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Analysis of Shellfish Growing Areas of Alabama, Florida and Georgia, USA - Using the Pearl Shellfish Sanitation Model

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ABSTRACT

According to the United States (U.S.), National Shellfish Sanitation Program (NSSP) standards, the shellfish growing areas in *modeling, shellfish sanitation, water quality, shellfish closure rules* the U.S. must be closed for harvest when the estimated 90th percentile of fecal coliform concentrations exceeds the NSSP limit of 14/43 Most Probable Number/100 mL (NSSP, 2009, NSSP, 2011). Pearl is a model that identifies harvest areas at risk for fecal coliform contamination (Conte and Ahmadi, 2012). Once the risk areas are identified, the Aquarius model can be used to adjust closure rules (Conte and Ahmadi, 2011). In multi-state analyses using the Pearl model, we have developed a hypothesis that state agencies are inadvertently applying the model's Pearl Limit of 8/26 MPN/100 mL in place of the NSSP limit of 14/43 MPN/100 mL for a 5-tube test to guard against shellfish-related illnesses (Conte and Ahmadi, 2012; 2013; 2014). The datasets used to develop the hypothesis were from Oakland Bay, Washington (Pacific Northwest), Arcata Bay, California (Pacific Northern California), and seven shellfish bays of the Texas Gulf Coast (Western Gulf of Mexico). The main purpose of this paper is to test this hypothesis using different datasets from shellfish growing areas in the states of Alabama (Eastern Gulf of Mexico), Florida (Eastern Gulf of Mexico and south Atlantic Coast) and Georgia (South Atlantic Coast), all located in the southeastern United States. An additional objective is to use the state's datasets in Pearl analyses to detect the shellfish growing areas that pose a possible health risk to shellfish consumers during some periods

Keywords: modeling, shellfish sanitation, water quality, shellfish closure rules

1 Introduction

Pathogens associated with fecal material frequently contaminate shellfish growing areas. The presence of fecal coliform bacteria in ambient water samples taken from shellfish growing areas indicates potential fecal contamination. The NSSP mandates that state shellfish authorities shut down shellfish harvesting if water quality in the growing area drops below established food safety levels (NSSP, 2009). The NSSP's fecal coliform concentration standard for shellfish harvesting areas stipulates that the median or geometric mean of fecal coliform concentrations must not exceed 14 Most Probable Number (MPN)/100 mL. The standard also states that the estimated 90th percentile of the fecal coliform concentration may not exceed 43 MPN/100 mL, and that no more than 10 percent of fecal coliform concentration observations may exceed 43 MPN/100 mL for a 5-tube test. This is known as the "14/43" standard. The NSSP Model Ordinance requires the use of at least 30 samples to calculate 90th percentile when using Systematic Random Sampling, and that fecal coliform samples to be collected on a monthly or bi-monthly (every 2 months) schedule (Clem, 1994; NSSP, 2009).

Pearl is a model that identifies shellfish harvest areas with fecal contamination that pose risk if the shellfish are harvested for human consumption (Conte and Ahmadi, 2012). Once the risk areas are detected, the Aquarius model can be used to adjust closure rules for safe harvest (Conte and Ahmadi,

2011). In multi-state analyses using the Pearl model, we have developed a hypothesis that state agencies are inadvertently applying the model's Pearl Limit of 8/26 MPN/100 mL in place of the NSSP limit of 14/43 MPN/100 mL for a 5-tube test to guard against shellfish related illnesses (Conte and Ahmadi, 2012; 2013; 2014). The datasets used to develop the hypothesis were from Oakland Bay, Washington (Pacific Northwest), Arcata Bay, California (Pacific Northern California), and seven shellfish bays of the Texas Gulf Coast (Western Gulf of Mexico). The primary purpose of this paper is to test this hypothesis using different datasets from shellfish growing areas of Alabama (Eastern Gulf of Mexico), Florida (Eastern Gulf of Mexico and south Atlantic Coast) and Georgia (South Atlantic Coast), all located in the southeastern United States. An additional goal of this study is to detect the shellfish growing areas that pose a possible health risk to shellfish consumers during some periods.

2 Method

To test our hypothesis, we used the Pearl model to analyze fecal coliform samples from shellfish production areas of Alabama, Florida and Georgia. Using the model, we calculated three statistics: Percent True Negatives, Percent True Positives, and Percent False Negatives for a 5-tube test as described by Conte and Ahmadi (2014).

Percent True Negatives = 100*TN/T Equation 1
Percent True Positives = 100*TP/T Equation 2
Percent False Negatives = 100*FN/T Equation 3

where T denotes the total number of estimated 90th percentile values; TN denotes the number of estimated 90th percentile values below the Pearl limit of 26 MPN/100 mL; TP denotes the number of estimated 90th percentile values above the NSSP limit of 43 MPN/100 mL; and FN denotes the number of estimated 90th percentile values above the Pearl limit of 26 MPN/100 mL and below the NSSP limit of 43 MPN/mL.
Values appearing as True Negatives indicate that harvesting shellfish is safe; values appearing as Percent True Positives indicate that harvesting shellfish is not safe; and values appearing as Percent False Negatives mean harvesting shellfish is not safe, although permitted by the NSSP under current national standards.

3 Materials

The datasets used in this study were from shellfish growing areas of Alabama, Georgia, and Florida. Figure 1 shows these three states and their proximity to the Gulf of Mexico and Atlantic Ocean. Datasets include fecal coliform samples taken from Approved, Conditionally Approved, Restricted, Conditionally Restricted, and Prohibited shellfish growing areas.

Figure 1. Map of United States showing the states of Alabama, Florida and Georgia and their proximity to the Gulf of Mexico and Atlantic Ocean.

3.1 Alabama fecal coliform dataset

The Alabama fecal coliform dataset consists of 2,484 fecal coliform samples, collected by the Alabama Department of Public Health, from 21 shellfish stations in Conditionally Approved growing areas of Mobile Bay, Alabama (Figure 2) over 11 years from 11 January 2000 through 14 April 2011. The dataset is divided into two subsets: samples collected when the growing areas were open to harvest and samples collected when the growing areas were closed to harvest. The open-period subset consists of 1,487 samples organized into 878 groups. Each data point represents 30 fecal coliform samples.

