Georgia Coastal Water Quality
2000 - 2006

GEORGIA
DEPARTMENT OF NATURAL RESOURCES
COASTAL RESOURCES DIVISION

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

GCRC
Georgia Coastal Research Council

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For more information about the Water Quality Monitoring Programs mentioned in this report, please contact the GA DNR Coastal Resources Division at (912) 264-7218 or visit their website at http://www.CoastalGaDNR.org.

Suggested Citation

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About the Georgia Coastal Research Council:

The Georgia Coastal Research Council (GCRC) was established to provide mechanisms for improved scientific exchange between coastal scientists and decision makers, and to promote the incorporation of best-available scientific information into State and local resource management. The Council is not a policy organization, but rather seeks to provide unbiased, objective information about scientific issues. Baseline support for the program is shared by the Coastal Resources Division of the Georgia Department of Natural Resources (through the Coastal Management Program) and Georgia Sea Grant, with project-specific support from the National Science Foundation and other agencies. For more information please contact us at gcrc@uga.edu or see our website at http://www.gcrc.uga.edu.

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Background

The Coastal Resources Division (CRD) of the Georgia Department of Natural Resources (GA DNR) collects water quality data in support of a variety of programs. The Georgia Coastal Research Council recently compiled these observations into an integrated database and analyzed it for long-term and seasonal trends. As a part of that effort, we proposed a suite of indicators and recommended evaluation criteria intended to help classify and understand the causes of water quality degradation in Georgia. These indicators, which are described in a separate technical report, are dissolved oxygen, nitrogen, phosphorus, pH, chlorophyll *a*, transparency, and biochemical oxygen demand. In this brochure we use the GA DNR CRD data to assess the status of Georgia estuaries and coastal waters according to the criteria recommended for the first four of these indicators, as these are the only ones that had been collected prior to these recommendations. It is our hope that assessments of all seven of these indicators will be conducted on a regular basis in the future in order to provide ongoing information on the status of Georgia's estuarine and coastal waters.

The citation for the full technical report is:

> Sheldon, Joan E. and Merryl Alber. 2010. The condition of Georgia's coastal waters: development and analysis of water quality indicators. Technical report prepared by the Georgia Coastal Research Council, University of Georgia, Athens GA for the Georgia Department of Natural Resources, Coastal Resources Division, 173 pp.

It can be accessed at http://www.gcrc.uga.edu/Research/sheldon_indicators.html.

Georgia Coastal Water Quality Monitoring Programs

Georgia coastal waters are home to commercially and recreationally important species such as fish, shrimp, crabs and oysters as well as the smaller organisms on which they feed. They are also important areas for nutrient cycling and the treatment of waste and runoff. GA DNR CRD collects water quality data in order to gain a better understanding of the condition of our coastal waters. The data used in this report were collected as part of a variety of monitoring programs conducted to support fishing, shellfishing and other uses of the coast, such as boating and swimming. In all cases, samples were from surface waters and were usually collected during daylight hours, at various stages of the tide.

Shellfish Sanitation Program

GA DNR CRD manages Georgia's Shellfish Sanitation Program for the safe recreational and commercial harvest of oysters and clams. This program is funded by the State of Georgia and carried out in partnership with other agencies, including GA DNR Wildlife Resources Division and the GA Department of Agriculture. Shellfishing is managed according to U.S. Food and Drug Administration (FDA) National Shellfish Sanitation Program standards. One of CRD's main roles in the program is to monitor fecal coliform bacteria levels, and those results are reported regularly through the FDA and through closure announcements as needed; they are not repeated here. CRD also routinely collects data on salinity, water temperature, dissolved oxygen, and pH. Dissolved nutrient concentrations (nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen, total dissolved phosphorus, orthophosphate-phosphorus, and silicate) are measured at selected sites. Sites were generally monitored monthly until mid-2005, when sampling was reduced to bimonthly. Sampling sites reported on here are in current or former growing areas and are not necessarily in areas that are currently approved for harvest.

Sound and River Nutrient Monitoring Programs

These two closely related programs measure nutrients and other water quality parameters in Georgia's estuaries (the Sound program) and the lower reaches of the Ogeechee, Altamaha and St. Marys rivers (the River program). The purpose of these programs, which are funded by the State of Georgia, is to assess trends in nutrient concentrations in Georgia coastal waters and to provide baseline data for resource managers to use in making management decisions. The nutrient data included in this study generally begin in mid-late 2001 for the sounds and in mid-2002 for the rivers. Dissolved nutrients that are monitored include nitrate-nitrogen, nitrite-nitrogen, ammonia-nitrogen, total dissolved phosphorus, orthophosphate-phosphorus, and silicate. Other parameters measured in the field include water temperature, salinity, specific conductance, dissolved oxygen, and pH. Sites were generally monitored monthly during the period covered by this report.

Beach Water Quality Monitoring Program

The purpose of this program, which is funded by federal BEACH Act Implementation Grants, is to monitor Georgia's recreational marine beaches for conditions that would specifically affect human health through contact with the water. The primary function of this program is to measure enterococci bacteria as the indicator organisms for marine recreational waters under the current U.S. EPA (1986) water quality standards and to begin the public notification process if the standards are violated. As with the Shellfish Sanitation Program, the bacteria counts are not reported here. CRD also measures other water quality parameters at beach sites, including water temperature, salinity, specific conductance, pH, dissolved oxygen, and turbidity, but not nutrients. Sites were monitored either weekly year-round or monthly April-November, depending on usage.

Water Quality Indicators

Increasing nutrient input is a prime concern for coastal systems worldwide. Excess inputs of nitrogen and phosphorus stimulate the growth of phytoplankton and/or bacteria and can lead to eutrophication (accelerated production of organic matter) and hypoxia (low dissolved oxygen). Hypoxia can result in death of fish and bottom-dwelling organisms as well as many other sublethal effects including reduced growth and reproduction, migration to avoid poor conditions, reduction of spawning grounds and nursery habitats, and increased vulnerability to predation. Other symptoms of eutrophication include the stimulation of nuisance and toxic algal blooms, increases in turbidity, and changes in food webs.

Another potential concern is pH stability of oceans and coastal areas. pH is a measurement of the acidity or alkalinity of water. pH can be affected by ocean acidification due to rising atmospheric carbon dioxide levels, or by effluents or runoff that contain chemicals that can change the pH of the receiving water. The buffering capacity of seawater is often thought to protect estuaries and coastal waters against pH changes large enough to affect organisms, but there is mounting evidence that estuaries can experience pH changes that may be stressful to their inhabitants.

This report focuses on four parameters that address the potential issues of eutrophication and pH stability in Georgia coastal waters. Below we explain the criteria that we used to designate a water quality observation as "good", "fair", or "poor". The effects of a given amount and form of nutrient (nitrogen or phosphorus) can vary from one estuary to another, so localized criteria are best but they are costly to develop. Until such local studies can be done, this report uses nutrient criteria derived for national eutrophication studies.

Dissolved Oxygen

Low dissolved oxygen is a primary consequence of eutrophication. An extensive review of the scientific literature identified oxygen levels that have been shown to be protective of broad groups of estuarine organisms (e.g. fish, crustaceans, molluscs). In this report, less than (<) 3 mg dissolved oxygen per liter was considered "poor", 3 to 5.5 mg "fair", and greater than (>) 5.5 mg "good".

Nitrogen

Excess nitrogen is frequently the primary cause of eutrophication in estuaries. Nitrogen is present in estuaries in many forms. There are several common inorganic forms (such as those found in chemical fertilizers), as well as a variety of organic compounds (such as those found in wastewater) that can be used by bacteria or phytoplankton to varying degrees. Measuring total dissolved nitrogen (TDN) is a good way to measure most of these forms together. Since only dissolved inorganic nitrogen (DIN) (ammonia, nitrate, and nitrite) measurements were available for Georgia coastal waters, this report used DIN concentrations as a rough estimate of nitrogen status, assuming that together they constitute about 25% of TDN in Georgia coastal waters (the remainder being dissolved organic nitrogen). DIN concentrations > 0.25 mg per liter were considered "poor", 0.025 to 0.25 mg "fair", and < 0.025 mg "good".

Phosphorus

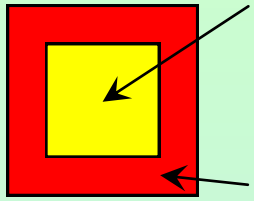
Phosphorus is also present in estuaries in both inorganic and organic forms, so total dissolved phosphorus (TDP) is a good way to measure most of these forms together. In Georgia, geologic sources may contribute significant amounts of phosphorus to estuaries, which are compounded by additional sources from human activities. TDP concentrations > 0.1 mg per liter were considered "poor", 0.01 to 0.1 mg "fair", and < 0.01 mg "good".

pH

pH outside the normal range can be stressful to organisms: the scientific literature suggests that 0.5 unit decreases from normal pH are well tolerated by most organisms, whereas a decrease of 0.5 to 1 units or more can result in stress responses and more serious effects, especially when combined with hypoxia. However, what constitutes "normal" can vary from one location to another, especially in estuaries, where pH varies with salinity. Freshwater pH is usually near neutral, but blackwater systems have acidic pH (< 7) in low-salinity waters. Oceanic pH is slightly alkaline (> 7). The pH criteria are based on changes from normal for a given salinity for different types of estuaries. A deviation of > 1 was considered "poor", 0.5 to 1 "fair", and < 0.5 "good".

