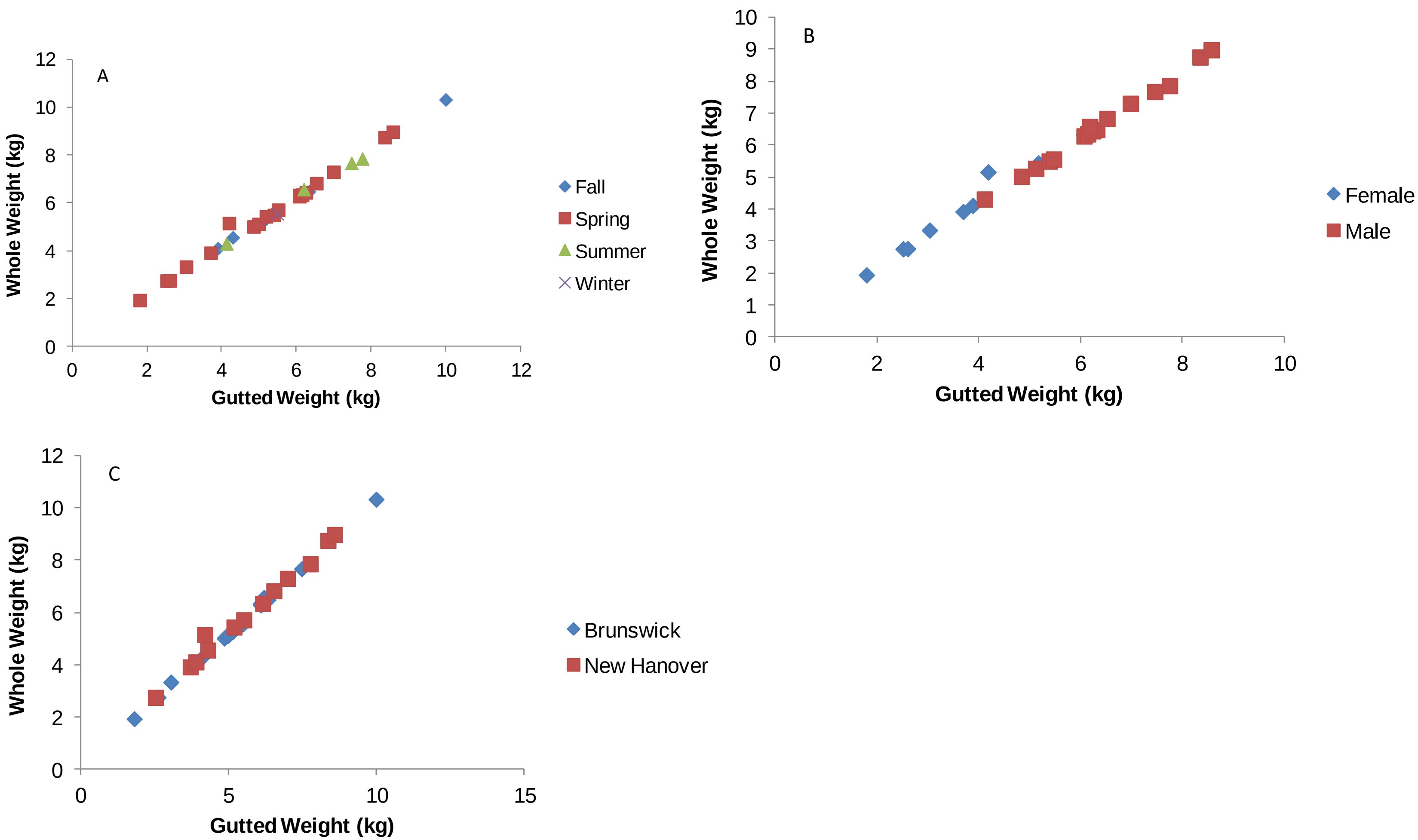

Figure A28. (A) Gutted weight (kg) to whole weight (kg) by season, (B) gutted weight (kg) to whole weight (kg) by gender, and (C) gutted weight (kg) to whole weight (kg) by county scatter plots for hogfish.