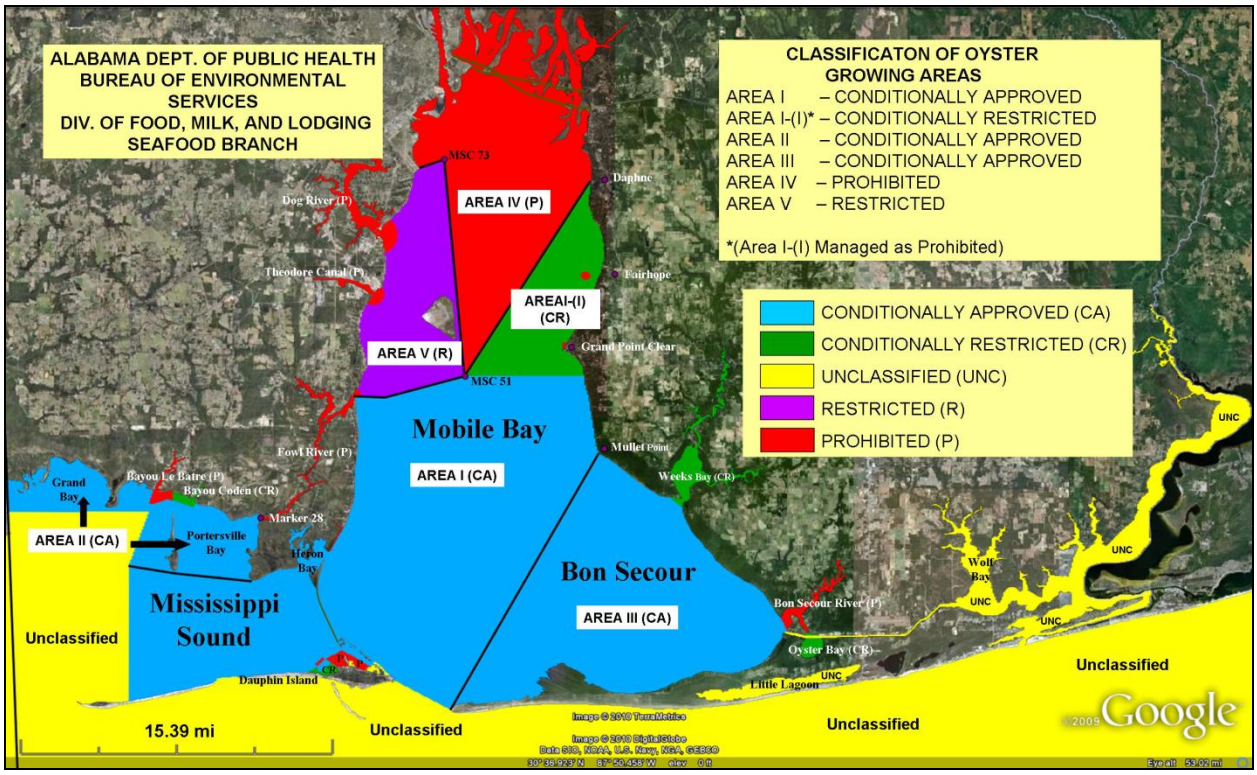

Figure 2. Alabama Department of Public Health Classification Map of Oyster Growing Areas (ADPH, 2015).

3.2 Florida fecal coliform dataset

The Florida fecal coliform dataset consists of 138,446 fecal coliform samples, collected by the Division of Aquaculture, Florida Department of Agriculture and Consumer Services, from Florida shellfish growing areas located in coastal areas of both the Gulf of Mexico and Atlantic Ocean (Figure 3); and over a period of 30 years from 6 March 1979 to 2 July 2010. The Florida dataset is divided into five subsets: The first subset consists of 17,198 samples collected from Approved areas. The second subset consists of 92,953 samples collected from Conditionally Approved areas. The third subset consists of 697 samples collected from Restricted areas. The fourth subset consists of 11,782 samples collected from Conditionally Restricted areas. The fifth subset consists of 15,816 samples collected from Prohibited areas.

The Conditionally Approved subset is used to extract a subset consisting of 36,537 samples collected from 1 June 2000 to 2 July 2010 at 243 stations in 12 bays, sounds, and lagoons in Florida (Apalachicola Bay , Cedar Key , Choctawhatchee Bay , Citrus County, East Bay , Horseshoe Beach , Indian Lagoon , North Bay , Pensacola Bay , Suwannee Sound , Waccasassa Bay , West Bay , and Withlacoochee Bay).

The Conditionally Approved subset dataset of 36,537 samples is further divided into two subsets: samples collected when the growing areas were open to harvest and samples collected when the growing areas were closed to harvest. The open-period subset consists of 17,141 samples organized into 10,100 groups. Each data point represents 30 fecal coliform samples.