Key to Indicator Tables

The indicator tables used throughout this report present the water quality status for each indicator parameter for each monitoring site during each calendar year. Status is presented as colored squares indicating the median and extreme conditions at the site for the year.



Median Conditions

The inner square represents the classification of the median value for the year. The median is the value in the middle of the data, with half of the observations being below the median and half above it. Squares colored green correspond to good conditions, yellow to fair, and red to poor.

Extreme Episodes

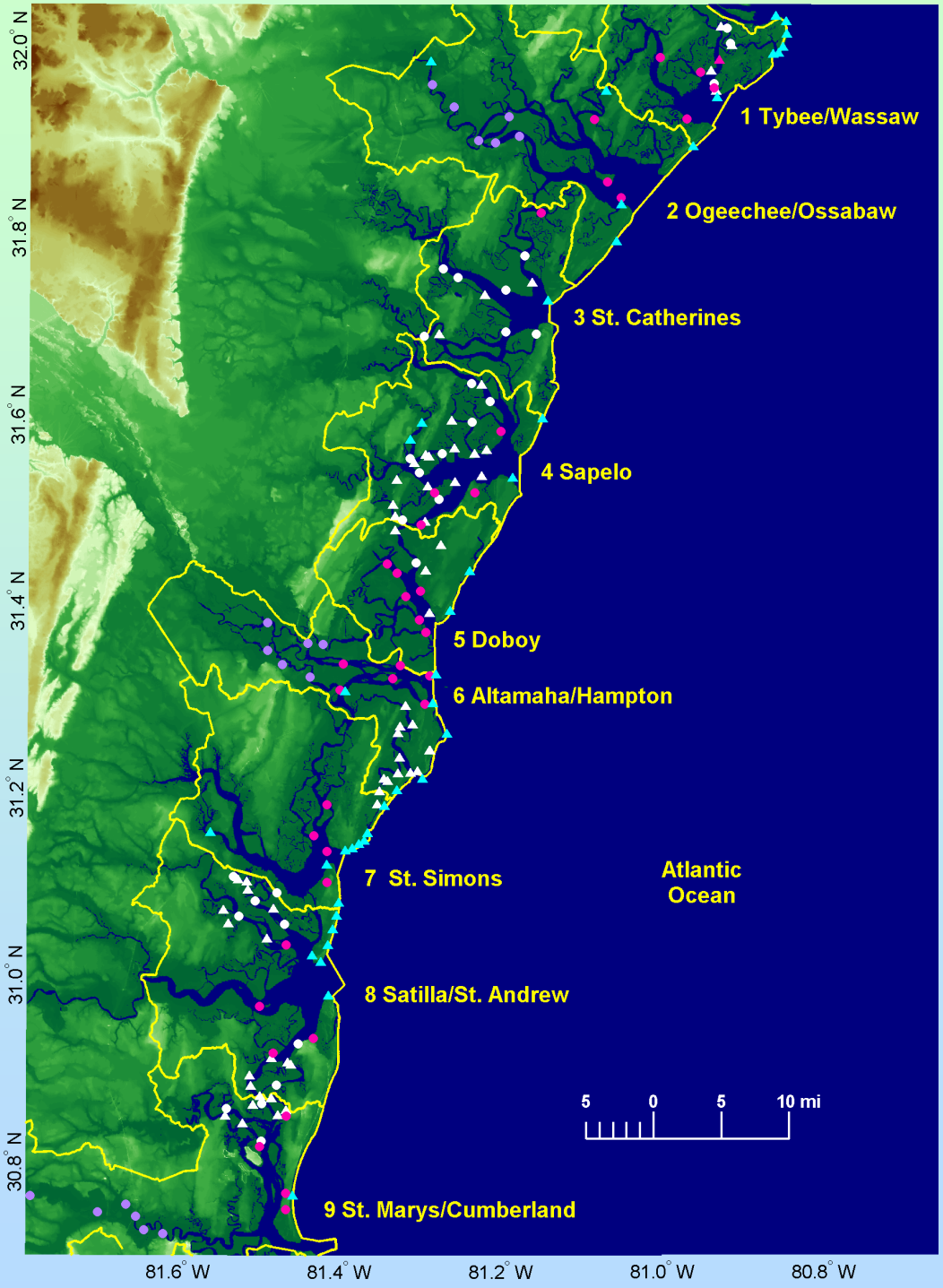
The outer square represents the classification of the extreme conditions observed at the site over the course of the year. These conditions are reported for dissolved oxygen and pH because a single poor episode of these water quality parameters could do lasting harm. Extreme conditions are not reported for nitrogen and phosphorus because chronic nutrient over-enrichment is more of a concern for long-term water quality than a single brief episode. These observations therefore do not have an outer square. For dissolved oxygen, the minimum value observed over the year is compared to the criteria and classified as good, fair or poor. For pH, the largest deviation from normal over the year, whether higher or lower (usually lower), is evaluated. Outer squares colored green correspond to good conditions, yellow to fair, and red to poor.

The example to the left is for an indicator that had a fair (yellow) median value, meaning that conditions were fair or better for at least half the year, and a poor (red) extreme value, meaning that conditions were poor at least once during the year.

Indicator Criteria used for Water Quality Status of Georgia Coastal Waters

	Dissolved Oxygen mg per liter	**Dissolved Inorganic Nitrogen** mg per liter	**Total Dissolved Phosphorus** mg per liter	**Δ pH** unit deviation
Good	> 5.5	< 0.025	< 0.01	< 0.5
Fair	3.0 – 5.5	0.025 – 0.250	0.01 – 0.10	0.5 – 1.0
Poor	< 3.0	> 0.250	> 0.10	> 1.0
Insufficient Data	Median: < 5 samples per year, or a missing season Minimum: < 2 samples during summer	< 5 samples per year, or a missing season	< 5 samples per year, or a missing season	< 5 samples per year, or a missing season

Georgia DNR Coastal Resources Division Sampling Sites and Data



Estuarine Regions of Coastal Georgia

The Georgia coast spans approximately 100 miles, with nine major sounds and countless tidal creeks connecting to the Atlantic Ocean. The GA DNR CRD sampling sites were divided into nine regions organized around the major sounds and nearby coastal areas. Each sampling location was assigned to a region using watershed boundaries (yellow) as a guide. Each region may contain sites sampled in the River (purple), Sound (pink), Shellfish (white), and/or Beach (cyan) monitoring programs.

Data Used in this Report

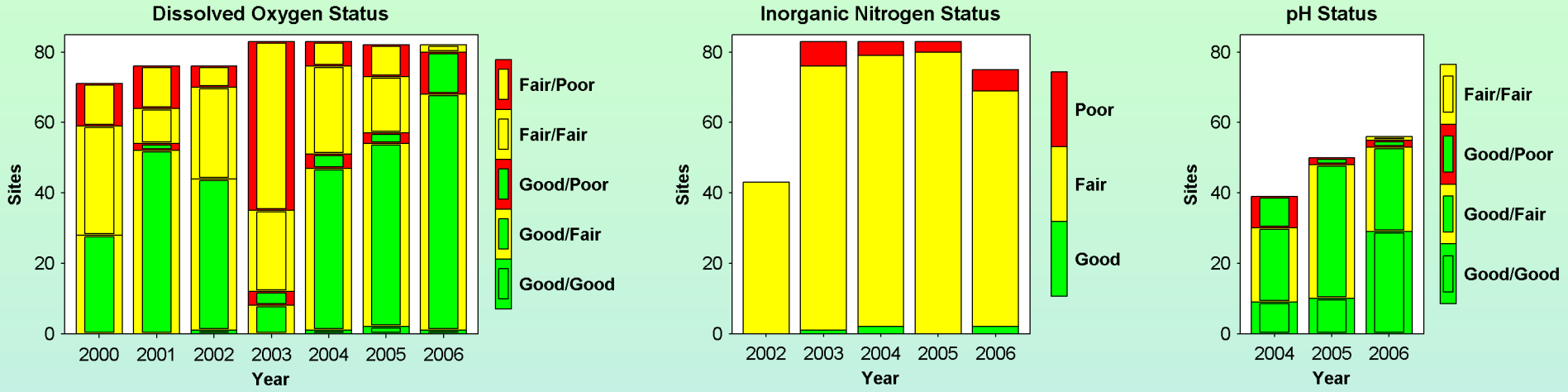
This report focuses on the period 2000-2006. Water quality status is presented only for sites having at least 5 observations within a given year, with observations spread throughout the year to minimize seasonal bias. Dissolved oxygen measurements began in early 2000 at most Shellfish, River, and Sound sites, and in mid-2004 at Beach sites. Nitrogen and phosphorus measurements began gradually starting mid-2001, so evaluation of annual nutrient status at most sites starts in 2002. Even though pH measurements began in 2002 or 2003 at many sites, sampling frequency was insufficient to evaluate annual status until 2004.