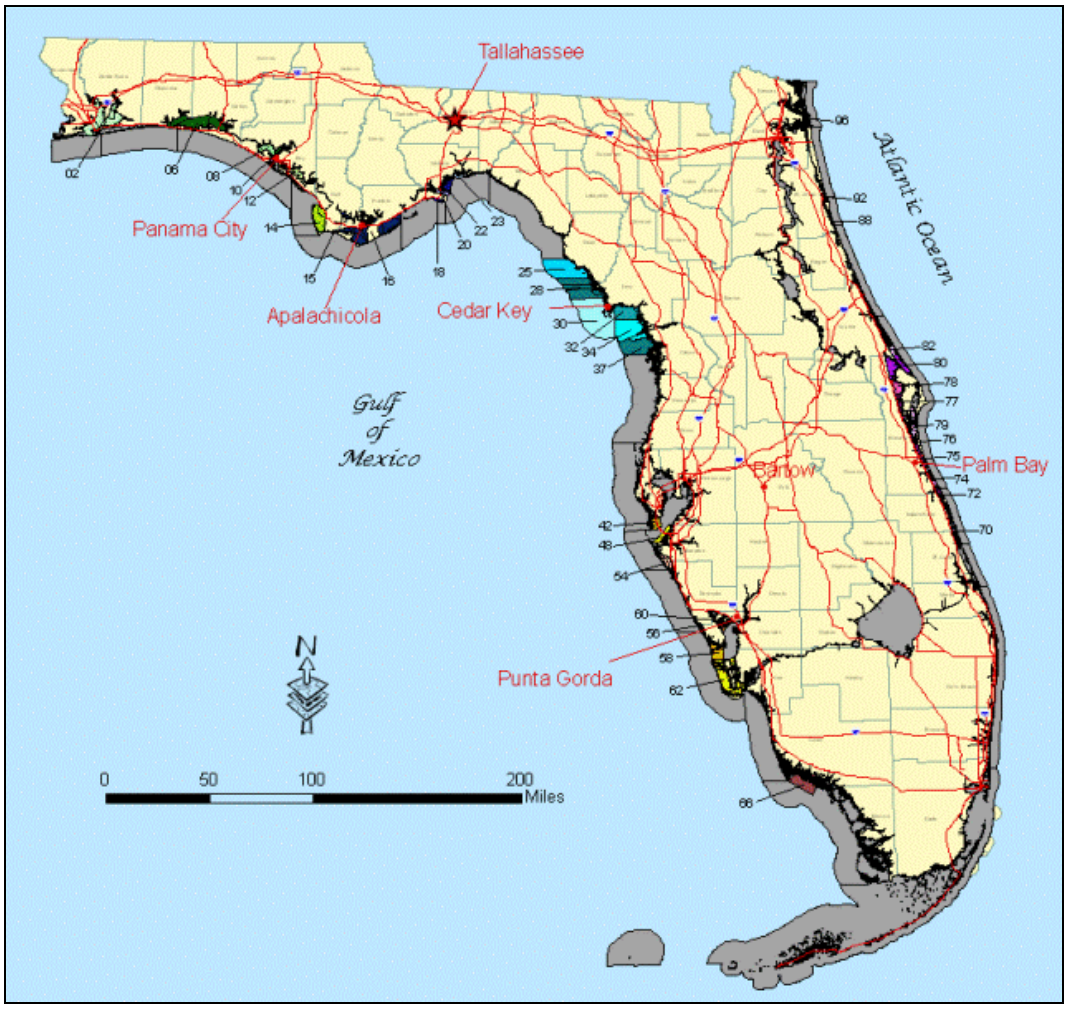

Figure 3. Florida Shellfish Harvesting Area Map (FDACS, 2015).

3.3 Georgia fecal coliform dataset

The Georgia fecal coliform dataset consists of 6,452 fecal coliform samples, collected by the Georgia Department of Natural Resource, from 72 shellfish stations in the Approved shellfish growing areas of six sounds (Cumberland, Doboy, Sapelo, St. Andrew, St. Catherines, and Wassaw) (Figure 4) over 11 years from 4 January 2000 through 15 December 2010.

The dataset is divided into two subsets: samples collected when the growing areas were open to harvest and samples collected when the growing areas were closed to harvest. The open-period subset consists of 6,338 samples organized into 4,250 groups. Each data point represents 30 fecal coliform samples.

Figure 4. Georgia Shellfish Harvesting Area Map (GCTA, 2015).

4. Results

In this section, the tabular outputs of the Pearl model are discussed for Alabama, Florida, and Georgia. They are outlined in the appendix as tables A1-A3. The tables also list the shellfish growing areas that pose a possible health risk to shellfish consumers during some periods.

4.1 Alabama

Overall, 98.86 percent of the estimated 90th percentiles of fecal coliform samples collected when the growing areas were open to harvest are below the Pearl Limit of 26 MPN/100 ml (True Negatives). Only 1.14 percent of data points are between the NSSP limit of 43 MPN/100 mL and the Pearl Limit of 26 MPN/100 mL (False Negatives). There are no data points above the NSSP limit of 43 MPN/100 mL (True

Positives) (Table A1, Appendix).

All 21 stations, except station number 153A in Area II, comply with the 100 percent True Negative criteria. Station number 153A in Area II requires special attention. For this station, twenty percent of the estimated 90th percentile values for fecal coliform samples are between the NSSP limit of 43 MPN/100 mL and the Pearl Limit of 26 MPN/100 mL (False Negatives). Eighty percent of the estimated 90th percentile values for fecal coliform samples are below the Pearl Limit of 26 MPN/100 mL (True Negatives).

4.2 Florida

Overall, 96.53 percent of the estimated 90th percentile values for fecal coliform samples collected when the growing areas were open to harvest are below the Pearl Limit of 26 MPN/100 ml (True Negatives). Only 3.08 percent of data points are between the NSSP limit of 43 MPN/100 mL and the Pearl Limit of 26 MPN/100 mL (False Negatives). Only 0.39 percent of data points are above the NSSP limit of 43 MPN/100 mL (True Positives)(Table A2, Appendix).

The data points for 91 percent of stations (221 stations of 243 stations) are below the Pearl Limit of 26 MPN/100 ml (True Negatives). The data points for 7 percent of stations (17 stations of 243 stations) are below the NSSP limit of 43 MPN/100 mL, but above the Pearl Limit of 26 MPN/100 ml (False Negatives). The data points of only 2 percent of stations (5 stations of 243 stations) are above the NSSP limit of 43 MPN/100 mL (True Positives).

4.3 Georgia

Overall, 92.42 percent of the estimated 90th percentile values for fecal coliform samples are below the Pearl Limit of 26 MPN/100 ml (True Negatives). Only 6.68 percent of the estimated 90th percentiles of fecal coliform samples are between the Pearl Limit of 26 MPN/100 mL and the NSSP Limit of 43 MPN/100 mL (False Negatives); and 0.89 percent of the estimated 90th percentiles of fecal coliform samples are above the NSSP limit of 43 MPN/100 ml (True Positives) (Table A3, Appendix).

The data points for 75 percent of stations (54 stations of 72 stations) are below the Pearl Limit of 26 MPN/100 ml (True Negatives). The data points for 18 percent of stations (13 stations of 72 stations) are below the NSSP limit of 43 MPN/100 mL, but above the Pearl Limit of 26 MPN/100 ml (False Negatives). The data points of only 7 percent of stations (5 stations of 72 stations) are above the NSSP limit of 43 MPN/100 mL (True Positives).

4.4 Summary for all three states

Table 1 shows a summary of sampling stations in shellfish growing areas of Alabama, Florida, and Georgia. For all three states, the data points of 2.98 % (10 stations) are above the NSSP Limit of 43 MPN/mL (True Positives); the data points of 9.23 % (31 stations) are between the NSSP Limit of 43 MPN/mL and the Pearl Limit of 26 MPN/mL (False Negatives); and the data points of 87.80 % (295 stations) are below the Pearl limit of 26 MPN/mL (True Negatives).

Table 1.
Summary of sampling stations in shellfish growing areas of Alabama, Florida, and Georgia, USA.