The next page provides an overview of water quality coastwide from 2000-2006 using a subset of 83 sites (denoted by **circles** on the map) that had data available for most indicators for each year, including nutrients. Sites denoted by **triangles**, including all beach sites, were not included. The regional pages that follow focus on the water quality at all of the individual sites in each of these regions.

Overview of Water Quality through Time

The figures below present the total number of sites that were classified into each status category from a subset of 83 sites (denoted by circles on the previous page) for which complete data were available.

Number of Sites in each Water Quality Status Category for each Calendar Year



No clear long-term trends in water quality were apparent over the period covered by this report (2000-2006). However, the weather during this period was extreme relative to historical records, and some of the year-to-year variations observed in water quality appear to be linked to patterns of freshwater input (rainfall, runoff, and streamflow). The beginning of the period (2000-2002) marked the end of a severe 4-year drought, whereas 2003 was an extremely wet year with high streamflows. 2004-2005 had near-normal to high streamflows, and another drought began in mid-2006. These changes in freshwater input may help explain dissolved oxygen and nutrient concentrations, as described below, but it will take additional years of data collection before any underlying, longer-term trends may emerge. In addition, the time span of data included in this analysis (7 years or less) is close to the length of known climatological cycles such as El Niño: only about one cycle is represented here. A longer record is necessary to evaluate the effects of these cycles over time.

Dissolved Oxygen

During 2000-2002 (the end of a drought), 40-70% of these sites had good median dissolved oxygen levels, but fair or poor extreme values were common. Dissolved oxygen levels were markedly lower in 2003, possibly in response to increased nutrient concentrations (see below). Median oxygen levels were fair at 85% of sites in 2003, and poor extreme values occurred at 60% of sites. In the following years, dissolved oxygen levels improved, with good median conditions at 60% or more sites and poor extreme values at only about 15% of sites.

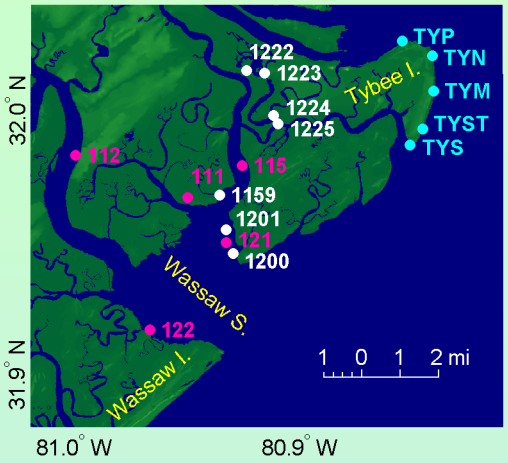
Nitrogen and Phosphorus

Nitrogen sampling was incomplete at many sites in 2002, but those sampled had fair median conditions. Nitrogen concentrations were higher in 2003 than in later years, although most were still classified as fair. It may be that higher delivery of nutrients (especially nitrogen) during high streamflow conditions in 2003 led to decreases in dissolved oxygen. Median phosphorus conditions (not shown) were fair at all sites during the study period.

pH

With only 3 years of data, pH patterns are inconclusive. During 2004-2006 median conditions were good at almost all sites, but fair and poor extreme values occurred at over half of the sites.

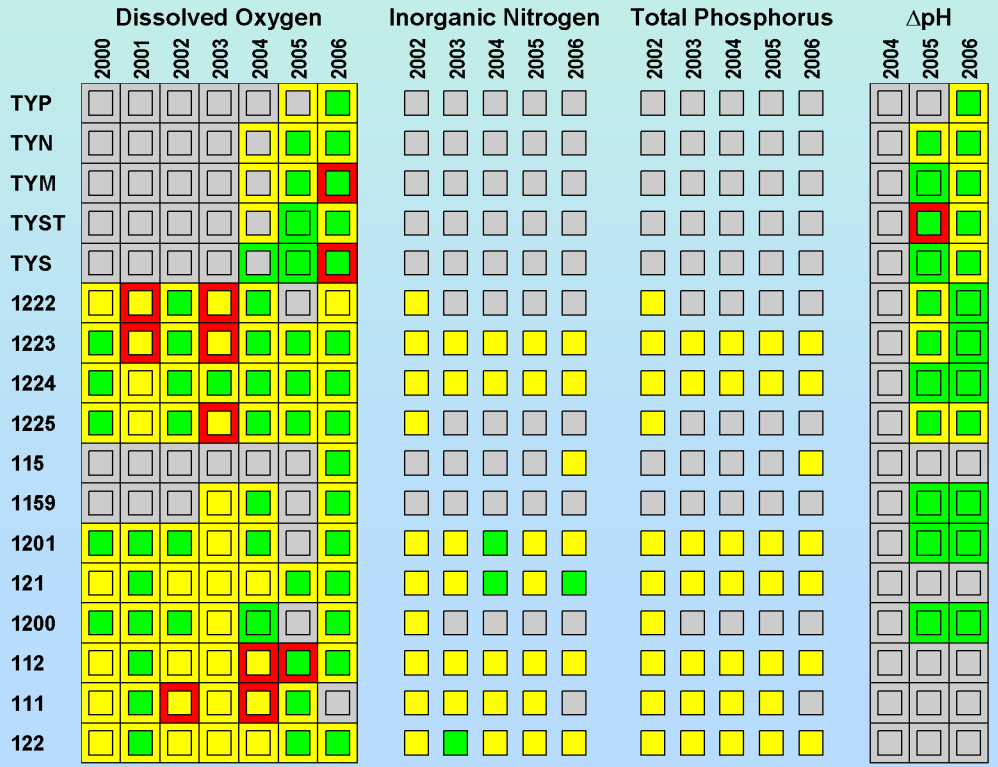
Region 1: Tybee Beaches and Wassaw Sound



Wassaw Sound is an estuary between Tybee Island (to the north) and Wassaw Island (to the south). Tybee Island is a beach resort area, whereas Wassaw Island is a National Wildlife Refuge managed by the U.S. Fish and Wildlife Service. The Savannah River, a heavily industrialized river that is not currently monitored by GA DNR CRD, flows out north of Tybee Island, delivering an average of 12,100 cubic feet of freshwater per second to the coastal zone. There are connections to Wassaw Sound through the Wilmington and Bull Rivers. Shellfish harvest areas are found in Oyster and Lazaretto creeks north of the sound and on the northeast edge of the sound. The estuary and coastal areas support commercial and recreational fisheries for shrimp and blue crabs. This region includes sites sampled through the Sound (pink), Shellfish (white), and Beach (cyan) monitoring programs.

Oxygen

Median dissolved oxygen conditions were fair in the sound and upper Oyster Creek during 2000, and good in other shellfish sites in lower Oyster and Lazaretto Creeks and the northeast side of the sound. Annual extreme conditions were fair. In 2001, median oxygen conditions were good and extreme conditions were fair in the sound, whereas Oyster and Lazaretto Creeks had fair median conditions with some poor extreme episodes. Conditions reversed in 2002, with creeks having generally good median conditions with fair extreme episodes, and the sound having mostly fair median conditions with poor extreme episodes noted at one site. In 2003, most sites had fair median conditions, and poor extreme episodes were noted in the creeks. Conditions generally improved in 2004-2006, with good median conditions and fair extreme episodes at most sites, but poor episodes were noted in the sound. Beaches had generally good median oxygen conditions, but annual extreme episodes ranged from good to poor.



Nitrogen

Dissolved inorganic nitrogen was generally fair during the study period. Median conditions were good at one Sound site in 2003, at two other sites in 2004, and at one Sound site in 2006.

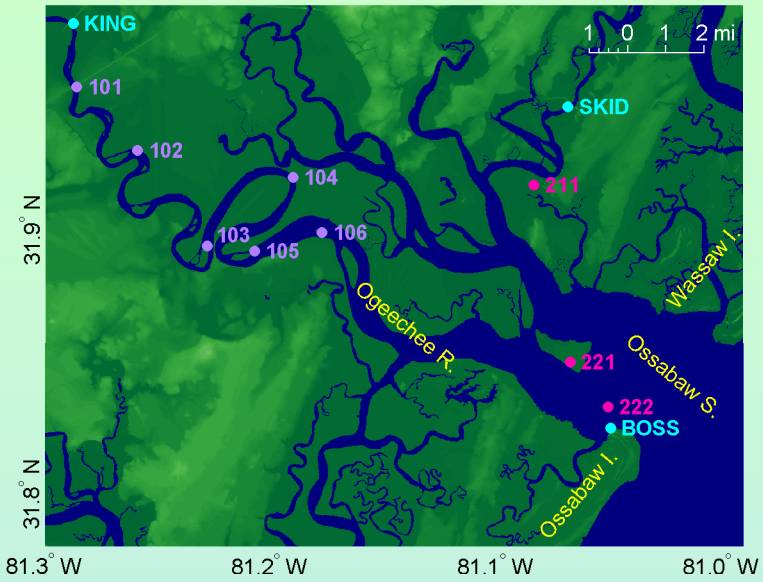
Phosphorus

Total dissolved phosphorus was fair during the study period.

pH

pH criteria are based on fluctuations around the normal condition. pH stability in this region was generally good during 2005-2006, with fair extreme episodes in Oyster and Lazaretto Creeks and at the beaches, and poor episodes at Tybee Island Strand.

Region 2: Ogeechee River and Ossabaw Sound



Ossabaw Sound is an estuary between Wassaw Island (to the north) and Ossabaw Island (to the south). Wassaw Island is a National Wildlife Refuge managed by the U.S. Fish and Wildlife Service. Ossabaw Island is a state-owned Heritage Preserve operated by GA DNR and a private foundation. The blackwater Ogeechee River provides an average of 3,800 cubic feet of freshwater per second to the sound and coastal zone. The Little Ogeechee and Vernon Rivers join before emptying into the sound north of the Ogeechee River. The Vernon River connects to the Wilmington/Wassaw region to the north (not shown) through the Skidaway River. The estuary and coastal areas support commercial and recreational fisheries for shrimp and blue crabs. Endangered shortnose sturgeon and a struggling population of Atlantic sturgeon are found in the river and estuary. This region includes sites sampled through the River (purple), Sound (pink), and Beach (cyan) monitoring programs.

Oxygen

Median and extreme dissolved oxygen conditions were generally fair in 2000, although good median conditions were observed at 3 sites in the Ogeechee River. In 2001, median conditions were good and extreme conditions were fair at all sites. Conditions in 2002 were similar at most sites but the sound and Delegal Creek (site 211) degraded to fair median conditions with some poor episodes. In 2003, median conditions were fair at all sites, and there were poor episodes at all the Ogeechee River sites. Conditions improved in 2004-2006, with good median conditions and fair extreme conditions at most sites. There were poor episodes at Delegal Creek in 2004 and at one Sound site in 2006.

Nitrogen

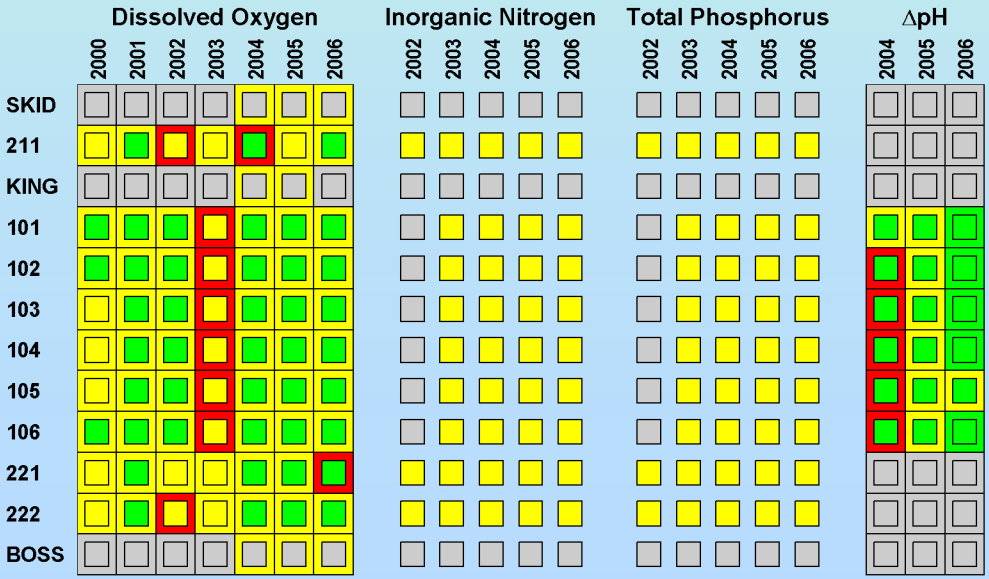
Dissolved inorganic nitrogen was fair during the study period.

Phosphorus

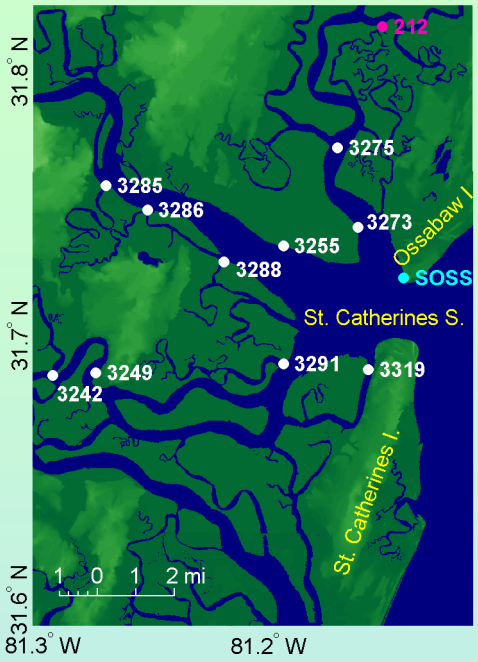
Total dissolved phosphorus was fair during the study period.

pH

The upper reaches of most estuaries fed by blackwater streams are acidic because of the low pH of the incoming freshwater. The Ogeechee/Ossabaw system is unique in that brown tannic low-pH water from forested wetlands in the coastal plain combines with higher-pH carbonate-rich water from Magnolia Springs to make the lower river and upper estuary pH near neutral. The pH in the estuary increases somewhat as river water mixes with the high-pH coastal ocean water, but it is still naturally low. pH was measured only at Ogeechee River sites, and was evaluated based on fluctuations from normal. Median pH stability was good at all sites in 2004-2006, but extreme conditions ranged from mostly poor in 2004, to fair in 2005, to mostly good in 2006.



Region 3: St. Catherines Sound



St. Catherines Sound is an estuary between Ossabaw Island (to the north) and St. Catherines Island (to the south). Ossabaw Island is a state-owned Heritage Preserve operated by GA DNR and a private foundation. St. Catherines Island is largely a private exotic wildlife reserve owned by a foundation, although the beach is open to the public. Freshwater input is low, with connections from the Bear River (north), Medway River (northwest) and North Newport River (southwest). Shellfish harvest areas are currently found in the Medway and Bear rivers. The estuary and coastal areas also support commercial and recreational fisheries for blue crabs. This region primarily includes sites sampled through the Shellfish Monitoring Program (white), with one Sound (pink) and one Beach (cyan) site.

Oxygen

Few observations of dissolved oxygen were made prior to 2003, but extreme conditions observed in the summer of 2002 were fair. In 2003, median conditions were fair (with one exception, classified as good), but poor episodes were noted at each site. Conditions improved in 2004, with fair to good median conditions in the region and fair extreme conditions at all sites but one, which was poor. 2005 was similar but with no poor extreme conditions. In 2006, all sites had good median conditions, and extreme conditions ranged from good in the Bear River to poor in Buckhead Creek, with fair extreme conditions elsewhere.

Nitrogen

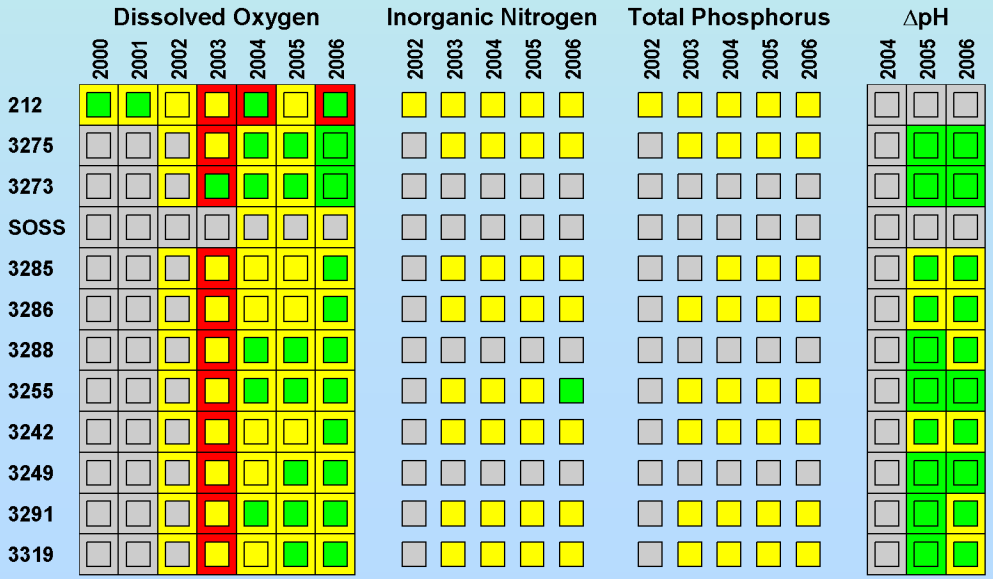
Dissolved inorganic nitrogen was generally fair during the study period, with good median conditions at one site in the Medway River in 2006.