State	True Positives	False Negatives	True Negatives	Total
Alabama	0.00 % (0 stations)	4.76 % (1 stations)	95.24 % (20 stations)	100.00 % (21 stations)
Florida	2.06 % (5 stations)	7.00 % (17 stations)	90.95 % (221 stations)	100.00 % (243 stations)
Georgia	6.94 % (5 stations)	18.06 % (13 stations)	75.00 % (54 stations)	100.00 % (72 stations)
Total	2.98 % (10 stations)	9.23 % (31 stations)	87.80 % (295 stations)	100.00 % (336 stations)

Table 2 shows a summary of fecal coliform observations in shellfish growing areas of Alabama, Florida, and Georgia. Each data point represents 30 samples. For all three states, 77 data points (0.51 %) () are above the NSSP limit of 43 MPN/mL (True Positives); 605 data points (3.97 %) are between the NSSP Limit of 43 MPN/mL and the Pearl Limit of 26 MPN/mL (False Negatives); and 14,546 data points (95.52 %) are below the Pearl limit of 26 MPN/mL (True Negatives).

Table 2.
Summary of fecal coliform observations in shellfish growing areas of Alabama, Florida, and Georgia, USA. Each data point represents 30 samples.

State	True Positives	False Negatives	True Negatives	Total
Alabama	0.00 % (0 data points)	1.14 % (10 data points)	98.86 % (868 data points)	100.00 % (878 data points)
Florida	0.39 % (39 data points)	3.08 % (311 data points)	96.53 % (9,750 data points)	100.00 % (10,100 data points)
Georgia	0.89 % (38 data points)	6.68 % (284 data points)	92.42 % (3,928 data points)	100.00 % (4,250 data points)
Total	0.51 % (77 data points)	3.97 % (605 data points)	95.52 % (14,546 data points)	100.00 % (15,228 data points)

5 Discussion

In the application of the Pearl model to sanitation datasets from the three states, the model was applied to the existing classifications present in the growing areas. The results for this study were rapidly assessed using Pearl's function that calculates the percentage of True Positive, False Negative, and True Negative values appearing in each dataset; and these results are shown using the tabular output format (Tables A1, A2, and A3).

Shellfish production areas with fecal coliform datapoints appearing as either False Negatives or True Positives should be examined for potential adjustments of closure rules, if these infractions are occuring in the present time.

Alabama shows 5 percent of the stations (one station) having data points appearing as False Negatives and no stations with data points appearing as True Negatives. Florida shows 7 percent of the stations (17 station) having datapoints appearing as False Negatives and 2 percent of stations (5 stations) having data points appearing as True Positives

Georgia shows 18 percent of stations (13 stations) having data points appearing as False Negatives and 7 percent of stations (5 stations) having data points appearing as True Positives. Over all, for the three states, 9 percent of stations (31 of 336 stations) having datapoints appearing as False Negatives and 3 percent of stations (10 of 336 stations) having data points appearing as True Positives.

The percentage of True Negative values for shellfish production bays in Alabama, Florida and Georgia (Tables A1, A2 and A3) reveal that the vast majority (95.52 percent) of production areas exhibit 100 percent True Negative values. The results of this tri-state analyses of fecal coliform datasets show a strikingly similar pattern to results observed in Oakland Bay, Washington (Conte & Ahmadi, 2012), Arcata Bay, California (Conte & Ahmadi, 2013) and the seven shellfish production bays in Texas (Conte and Ahmadi, 2014). In all six state shellfish studies, the vast majority of fecal coliform data points for the estimated 90^{th} percentile values appear below the Pearl limit of 26 MPN/100 mL for a five-tube test, and their upper limits appeared below the NSSP limit of 43 MPN/100 mL. The shellfish closure rules applied by shellfish agencies in Alabama, Florida and Georgia resulted in 95.5 percent of the estimated 90^{th} percentile values of fecal coliform data points appearing below 26 MPN/100 mL for a five-tube test, demonstrating that the shellfish agencies in the six states studied inadvertently employ the Pearl Limit of 26 MPN/100 mL and not the NSSP standard.

Overall, for the three states analyzed in this study, 4.0 percent of the estimated 90^{th} percentile values of fecal coliform data points appeared as False Negatives (Between the Pearl and NSSP limits) and only 0.5 percent of the estimated 90^{th} percentile values of fecal coliform data points appeared as True Positives (above the NSSP limits), To determine the exact timing of infractions, Pearl's scattergram outputs can be used as demonstrated by Conte and Ahmadi (2012; 2013; 2014).

6 Conclusion

The Pearl model was originally developed using the datasets from California, Washington, and Texas, located in the Pacific Northwest, Pacific Coast of California and Texas Gulf Coast, respectively. From these multi-state analyses, we developed a hypothesis that state agencies are inadvertently applying the model's Pearl Limit of 8/26 MPN/100 mL in place of the NSSP limit of 14/43 MPN/100 mL, for a 5-tube test, to guard against shellfish related illnesses (Conte and Ahmadi, 2012; 2013; 2014). In this paper we

tested the hypothesis using different datasets from shellfish growing areas of Alabama (Eastern Gulf of Mexico), Florida (Eastern Gulf of Mexico and south Atlantic Coast) and Georgia (South Atlantic Coast), all located in the southeastern United States. The results show that the hypothesis has been validated by these different multi-states analyses. Based on the 8/26 MPN/100 mL hypothesis, we have also identified the shellfish growing areas that pose a possible health risk to shellfish consumers. The Pearl scattergram function can be applied to determine when the infractions occurred.

Acknowledgments

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Appendix

Table A1

Percent true negative values of fecal coliform samples collected by the Alabama Department of Public Health, from 21 shellfish stations in Conditionally Approved growing areas of Mobile Bay, Alabama over 11 years from 1 January 2000 through 14 April 2011. The stations with problems are highlighted in pink.