Phosphorus

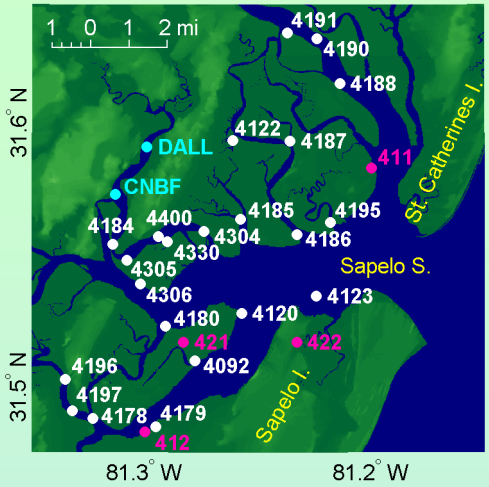
Total dissolved phosphorus was fair during the study period.

pH

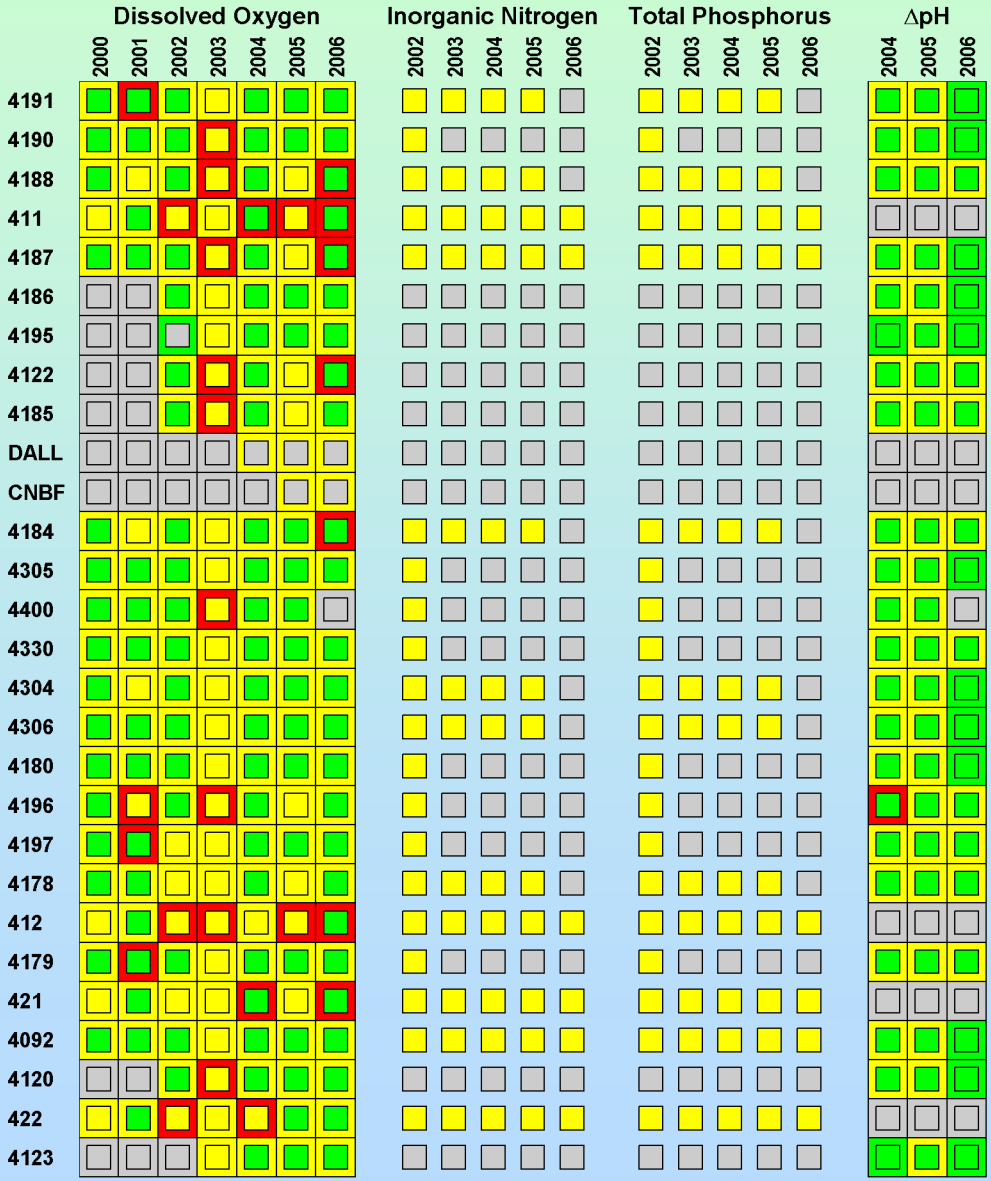
pH criteria are based on fluctuations around the normal condition. pH stability in this region was generally good during 2005-2006, with fair extreme episodes in the Medway River and the North Newport River.



Region 4: Sapelo Sound



Sapelo Sound is an estuary between St. Catherines Island (to the north) and Sapelo and Blackbeard Islands (to the south). St. Catherines Island is largely a private exotic wildlife reserve (see Region 3). Sapelo Island is largely a research and historical site, with the University of Georgia Marine Institute, the Sapelo Island National Estuarine Research Reserve, and GA DNR state park facilities, although there is also a resident community in Hog Hammock. Freshwater input is low, with connections from the Sapelo River (west), South Newport River (north), and Mud River (south). Shellfish harvest areas are found in many of the creeks in this region, and the estuary and coastal areas support commercial and recreational fisheries for shrimp and blue crabs. This region includes sites sampled through the Sound (pink), Shellfish (white), and Beach (cyan) monitoring programs.



Oxygen

Median dissolved oxygen conditions were good at most sites during 2000-2002, with fair conditions at a few different sites each year. Extreme conditions were generally fair during that time, with poor episodes at a few different sites in 2001 and 2002. During 2003, median conditions were fair at all sites, and extreme conditions were fair to poor. Median conditions improved to generally good during 2004-2006, with fair extreme conditions at most sites, although there were poor episodes in the South Newport River and several other creeks north of the sound and in the Mud River area to the south.

Nitrogen

Dissolved inorganic nitrogen was fair during the study period.

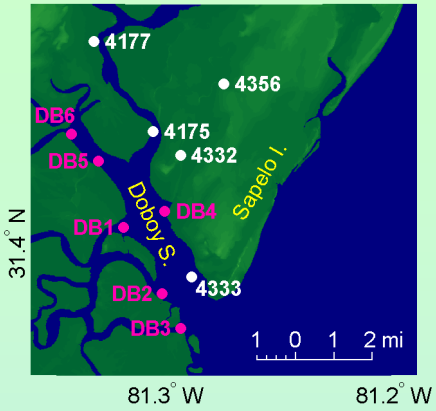
Phosphorus

Total dissolved phosphorus was fair during the study period.

pH

pH criteria are based on fluctuations around the normal condition. Median pH stability in this region was good at all sites. Extreme conditions ranged from mostly fair in 2004-2005 (with one poor site) to mixed good and fair in 2006.

Region 5: Doboy Sound



Doboy Sound is an estuary south of Sapelo Island (see Region 4). It indirectly receives Altamaha River water via the Darien River from the southwest (see Region 6 map), especially during high flow periods. Shellfish harvest areas are currently found in creeks to the north (New Teakettle Creek and Mud River), and the estuary supports commercial and recreational fisheries for blue crabs. This region includes sites sampled through the Sound (pink) and Shellfish (white) monitoring programs.

Oxygen

Median dissolved oxygen conditions in 2000 were fair in upper Doboy Sound and good at other sites, with fair extreme conditions throughout the region. Conditions in 2001 were similar except for poor extreme conditions at two upstream creek shellfish sites. In 2002, all sites had good median conditions and fair extreme conditions. Most sites exhibited fair median and extreme conditions during 2003, but improved during 2004-2006 with good median conditions at all sites, although extreme conditions generally remained fair.

Nitrogen

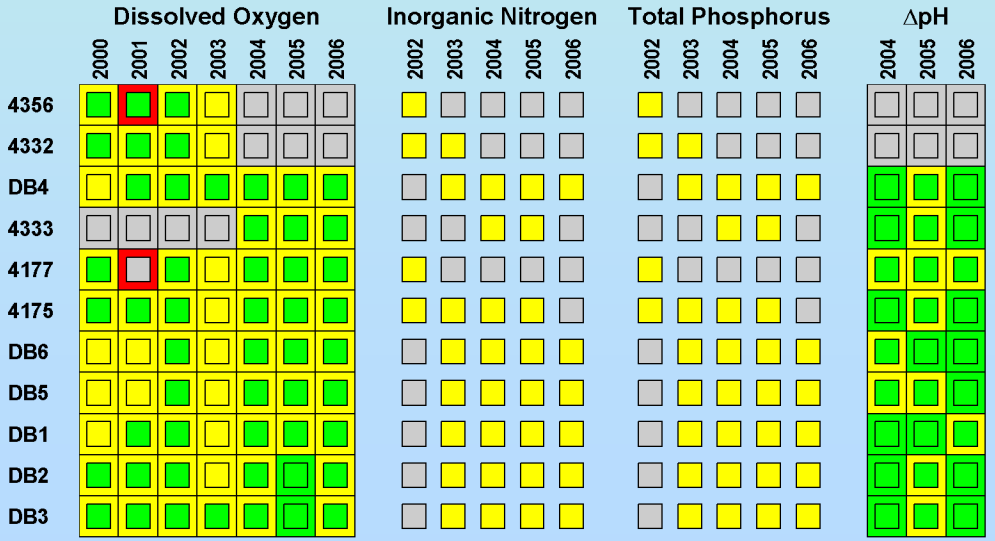
Dissolved inorganic nitrogen was fair during the study period.

Phosphorus

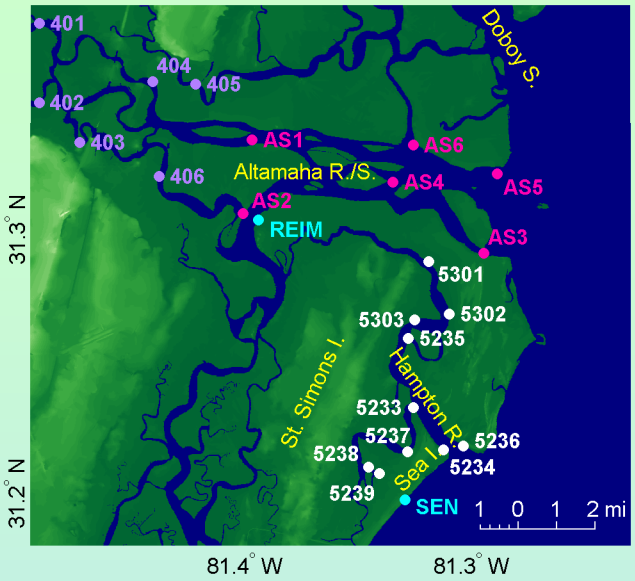
Total dissolved phosphorus was fair during the study period.

pH

pH criteria are based on fluctuations around the normal condition. pH stability in this region was generally good during the study period, with occasional fair extreme conditions, which were more prevalent in 2005 than in 2004 or 2006. The upstream Old Teakettle Creek shellfish site (4177) had fair extreme conditions each year.



Region 6: Altamaha River/Sound and Hampton River



The Altamaha River watershed is the largest in Georgia and one of the largest on the U.S. east coast. The river, which carries an average of 14,000 cubic feet of freshwater per second, empties into Altamaha Sound north of St. Simons Island (see Region 7). The estuary has several channels, some of which reconnect and others which distribute water to other sounds. The Darien River (sampled at site 405) carries water to Doboy Sound to the north, while the Hampton River empties into the ocean north of Sea Island. Former shellfish harvest areas were found around the Hampton River, and the estuary and coastal areas also support commercial and recreational fisheries for blue crabs. Endangered shortnose sturgeon and a recovering population of Atlantic sturgeon are found in the river and estuary. This region includes sites sampled through the River (purple), Sound (pink), Shellfish (white), and Beach (cyan) monitoring programs.

Oxygen

Annual median dissolved oxygen was good at most sites during the study period except for fair conditions at the upper River sites in 2000 and a few scattered sites in 2003. Extreme conditions were generally fair except in 2003, when poor episodes were noted at most River sites.

Nitrogen

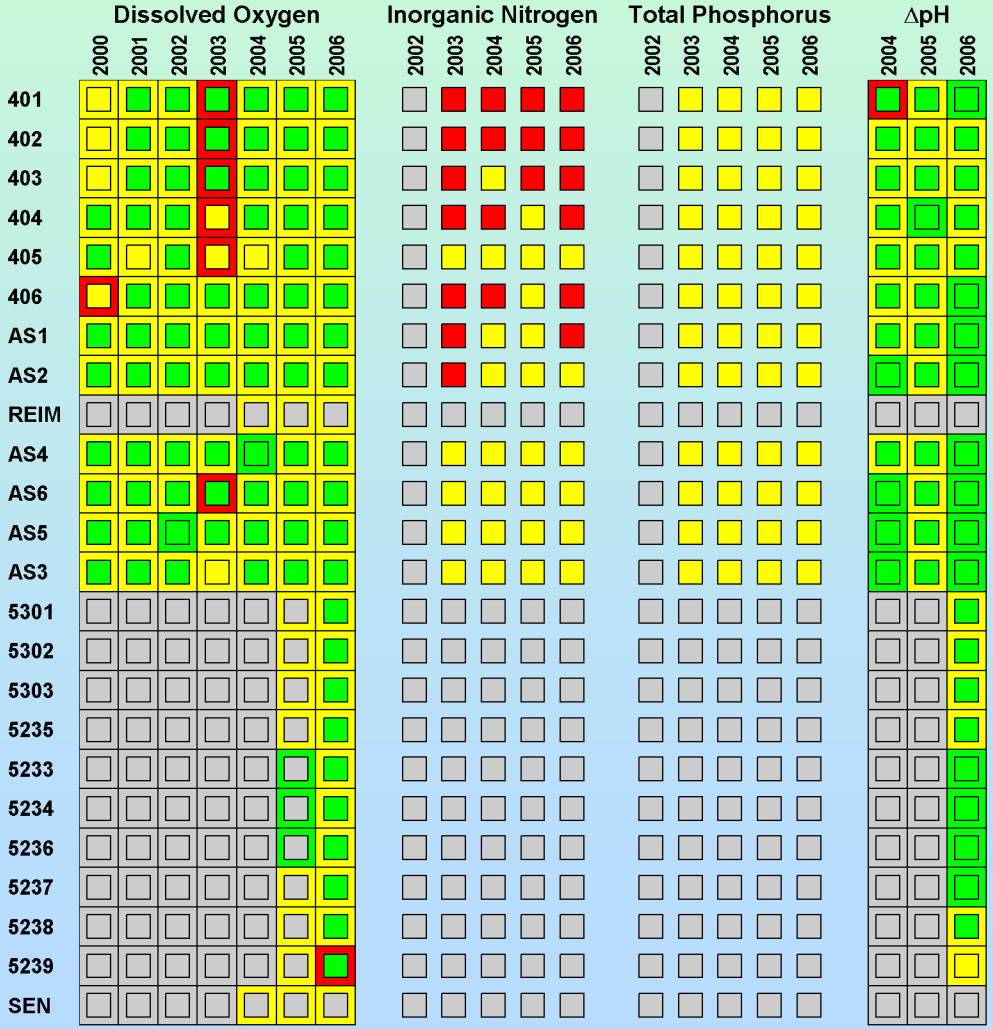
Median dissolved inorganic nitrogen was poor at most sites in the Altamaha River and upper sound during the study period, and fair in the Darien River (site 405) and the lower sound. This likely reflects the fact that the primary sources of nitrogen to the Altamaha River estuary are upstream in the watershed.

Phosphorus

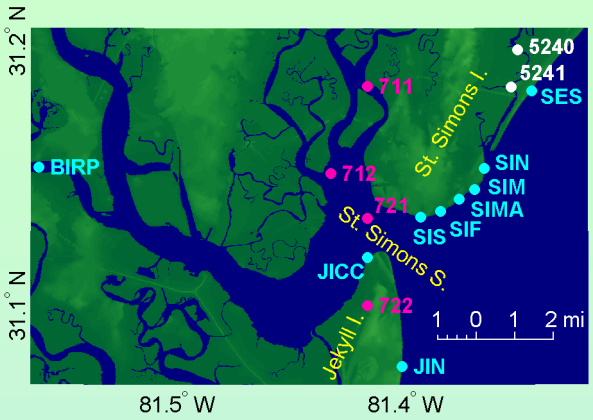
Total dissolved phosphorus was fair during the study period.

pH

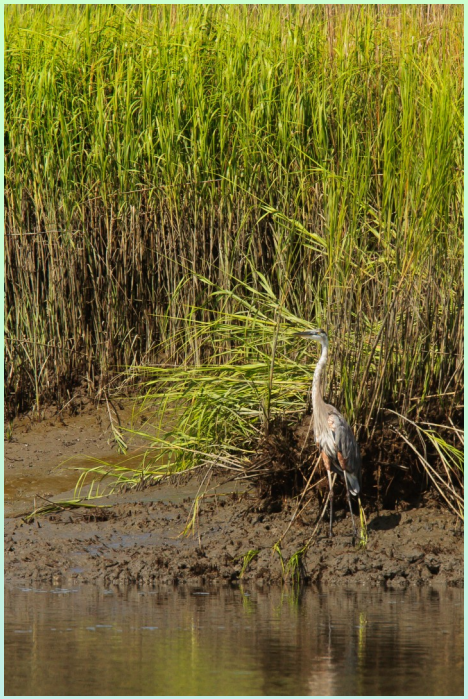
pH criteria are based on fluctuations around the normal condition. Median pH stability in Altamaha River/Sound was generally good, but the extreme conditions varied annually. In 2004, extreme conditions were fair-poor in the river but better in the sound. In 2005 they were generally fair, and in 2006 they were generally fair in the river and good in the sound. In the Hampton River in 2006, median pH stability was good while extreme conditions ranged from fair to good.