Region	Station	True Positive %	False Negative %	True Negative %	Total Count
Mobile Bay	AREA2:153A	0.00	20.00	80.00	50
Mobile Bay	AREA1:118	0.00	0.00	100.00	49
Mobile Bay	AREA1:119A	0.00	0.00	100.00	46
Mobile Bay	AREA1:120	0.00	0.00	100.00	50
Mobile Bay	AREA1:123A	0.00	0.00	100.00	51
Mobile Bay	AREA1:125	0.00	0.00	100.00	12
Mobile Bay	AREA1:126	0.00	0.00	100.00	7
Mobile Bay	AREA1:128	0.00	0.00	100.00	46
Mobile Bay	AREA2:139A	0.00	0.00	100.00	48
Mobile Bay	AREA2:154	0.00	0.00	100.00	49
Mobile Bay	AREA2:170	0.00	0.00	100.00	49
Mobile Bay	AREA2:176	0.00	0.00	100.00	47
Mobile Bay	AREA2:178	0.00	0.00	100.00	46
Mobile Bay	AREA3:104A	0.00	0.00	100.00	41
Mobile Bay	AREA3:104B	0.00	0.00	100.00	43
Mobile Bay	AREA3:106	0.00	0.00	100.00	40
Mobile Bay	AREA3:107B	0.00	0.00	100.00	40
Mobile Bay	AREA3:112A	0.00	0.00	100.00	41
Mobile Bay	AREA3:114	0.00	0.00	100.00	40
Mobile Bay	AREA3:83	0.00	0.00	100.00	40
Mobile Bay	AREA3:92	0.00	0.00	100.00	43
Mobile Bay Summary		0.00	1.14	98.86	878
Alabama Summary		0.00	1.14	98.86	878

Table A2

Percent true negative values of fecal coliform samples, collected by the Division of Aquaculture, Florida Department of Agriculture and Consumer Services, from all classifications of shellfish growing areas of Florida over 30 years from 3/6/1979 to 7/2/2010. The stations with problems are highlighted in pink.

Region	Station	True Positive %	False Negative %	True Negative %	Total Count
Apalachicola Bay	16APAL:257	0.00	100.00	0.00	14
Apalachicola Bay	16APAL:270	0.00	100.00	0.00	14
Apalachicola Bay	16APAL:347	0.00	45.16	54.84	62
Apalachicola Bay	16APAL:354	5.00	36.67	58.33	60
Apalachicola Bay	16APAL:322	0.00	27.42	72.58	62
Apalachicola Bay	16APAL:373	0.00	15.25	84.75	59
Apalachicola Bay	16APAL:403	0.00	14.29	85.71	49
Apalachicola Bay	16APAL:357	0.00	11.86	88.14	59
Apalachicola Bay	16APAL:259	0.00	9.09	90.91	11
Apalachicola Bay	16APAL:352	0.00	7.94	92.06	63
Apalachicola Bay	16APAL:100	0.00	0.00	100.00	60
Apalachicola Bay	16APAL:140	0.00	0.00	100.00	60
Apalachicola Bay	16APAL:150	0.00	0.00	100.00	60
Apalachicola Bay	16APAL:151	0.00	0.00	100.00	60
Apalachicola Bay	16APAL:152	0.00	0.00	100.00	67
Apalachicola Bay	16APAL:153	0.00	0.00	100.00	67
Apalachicola Bay	16APAL:155	0.00	0.00	100.00	68
Apalachicola Bay	16APAL:160	0.00	0.00	100.00	67
Apalachicola Bay	16APAL:205	0.00	0.00	100.00	20
Apalachicola Bay	16APAL:221	0.00	0.00	100.00	14
Apalachicola Bay	16APAL:225	0.00	0.00	100.00	14
Apalachicola Bay	16APAL:230	0.00	0.00	100.00	13
Apalachicola Bay	16APAL:234	0.00	0.00	100.00	14
Apalachicola Bay	16APAL:235	0.00	0.00	100.00	13
Apalachicola Bay	16APAL:240	0.00	0.00	100.00	15
Apalachicola Bay	16APAL:244	0.00	0.00	100.00	15
Apalachicola Bay	16APAL:246	0.00	0.00	100.00	15
Apalachicola Bay	16APAL:255	0.00	0.00	100.00	13
Apalachicola Bay	16APAL:340	0.00	0.00	100.00	69
Apalachicola Bay	16APAL:341	0.00	0.00	100.00	68
Apalachicola Bay	16APAL:342	0.00	0.00	100.00	67
Apalachicola Bay	16APAL:349	0.00	0.00	100.00	62
Apalachicola Bay	16APAL:371	0.00	0.00	100.00	59
Apalachicola Bay	16APAL:372	0.00	0.00	100.00	59
Apalachicola Bay	16APAL:375	0.00	0.00	100.00	59
Apalachicola Bay	16APAL:410	0.00	0.00	100.00	15
Apalachicola Bay Summary		0.19	7.92	91.89	1,566
Cedar Key	30CEDA:481	0.00	12.50	87.50	48
Cedar Key	30CEDA:111	0.00	0.00	100.00	48
Cedar Key	30CEDA:118	0.00	0.00	100.00	70

Cedar Key	30CEDA:130	0.00	0.00	100.00	63
Cedar Key	30CEDA:170	0.00	0.00	100.00	53
Cedar Key	30CEDA:180	0.00	0.00	100.00	48
Cedar Key	30CEDA:190	0.00	0.00	100.00	51
Cedar Key	30CEDA:200	0.00	0.00	100.00	49
Cedar Key	30CEDA:441	0.00	0.00	100.00	47
Cedar Key	30CEDA:448	0.00	0.00	100.00	45
Cedar Key	30CEDA:451	0.00	0.00	100.00	46
Cedar Key	30CEDA:690	0.00	0.00	100.00	45
Cedar Key	30CEDA:700	0.00	0.00	100.00	45
Cedar Key	30CEDA:702	0.00	0.00	100.00	46
Cedar Key	30CEDA:704	0.00	0.00	100.00	46
Cedar Key	30CEDA:711	0.00	0.00	100.00	46
Cedar Key	30CEDA:712	0.00	0.00	100.00	45
Cedar Key	30CEDA:713	0.00	0.00	100.00	43
Cedar Key	30CEDA:715	0.00	0.00	100.00	45
Cedar Key	30CEDA:716	0.00	0.00	100.00	40
Summaey Count		0.00	0.62	99.38	969
Choctawhatchee Bay	06CHOC:320	0.00	29.41	70.59	34
Choctawhatchee Bay	06CHOC:204	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:208	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:211	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:212	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:221	0.00	0.00	100.00	33
Choctawhatchee Bay	06CHOC:270	0.00	0.00	100.00	34
Choctawhatchee Bay	06CHOC:350	0.00	0.00	100.00	30
Choctawhatchee Bay	06CHOC:351	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:420	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:430	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:431	0.00	0.00	100.00	33
Choctawhatchee Bay	06CHOC:440	0.00	0.00	100.00	34
Choctawhatchee Bay	06CHOC:450	0.00	0.00	100.00	34
Choctawhatchee Bay	06CHOC:470	0.00	0.00	100.00	35
Choctawhatchee Bay	06CHOC:502	0.00	0.00	100.00	28
Choctawhatchee Bay	06CHOC:532	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:538	0.00	0.00	100.00	28
Choctawhatchee Bay	06CHOC:544	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:546	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:548	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:570	0.00	0.00	100.00	33
Choctawhatchee Bay	06CHOC:608	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:610	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:612	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:614	0.00	0.00	100.00	34
Choctawhatchee Bay	06CHOC:619	0.00	0.00	100.00	100
Choctawhatchee Bay	06CHOC:621	0.00	0.00	100.00	34
Choctawhatchee Bay	06CHOC:622	0.00	0.00	100.00	33