Region 7: St. Simons Sound



St. Simons Sound is an estuary between St. Simons Island (to the north) and Jekyll Island (to the south), both popular tourist destinations with busy marinas and public beaches. The Mackay and Frederica Rivers convey fresher water from the Altamaha River through Buttermilk Sound (from the north, not shown), whereas freshwater inflow from the Turtle/Brunswick River from the west is negligible. Several National Priority List cleanup sites exist in this region, including LCP Chemical and Terry Creek Dredge Spoil/Hercules Outfall, which are adjacent to waterways. There are former shellfish harvest areas in creeks on St. Simons Island, and the estuary and coastal areas support commercial and recreational fisheries for shrimp and blue crabs. This region includes sites sampled through the Sound (pink), Shellfish (white), and Beach (cyan) monitoring programs.



Oxygen

Dissolved oxygen data were incomplete in 2000, but fair to poor extreme conditions were noted. During 2001-2003 only 4 sites were sampled, but conditions were consistent among them. In 2001 median conditions were good and extreme conditions were fair; during 2002 conditions were fair in terms of both medians and extremes; and in 2003 median conditions were fair but extreme episodes were poor. More sites were sampled starting in 2004, when oxygen conditions were again fair in terms of both median and extreme conditions. In 2005 the median conditions improved to mostly good even though extreme conditions degraded to poor at most sites. Conditions generally improved in 2006, with most sites having good median conditions and fair extreme conditions.

Nitrogen

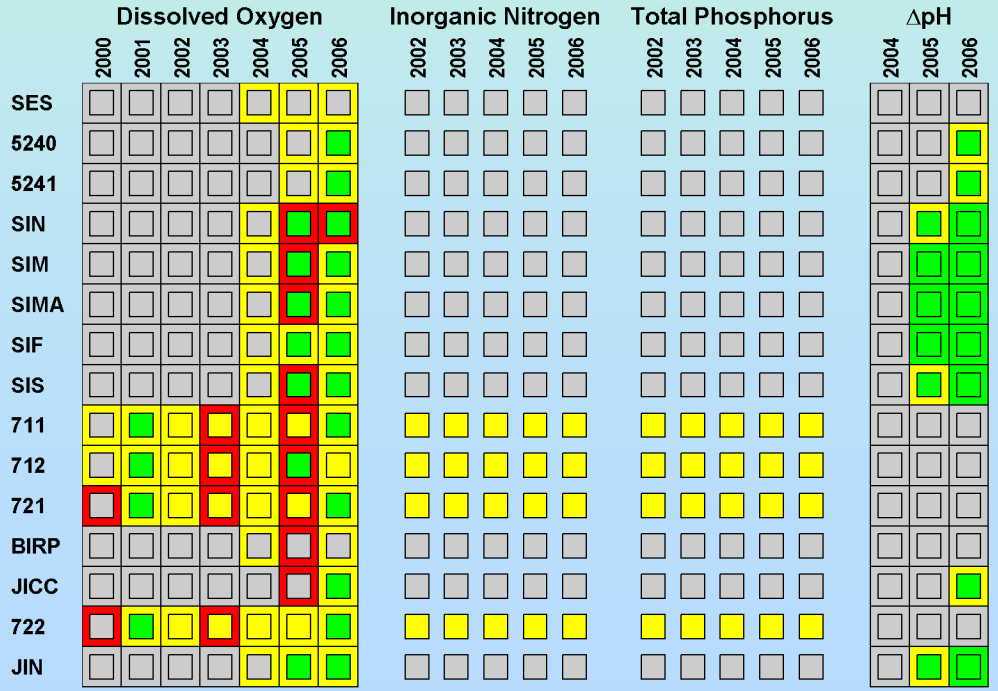
Dissolved inorganic nitrogen was fair during the study period, but only 4 sites were sampled.

Phosphorus

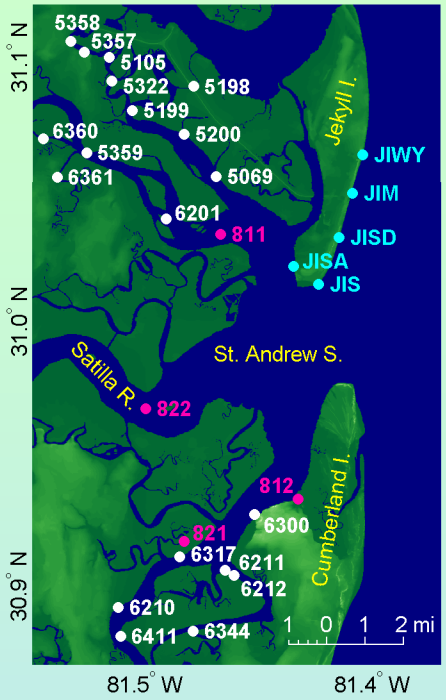
Total dissolved phosphorus was fair during the study period, but only 4 sites were sampled.

pH

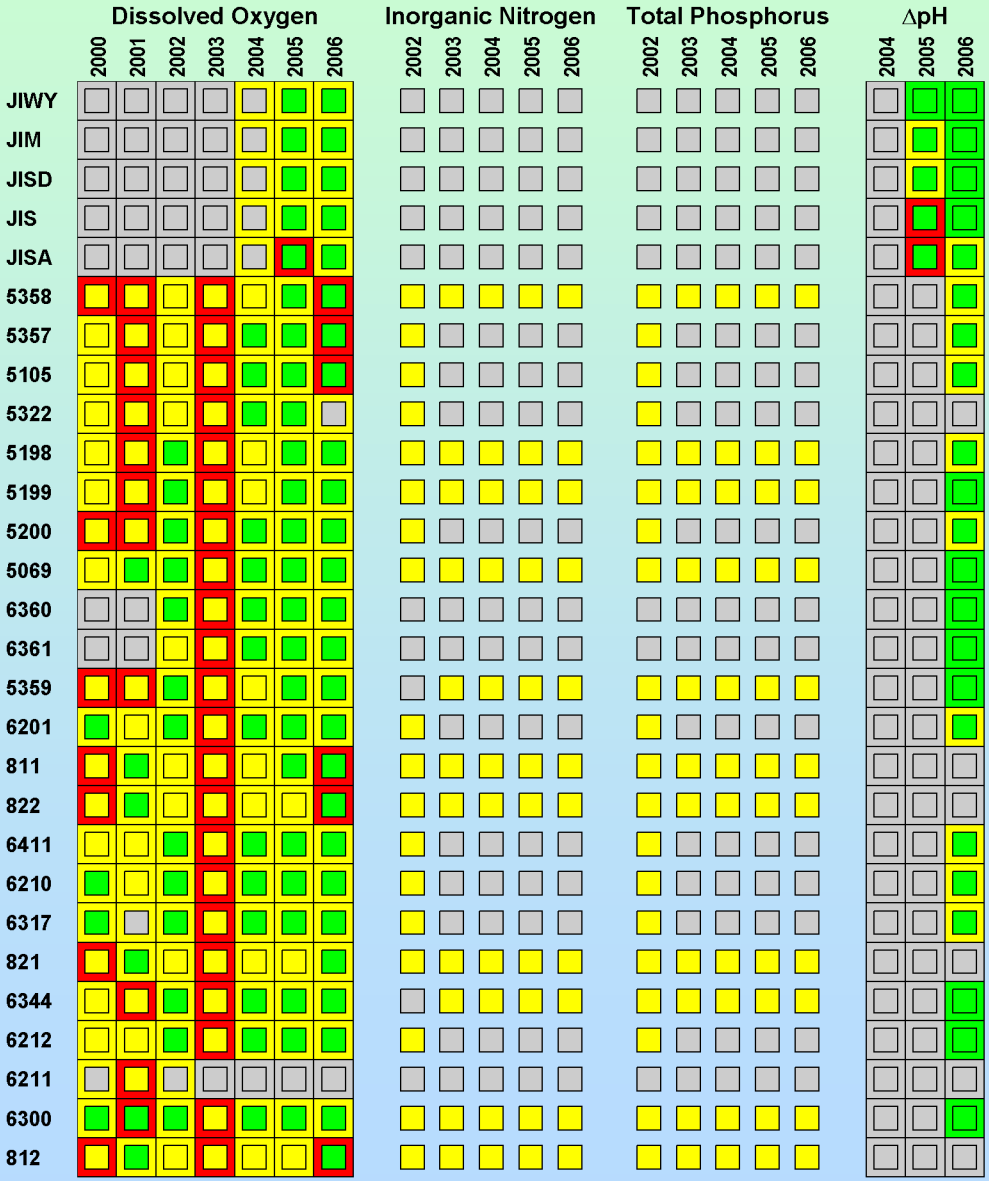
pH criteria are based on fluctuations around the normal condition. pH stability in this region was generally good in terms of both median and extreme conditions, with occasional fair episodes, but the data are limited to 2005-2006.