Choctawhatchee Bay	06CHOC:624	0.00	0.00	100.00	33
Choctawhatchee Bay	06CHOC:760	0.00	0.00	100.00	28
Choctawhatchee Bay	06CHOC:850	0.00	0.00	100.00	29
Choctawhatchee Bay	06CHOC:870	0.00	0.00	100.00	29
Choctawhatchee Bay Summary		0.00	0.92	99.08	1,082
Citrus County	37CITR:651	0.00	0.00	100.00	9
Citrus County Summary		0.00	0.00	100.00	9
East Bay	12EBAY:930	0.00	0.00	100.00	33
East Bay	12EBAY:941	0.00	0.00	100.00	37
East Bay	12EBAY:942	0.00	0.00	100.00	33
East Bay	12EBAY:943	0.00	0.00	100.00	33
East Bay	12EBAY:950	0.00	0.00	100.00	34
East Bay	12EBAY:951	0.00	0.00	100.00	37
East Bay	12EBAY:959	0.00	0.00	100.00	62
East Bay	12EBAY:960	0.00	0.00	100.00	33
East Bay	12EBAY:963	0.00	0.00	100.00	32
East Bay	12EBAY:964	0.00	0.00	100.00	34
East Bay	12EBAY:965	0.00	0.00	100.00	34
East Bay	12EBAY:967	0.00	0.00	100.00	41
East Bay	12EBAY:968	0.00	0.00	100.00	33
East Bay	12EBAY:969	0.00	0.00	100.00	34
East Bay	12EBAY:970	0.00	0.00	100.00	36
East Bay	12EBAY:973	0.00	0.00	100.00	30
East Bay	12EBAY:975	0.00	0.00	100.00	29
East Bay Summary		0.00	0.00	100.00	605
Horseshoe Beach	25HORS:112	0.00	0.00	100.00	32
Horseshoe Beach	25HORS:117	0.00	0.00	100.00	32
Horseshoe Beach	25HORS:118	0.00	0.00	100.00	30
Horseshoe Beach	25HORS:121	0.00	0.00	100.00	32
Horseshoe Beach	25HORS:122	0.00	0.00	100.00	32
Horseshoe Beach	25HORS:125	0.00	0.00	100.00	32
Horseshoe Beach	25HORS:141	0.00	0.00	100.00	11
Horseshoe Beach	25HORS:165	0.00	0.00	100.00	32
Horseshoe Beach	25HORS:360	0.00	0.00	100.00	30
Horseshoe Beach	25HORS:361	0.00	0.00	100.00	31
Horseshoe Beach	25HORS:362	0.00	0.00	100.00	31
Horseshoe Beach	25HORS:371	0.00	0.00	100.00	32
Horseshoe Beach	25HORS:372	0.00	0.00	100.00	32
Horseshoe Beach	25HORS:373	0.00	0.00	100.00	32
Horseshoe Beach	25HORS:374	0.00	0.00	100.00	31
Horseshoe Beach	25HORS:376	0.00	0.00	100.00	30
Horseshoe Beach	25HORS:377	0.00	0.00	100.00	31
Horseshoe Beach	25HORS:378	0.00	0.00	100.00	30
Horseshoe Beach	25HORS:397	0.00	0.00	100.00	31
Horseshoe Beach Summary		0.00	0.00	100.00	574
Indian Lagoon	15INDL:100	0.00	0.00	100.00	26
Indian Lagoon	15INDL:110	0.00	0.00	100.00	27

Indian Lagoon	15INDL:120	0.00	0.00	100.00	23
Indian Lagoon	15INDL:128	0.00	0.00	100.00	19
Indian Lagoon	15INDL:130	0.00	0.00	100.00	22
Indian Lagoon Summary		0.00	0.00	100.00	117
North Bay	10NBAY:252	53.57	41.07	5.36	56
North Bay	10NBAY:440	0.00	32.50	67.50	40
North Bay	10NBAY:250	0.00	0.00	100.00	8
North Bay	10NBAY:251	0.00	0.00	100.00	39
North Bay	10NBAY:400	0.00	0.00	100.00	35
North Bay	10NBAY:430	0.00	0.00	100.00	35
North Bay	10NBAY:432	0.00	0.00	100.00	35
North Bay	10NBAY:441	0.00	0.00	100.00	39
North Bay	10NBAY:450	0.00	0.00	100.00	49
North Bay	10NBAY:461	0.00	0.00	100.00	40
North Bay	10NBAY:462	0.00	0.00	100.00	39
North Bay	10NBAY:520	0.00	0.00	100.00	39
North Bay	10NBAY:870	0.00	0.00	100.00	36
North Bay	10NBAY:871	0.00	0.00	100.00	35
North Bay	10NBAY:872	0.00	0.00	100.00	35
North Bay	10NBAY:873	0.00	0.00	100.00	35
North Bay	10NBAY:874	0.00	0.00	100.00	34
North Bay	10NBAY:880	0.00	0.00	100.00	35
North Bay	10NBAY:890	0.00	0.00	100.00	35
North Bay	10NBAY:901	0.00	0.00	100.00	38
North Bay	10NBAY:902	0.00	0.00	100.00	39
North Bay	10NBAY:910	0.00	0.00	100.00	38
North Bay Summary		3.69	4.42	91.89	814
Pensacola Bay	02PENS:580	0.00	0.00	100.00	55
Pensacola Bay	02PENS:581	0.00	0.00	100.00	30
Pensacola Bay	02PENS:582	0.00	0.00	100.00	31
Pensacola Bay	02PENS:583	0.00	0.00	100.00	30
Pensacola Bay	02PENS:584	0.00	0.00	100.00	31
Pensacola Bay	02PENS:610	0.00	0.00	100.00	54
Pensacola Bay	02PENS:640	0.00	0.00	100.00	51
Pensacola Bay	02PENS:650	0.00	0.00	100.00	27
Pensacola Bay	02PENS:660	0.00	0.00	100.00	27
Pensacola Bay	02PENS:680	0.00	0.00	100.00	49
Pensacola Bay	02PENS:685	0.00	0.00	100.00	50
Pensacola Bay	02PENS:690	0.00	0.00	100.00	27
Pensacola Bay	02PENS:700	0.00	0.00	100.00	27
Pensacola Bay	02PENS:710	0.00	0.00	100.00	27
Pensacola Bay	02PENS:720	0.00	0.00	100.00	80
Pensacola Bay	02PENS:730	0.00	0.00	100.00	27
Pensacola Bay	02PENS:740	0.00	0.00	100.00	27
Pensacola Bay	02PENS:790	0.00	0.00	100.00	50
Pensacola Bay	02PENS:795	0.00	0.00	100.00	79
Pensacola Bay	02PENS:800	0.00	0.00	100.00	50