Region 8: Satilla River and St. Andrew Sound



St. Andrew Sound is an estuary between Jekyll Island (to the north) and Cumberland Island (to the south). Jekyll Island is home to busy marinas and public beaches, while Cumberland Island is designated a National Seashore, with both historical and natural resources. The Satilla River (a blackwater river that is not currently monitored by GA DNR CRD) provides an average of 2,700 cubic feet of freshwater per second to the sound and coastal zone. Shellfish harvest areas are found in creeks both north (Jointer Creek, Little Satilla River) and south (Cumberland River) of the sound, and the estuary and coastal areas support commercial and recreational fisheries for shrimp and blue crabs. The river contains a struggling population of Atlantic sturgeon, and endangered shortnose sturgeon are also occasionally sighted. This region includes sites sampled through the Sound (pink), Shellfish (white), and Beach (cyan) (color) monitoring programs.



Oxygen

Median dissolved oxygen conditions were fair at most sites during 2000-2001, with fair to poor extreme conditions. Conditions improved overall in 2002, with fair to good median conditions and fair extreme conditions. All sites had fair median conditions with poor episodes during 2003, but improved during 2004-2006 with generally good median conditions and fair extreme conditions at most sites. Jointer Creek and sound sites had more of a tendency for poor episodes compared to other sites.

Nitrogen

Dissolved inorganic nitrogen was fair during the study period.

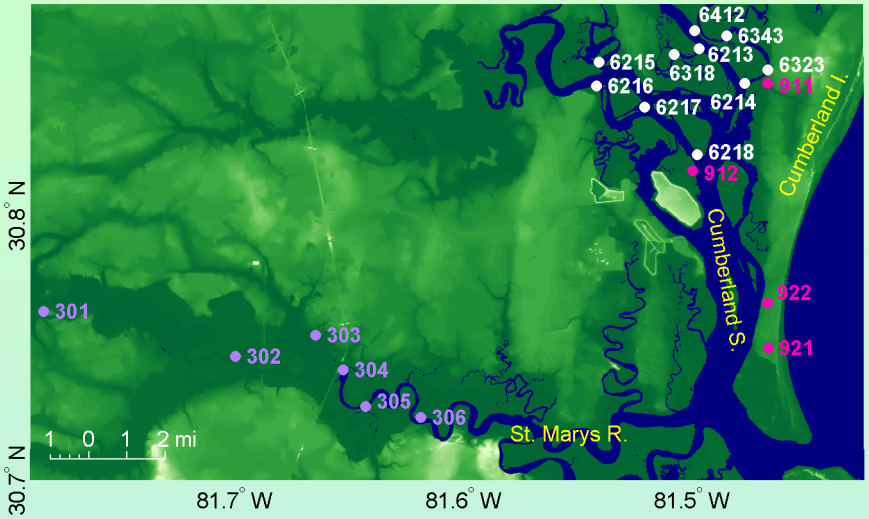
Phosphorus

Total dissolved phosphorus was fair during the study period.

pH

The Satilla River has a naturally low pH due to the tannins that stain the water dark brown. This affects pH in St. Andrew Sound and nearby creeks as well. pH criteria are based on fluctuations around this naturally low normal condition. pH stability in this region was generally good, with some fair and poor extreme conditions, but the data are limited prior to 2006.

Region 9: St. Marys River and Cumberland Sound



Cumberland Sound is an estuary between the mainland and Cumberland Island, a National Seashore with both historical and natural resources. The Kings Bay Naval Submarine Base is located on the western side of the sound. The southern entrance of the sound connects with the lower St. Marys River, a blackwater river that has its origins in the Okefenokee Swamp and provides an average of 1,200 cubic feet of freshwater per second to the coastal zone. Shellfish harvest areas are found in the Brickhill River and Crooked River areas in the upper sound, and the estuary and coastal areas support shrimp and blue crab fisheries as well as sportfishing for a variety of species. There are occasional sightings of endangered shortnose sturgeon, but the historical breeding population of Atlantic sturgeon is apparently extirpated. This region includes sites sampled through the River (purple), Sound (pink), and Shellfish (white) monitoring programs.

Oxygen

Dissolved oxygen fluctuated greatly over the study period and was generally lower in the St. Marys River than in Cumberland Sound. In 2000, 2001, and 2003, median conditions were generally fair throughout the region, whereas in 2002 and 2004-2005 they were good in the sound but fair at the river sites. Extreme conditions in the river were usually poor, whereas those in the sound were poor in 2001 and 2003 but fair in other years. In 2006, all sites but one had good median conditions and fair extreme conditions.

Nitrogen

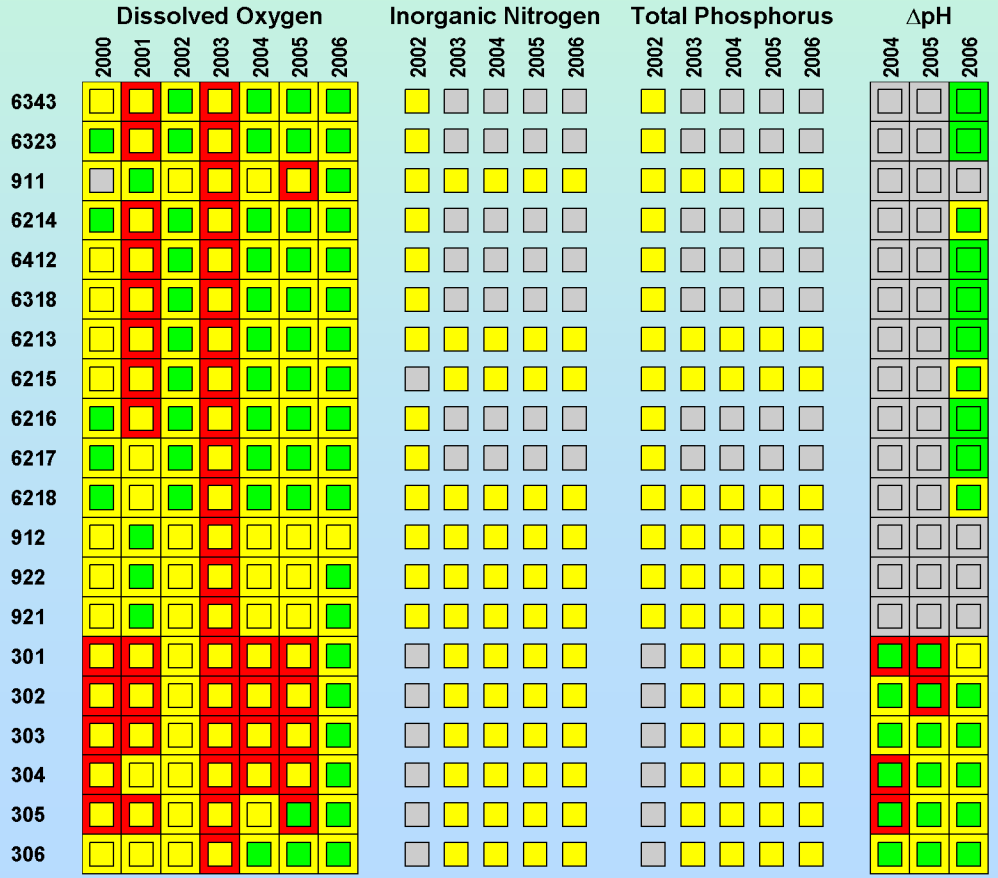
Dissolved inorganic nitrogen was fair during the study period.

Phosphorus

Total dissolved phosphorus was fair during the study period.

pH

As a blackwater river, the St. Marys River has a naturally low pH due to the tannins that stain the water dark brown. pH criteria are based on fluctuations around this naturally low normal condition. Median pH stability in this region was generally good, with fair and occasional poor extreme conditions in the river, but the data are limited prior to 2006.



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