Pensacola Bay	02PENS:810	0.00	0.00	100.00	50
Pensacola Bay	02PENS:820	0.00	0.00	100.00	50
Pensacola Bay	02PENS:850	0.00	0.00	100.00	22
Pensacola Bay	02PENS:860	0.00	0.00	100.00	50
Pensacola Bay	02PENS:880	0.00	0.00	100.00	34
Pensacola Bay	02PENS:890	0.00	0.00	100.00	34
Pensacola Bay	02PENS:900	0.00	0.00	100.00	33
Pensacola Bay	02PENS:910	0.00	0.00	100.00	52
Pensacola Bay Summary		0.00	0.00	100.00	1,154
Suwannee Sound	28SUWA:234	12.50	87.50	0.00	16
Suwannee Sound	28SUWA:223	4.26	59.57	36.17	47
Suwannee Sound	28SUWA:445	0.00	55.77	44.23	52
Suwannee Sound	28SUWA:481	0.00	37.50	62.50	48
Suwannee Sound	28SUWA:231	0.00	13.33	86.67	45
Suwannee Sound	28SUWA:237	0.00	2.17	97.83	46
Suwannee Sound	28SUWA:210	0.00	0.00	100.00	31
Suwannee Sound	28SUWA:214	0.00	0.00	100.00	46
Suwannee Sound	28SUWA:216	0.00	0.00	100.00	47
Suwannee Sound	28SUWA:218	0.00	0.00	100.00	46
Suwannee Sound	28SUWA:222	0.00	0.00	100.00	48
Suwannee Sound	28SUWA:224	0.00	0.00	100.00	47
Suwannee Sound	28SUWA:229	0.00	0.00	100.00	46
Suwannee Sound	28SUWA:235	0.00	0.00	100.00	45
Suwannee Sound	28SUWA:239	0.00	0.00	100.00	45
Suwannee Sound	28SUWA:245	0.00	0.00	100.00	45
Suwannee Sound	28SUWA:247	0.00	0.00	100.00	47
Suwannee Sound	28SUWA:401	0.00	0.00	100.00	47
Suwannee Sound	28SUWA:410	0.00	0.00	100.00	46
Suwannee Sound	28SUWA:420	0.00	0.00	100.00	47
Suwannee Sound	28SUWA:449	0.00	0.00	100.00	45
Suwannee Sound Summary		0.43	10.30	89.27	932
Waccasassa Bay	32WACC:666	3.28	40.98	55.74	61
Waccasassa Bay	32WACC:110	0.00	0.00	100.00	47
Waccasassa Bay	32WACC:120	0.00	0.00	100.00	47
Waccasassa Bay	32WACC:130	0.00	0.00	100.00	47
Waccasassa Bay	32WACC:133	0.00	0.00	100.00	47
Waccasassa Bay	32WACC:560	0.00	0.00	100.00	48
Waccasassa Bay	32WACC:590	0.00	0.00	100.00	48
Waccasassa Bay	32WACC:610	0.00	0.00	100.00	46
Waccasassa Bay	32WACC:611	0.00	0.00	100.00	11
Waccasassa Bay	32WACC:640	0.00	0.00	100.00	47
Waccasassa Bay	32WACC:650	0.00	0.00	100.00	48
Waccasassa Bay	32WACC:660	0.00	0.00	100.00	48
Waccasassa Bay	32WACC:670	0.00	0.00	100.00	47
Waccasassa Bay	32WACC:710	0.00	0.00	100.00	46
Waccasassa Bay	32WACC:720	0.00	0.00	100.00	45
Waccasassa Bay	32WACC:996	0.00	0.00	100.00	48

Waccasassa Bay	32WACC:998	0.00	0.00	100.00	47
Waccasassa Bay Summary		0.26	3.21	96.53	778
West Bay	08WBAY:840	0.00	18.18	81.82	77
West Bay	08WBAY:390	0.00	0.00	100.00	22
West Bay	08WBAY:740	0.00	0.00	100.00	80
West Bay	08WBAY:741	0.00	0.00	100.00	24
West Bay	08WBAY:750	0.00	0.00	100.00	80
West Bay	08WBAY:751	0.00	0.00	100.00	76
West Bay	08WBAY:752	0.00	0.00	100.00	77
West Bay	08WBAY:753	0.00	0.00	100.00	77
West Bay	08WBAY:755	0.00	0.00	100.00	77
West Bay	08WBAY:756	0.00	0.00	100.00	77
West Bay	08WBAY:810	0.00	0.00	100.00	77
West Bay	08WBAY:811	0.00	0.00	100.00	77
West Bay	08WBAY:812	0.00	0.00	100.00	76
West Bay	08WBAY:830	0.00	0.00	100.00	77
West Bay	08WBAY:850	0.00	0.00	100.00	76
West Bay	08WBAY:860	0.00	0.00	100.00	76
West Bay Summary		0.00	1.24	98.76	1,126
Withlacoochee Bay	34WITH:150	0.00	0.00	100.00	47
Withlacoochee Bay	34WITH:160	0.00	0.00	100.00	46
Withlacoochee Bay	34WITH:191	0.00	0.00	100.00	47
Withlacoochee Bay	34WITH:210	0.00	0.00	100.00	47
Withlacoochee Bay	34WITH:220	0.00	0.00	100.00	47
Withlacoochee Bay	34WITH:230	0.00	0.00	100.00	46
Withlacoochee Bay	34WITH:240	0.00	0.00	100.00	47
Withlacoochee Bay	34WITH:260	0.00	0.00	100.00	47
Withlacoochee Bay Summary		0.00	0.00	100.00	374
Florida Summary		0.39	3.08	96.53	10,100

Table A3

Percent true negative values of fecal coliform samples, collected by the Georgia Department of Natural Resource, from 72 shellfish stations in the Approved shellfish growing areas of six sounds (Cumberland, Doboy, Sapelo, St. Andrew, St. Catherines, and Wassaw) over 11 years from 1/4/2000 through 12/15/2010. The stations with problems are highlighted in pink.

Region	Station	True Positive %	False Negative %	True Negative %	Total Count
Cumberland	Cumberland:6300	26.87	23.88	49.25	67
Cumberland	Cumberland:6210	0.00	0.00	100.00	68
Cumberland	Cumberland:6212	0.00	0.00	100.00	66
Cumberland	Cumberland:6213	0.00	0.00	100.00	67
Cumberland	Cumberland:6214	0.00	0.00	100.00	68
Cumberland	Cumberland:6215	0.00	0.00	100.00	67
Cumberland	Cumberland:6216	0.00	0.00	100.00	67
Cumberland	Cumberland:6217	0.00	0.00	100.00	67

Cumberland	Cumberland:6218	0.00	0.00	100.00	67
Cumberland	Cumberland:6317	0.00	0.00	100.00	65
Cumberland	Cumberland:6318	0.00	0.00	100.00	68
Cumberland	Cumberland:6323	0.00	0.00	100.00	67
Cumberland	Cumberland:6343	0.00	0.00	100.00	68
Cumberland	Cumberland:6344	0.00	0.00	100.00	68
Cumberland	Cumberland:6411	0.00	0.00	100.00	67
Cumberland	Cumberland:6412	0.00	0.00	100.00	68
Cumberland Summary		1.67	1.49	96.84	1,075
Doboy	Doboy:4333	0.00	0.00	100.00	22
Doboy Summary		0.00	0.00	100.00	22
Sapelo	Sapelo:4356	5.56	94.44	0.00	18
Sapelo	Sapelo:4196	2.90	63.77	33.33	69
Sapelo	Sapelo:4197	14.49	33.33	52.17	69
Sapelo	Sapelo:4184	0.00	42.86	57.14	70
Sapelo	Sapelo:4177	0.00	17.91	82.09	67
Sapelo	Sapelo:4305	0.00	11.43	88.57	70
Sapelo	Sapelo:4178	0.00	8.70	91.30	69
Sapelo	Sapelo:4092	0.00	0.00	100.00	70
Sapelo	Sapelo:4120	0.00	0.00	100.00	52
Sapelo	Sapelo:4122	0.00	0.00	100.00	51
Sapelo	Sapelo:4123	0.00	0.00	100.00	32
Sapelo	Sapelo:4175	0.00	0.00	100.00	70
Sapelo	Sapelo:4179	0.00	0.00	100.00	70
Sapelo	Sapelo:4180	0.00	0.00	100.00	70
Sapelo	Sapelo:4185	0.00	0.00	100.00	52
Sapelo	Sapelo:4186	0.00	0.00	100.00	51
Sapelo	Sapelo:4187	0.00	0.00	100.00	70
Sapelo	Sapelo:4188	0.00	0.00	100.00	70
Sapelo	Sapelo:4190	0.00	0.00	100.00	70
Sapelo	Sapelo:4191	0.00	0.00	100.00	70
Sapelo	Sapelo:4195	0.00	0.00	100.00	39
Sapelo	Sapelo:4304	0.00	0.00	100.00	69
Sapelo	Sapelo:4306	0.00	0.00	100.00	70
Sapelo	Sapelo:4330	0.00	0.00	100.00	70
Sapelo	Sapelo:4332	0.00	0.00	100.00	19
Sapelo	Sapelo:4400	0.00	0.00	100.00	69
Sapelo Summary		0.83	8.94	90.23	1,566
St Andrew	St Andrew:6361	0.00	69.77	30.23	43
St Andrew	St Andrew:5357	0.00	19.40	80.60	67
St Andrew	St Andrew:5069	0.00	0.00	100.00	66
St Andrew	St Andrew:5105	0.00	0.00	100.00	67
St Andrew	St Andrew:5198	0.00	0.00	100.00	67
St Andrew	St Andrew:5199	0.00	0.00	100.00	67

St Andrew	St Andrew:5200	0.00	0.00	100.00	66
St Andrew	St Andrew:5322	0.00	0.00	100.00	66
St Andrew	St Andrew:5358	0.00	0.00	100.00	67
St Andrew	St Andrew:5359	0.00	0.00	100.00	67
St Andrew	St Andrew:6201	0.00	0.00	100.00	66
St Andrew	St Andrew:6360	0.00	0.00	100.00	43
St Andrew Summary		0.00	5.72	94.28	752
St Catherines	St Catherines:3288	0.00	65.79	34.21	38
St Catherines	St Catherines:3285	18.42	44.74	36.84	38
St Catherines	St Catherines:3286	0.00	55.26	44.74	38
St Catherines	St Catherines:3242	0.00	0.00	100.00	38
St Catherines	St Catherines:3249	0.00	0.00	100.00	38
St Catherines	St Catherines:3255	0.00	0.00	100.00	38
St Catherines	St Catherines:3273	0.00	0.00	100.00	38
St Catherines	St Catherines:3275	0.00	0.00	100.00	38
St Catherines	St Catherines:3291	0.00	0.00	100.00	38
St Catherines	St Catherines:3319	0.00	0.00	100.00	38
St Catherines Average		1.84	16.58	81.58	380
Wassaw	Wassaw:1225	0.00	10.00	90.00	70
Wassaw	Wassaw:1224	0.00	9.86	90.14	71
Wassaw	Wassaw:1222	0.00	5.71	94.29	70
Wassaw	Wassaw:1223	0.00	4.23	95.77	71
Wassaw	Wassaw:1201	0.00	1.41	98.59	71
Wassaw	Wassaw:1159	0.00	0.00	100.00	32
Wassaw	Wassaw:1200	0.00	0.00	100.00	70
Wassaw Average		0.00	4.84	95.16	455
Georgia Average		**0.89**	**6.68**	**92.42**	**4,250**